Structural Assessment

of the

USS Yorktown CV-10

Prepared for:

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USS YORKTOWN

Executive Summary

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1. Summary of Assessment Tasks

The team of Collins Engineers, Inc. (Collins), Ocean Technical Services LLC (OTS), and CB&I was engaged by the Patriots Point Development Authority (PPDA) to conduct a structural assessment of the USS Yorktown (CV-10), a decommissioned Essex-class aircraft carrier currently berthed at the Patriots Point Naval & Maritime Museum in Mount Pleasant, South Carolina. The assessment consisted of the following seven (7) tasks:

- Task 1: Assessment of Exterior Hull Above the Mud Line
- Task 2: Assessment of Exterior Hull Below the Mud Line Based on Literature
- Task 3: Assessment of Exterior Hull Below the Mud Line Based on Inspection
- Task 4: Visual Assessment of Accessible Compartments in the Bow Region
- Task 5: Visual Assessment of all Accessible Compartments in the Remainder of the Vessel
- Task 6: Estimation of Rates of Corrosion and Development of Ongoing Maintenance Plan
- Task 7: Interpretation of the Structural Assessment and Repair Recommendations

The assessments were performed by Collins and OTS between February and November of 2014. The engineer-diver assessments of Tasks 1 and 3 typically were performed by a team of three engineers, while the structural assessments were performed either by a marine surveyor or by a team of two engineers, one of whom was a licensed Professional Engineer registered in the State of South Carolina. The interior assessments were purely visual in nature; no material sampling or destructive testing was performed. Evaluations are based on Collins and OTS observations at the time of the inspections. Collins and OTS reserve the right to change our opinions, evaluations, and cost estimates should existing conditions change or additional information come to light.

A summary of the procedure for each task follows.

1.1. Task 1: Assessment of Exterior Hull Above the Mud Line

Task 1 of the Assessment consisted of four phases:

- A galvanic survey of the existing impressed current cathodic protection system
- A corrosion survey of the exposed portions of the USS Yorktown's hull with limited non-destructive testing
- A visual below water inspection of the exterior hull above the mud line
- A visual assessment of the exterior of the hull above the waterline from a Jon boat

Collins conducted Level I, Level II, and Level III examinations along the hull of the vessel. The Level I inspections consisted of visual and tactile examination of accessible surfaces from the splash zone to the channel bottom. The Level II inspections consisted of visual and tactile examination of localized portions of the vessel surfaces that were exposed via removal of the marine growth at 12 locations around the ship. These locations were specified as the highest priority locations by Ocean Technical Services (OTS), based on their years of experience with similar vessels and the results of the galvanic survey, and were considered representative samples for determination of the condition of the hull.

The 12 Level II and Level III inspection locations were concentrated toward the stern of the vessel, as PPDA already was aware of significant deterioration of the hull at the forward approximately 167 feet of the vessel. Because repair of this section was already anticipated, the majority of the inspection locations were performed aft of this section.

Where possible at each of the 12 locations, an approximately 2 ft x 2 ft area was cleaned at two elevations: 1) at the waterline, and 2) at the channel bottom. Level III inspections were also performed at these 12 locations. The Level III inspections consisted of non-destructive testing of the cleaned portions of the hull via an ultrasonic thickness (UT) gauge to obtain thickness measurements of the hull plate. These measurements were then compared to the original hull plate thickness specified on the original construction drawings to determine the extent of section loss of the hull plate.

1.2. Task 2: Assessment of Exterior Hull Below the Mud Line Based on Literature

Task 2 of the Assessment consisted of research regarding the anticipated corrosion of the hull plate below the mud line based on an extensive literature survey performed by CB&I and review of corrosion of similar vessels based on the team's previous experience regarding other historic vessels. The research plan for this task included the following activities:

- Collection and review of literature and other information related to steel in coastal soils.
- Review of existing specifications of the steel plate and hull coatings on the USS YORKTOWN
- Review of published research studies.
- Interview with other researchers.
- Laboratory studies.
- Research into coating application.
- Review of corrosion of similar vessels based on the team's previous experience

The results of this literature research were used to help determine the specific locations for the below the mud line inspections of the hull of the Yorktown.

1.3. Task 3: Assessment of Exterior Hull Below the Mud Line Based on Inspection

During Task 3, Collins conducted Level I, Level II, and Level III examinations (refer to Task 1 for description of these terms) below the channel bottom at seven locations along the hull. Jetting of the mud at these locations was performed to remove the silt and mud up to approximately six feet below the original channel bottom at locations specified by OTS. These locations were selected based on OTS's experience and literature research performed as part of Task 2 of the Structural assessment and summarized in the Task 2 report. The jetting was performed by Standard Diving Marine Contractors, in coordination with Collins' dive team.

1.4. Task 4: Visual Assessment of Accessible Compartments in the Bow Region

Task 4 of the Assessment consisted of a cursory visual assessment of the accessible interior compartments of the ship's bow area from the forward perpendicular to Frame 50, from the 4th Deck down through the 1st and 2nd Platforms and Hold. All easily accessible spaces were visually reviewed with notation made as to the overall structural condition, condition of easily accessible major structural members, bulkheads, floors and condition of foundations of components where applicable. The inspections in this area typically were performed by OTS, with Collins performing inspections in partially flooded compartments. Tanks, cofferdams, and other confined spaces were not visually reviewed by OTS or Collins; however, data recorded by CB&I (the Shaw Group) during their environmental assessment was included in the report for this task. Per the project scope, Collins/OTS did not perform detailed assessments from which repair drawings and/or specifications could be compiled.

1.5. Task 5: Visual Assessment of all Accessible Compartments in the Remainder of the Vessel

Task 5 of the Assessment consisted of a cursory visual assessment of the accessible interior compartments of the ship from Frame 50 to the stern, from the 4th Deck down through the 1st and 2nd Platforms and Hold. All easily accessible spaces were visually reviewed with notation made as to the overall structural condition, condition of easily accessible major structural members, bulkheads, floors and condition of foundations of components where applicable. Tanks, cofferdams, and other confined spaces were not visually reviewed by OTS or Collins; however, data recorded by CB&I (the Shaw Group) during their environmental assessment was included in the report for this task. Per the project scope, Collins/OTS did not perform detailed assessments from which repair drawings and/or specifications could be compiled.

1.6. Task 6: Estimation of Rates of Corrosion and Development of Ongoing Maintenance Plan

Task 6 of the Assessment consisted of a determination of the rates of corrosion and percentage loss for critical structural elements identified during the previous Tasks. The project team created a protocol for monitoring the corrosion and degradation of the vessel structure, including guidelines for monitoring and ongoing maintenance after the completion of any required repairs to the Yorktown.

1.7. Task 7: Interpretation of the Structural Assessment and Repair Recommendations

Task 7 of the Assessment consisted of conceptual recommendations for repairs and an order-of-magnitude cost estimate for repairs to the vessel. The cost estimate is included at the end of this executive summary.

2. Summary of Conditions Observed

2.1. Task 1: Assessment of Exterior Hull Above the Mud Line

Collins observed an approximately 1/2 in. thick typical layer of marine growth along the entire hull at both the port and starboard sides of the ship from the tidal zone to the channel bottom. The layer of marine growth prevented Collins from visually observing the steel-plated hull, preventing us from being able to observe typical minor deficiencies. However, some larger deficiencies could be seen through the marine growth.

During the Level I inspection, a 4 in. diameter hole was observed on the port side approximately 30 feet aft of the bow and approximately 8 feet below the black stripe (approximately 0.9 feet above MLW). The hole is visible above the waterline at low tide. The location of the hole appears to correspond to the upper portion of the 2nd Platform and appears to be in the approximate vicinity of the port-side Boatswain's Stores or S.D. Stores. The hole was observed to allow water infiltration into the interior of the vessel.

Pitting corrosion, typically 1/8 inch to 1 inch in diameter with up to 1/16 inch of penetration, was observed at each of the twelve locations exposed for Level II inspection. The pitting corrosion, which is localized corrosion that leads to small areas with section loss, was observed to have a uniform concentration.

The Level III inspections provided detailed data regarding the thickness of the hull plating and the degree of section loss present at the twelve cleaned locations. Level III inspection data obtained during Task 1 indicated a maximum loss of section of up to 6.06% with an average loss of section of 2.48%; this corresponds to relatively minimal corrosion and loss of section at the inspection locations. By extrapolating the data, Collins assumes the typical uninspected locations of the vessel will have approximately the same amount of section loss.

During Collins' review of the hull from a Jon boat, heavy pack rust was observed on the hull within the splash zone. Pack rust is a form of corrosion in which the metal is observed to have layers of rust form on top of one another creating a bubbled look. The pack rust extended along the full length of the vessel on the port side and at the forward approximately 150-ft and the aft approximately 100-ft of the starboard side. The pack rust was encompassed within an approximately 6-ft tall band within the splash zone that was approximately two-to-four feet tall. The thickness of the pack rust varied, with a maximum thickness of up to 1/2 in. The band was located approximately 10.5-11 feet above MLW, typically corresponding with the upper portion of the 1st Platform and the lower portion of the 4th Deck. Collins also observed several holes in the steel hull of the ship in the splash zone. These holes were initially obscured by pack rust, and were exposed by removing the pack rust accumulated on the outer surface of the hull. One hole was located on the starboard side of the ship, approximately 80 feet aft of the bow of the ship. Three holes were located on the port side of the ship in an area approximately 75 feet aft of the bow of the ship. Several previously patched holes were observed on the port side of the ship in the vicinity of these holes.

2.2. Task 2: Assessment of Exterior Hull Below the Mud Line Based on Literature

The Task 2 assessment indicated that the general corrosion rates on the USS Yorktown below the mud line are likely to be low due to the anaerobic environment. The governing corrosion mechanisms below the mud line are localized crevice, pitting, and microbiological corrosion. These mechanisms are dependent on multiple variables within a localized environment and the rate of localized corrosion by these mechanisms on the USS Yorktown cannot be determined.

Based on the research conducted during Task 2, it was recommended that below-the-mud line inspections be performed at locations identified by the cathodic protection potential survey, as locations where sharp changes in corrosion potential and limited cathodic protection effectiveness are present are likely locations for degradation. These locations included the bow and measured from the bow along the waterline: 200 ft. on the starboard side, 300 ft. on the port side, 550 ft. on the port and starboard sides, 700 ft. and 800 ft. on the starboard side, and the sternmost 150 ft. on the port side.

The Task 2 assessment also provided the recommendation that the immersion zone/mud zone interface and other likely locations where materials of different composition interface should be assessed, including locations where the soil type changes abruptly from clay to sand. It also recommended that if localized deposits are found on the hull, an example deposit should be removed to determine if localized corrosion is occurring underneath and that if severe corrosion is evident under a removed deposit, a sacrificial anode may be installed to protect the exposed metal.

2.3. Task 3: Assessment of Exterior Hull Below the Mud Line Based on Inspection

Similar to the observations of the hull plate during Task 1, pitting corrosion, typically 1/8 inch to 1 inch diameter with up to 1/16 inch of penetration, was observed at each of the seven locations exposed for Level II assessment below the mud line. The pitting observed by Collins was observed to have a uniform concentration at each inspection location, similar to Task 1. Due to the typical observation of pitting at each inspection location, Collins assumes the pitting extends along the entire hull at similar elevations below the channel bottom. While the pitting observed was up to 1/16 inch in penetration, the thickness measurements obtained during the Level III inspections may not show this localized section loss. Collins was unable to verify if any coating material remained during the assessment due to poor visibility and the typical surface corrosion.

Level III inspection data obtained during Task 3 indicated a maximum loss of section of up to 5.60% with an average loss of section of 3.57%; this corresponds to relatively minimal corrosion and loss of section at the inspection locations.

Based on the consistency of the thickness readings and visual observations at the exposed inspection areas in both Tasks 1 and 3 – which were at locations aft of Frame 50 that appear most likely to exhibit higher corrosion rates – it is likely that the typical uninspected portions of the vessel aft of Frame 50 will exhibit a similar degree of section loss.

2.4. Task 4: Visual Assessment of Accessible Compartments in the Bow Region

Significant deterioration was observed typically in this section of the ship. A deck by deck summary of the conditions observed follows.

At the 4th deck, all spaces forward of Frame 19 are flooded and/or exhibit severe deterioration for which near term repair is recommended.

At the 1st Platform (5th deck), severe deterioration for which near term repair is recommended was observed forward of Frame 26. Flooding was also observed between frames 32 and 39, for which near term repair is recommended.

At the 2nd Platform (6th deck), severe deterioration for which near term repair is recommended was observed forward of Frame 26 and between frames 38 and 42. At the Hold level (7th deck), the spaces forward of Frame 26 and from Frames 44 to 50 are flooded and/or exhibit severe deterioration for which near term repair is recommended.

The remaining spaces in this section of the ship were generally found to be in structurally sound condition with varying degrees of minor deterioration that typically included peeling paint and light surface corrosion.

While not structural in nature, potential environmental and/or health hazards were observed in a number of compartments, including asbestos, “red lead” primer, and oil/fluid spills or leaks. A complete environmental assessment of the vessel was performed by The Shaw Group (Shaw) in 2013 and was not included in the scope of this structural assessment. A summary of Shaw’s findings and recommendations was provided in Shaw’s report dated April 12th, 2013. During the environmental assessment of the Yorktown performed by Shaw, a cursory review of the structural condition of the reviewed tanks was performed. There were 32 tanks located within the scope of Task 4 of this assessment. Of these tanks, 14 were inaccessible, 16 exhibited minor deterioration, and 2 exhibited moderate deterioration; none exhibited significant deterioration.

2.5. Task 5: Visual Assessment of all Accessible Compartments in the Remainder of the Vessel

The structural conditions observed during the Task 5 assessments varied greatly with level and location. A deck by deck summary of the conditions observed follows.

The compartments of the 4th Deck were generally found to be in structurally sound condition with varying degrees of minor deterioration that typically included peeling paint and light surface corrosion. Deformation of transverse bulkheads was observed at several locations on the 4th Deck, and many bulkheads have been torch-cut previously.

The compartments of the 1st Platform (5th Deck) were generally found to be in structurally sound condition with varying degrees of deterioration that typically included peeling paint and light surface corrosion; isolated compartments at the forward and aft portions of the vessel exhibited severe deterioration.

The compartments of the 2nd Platform (6th Deck) were generally found to have varying degrees of deterioration that typically included peeling paint and corrosion; isolated compartments at the forward and aft portions of the vessel were observed to be in a state of severe deterioration.

The compartments of the Hold level (7th Deck) were generally found to have varying degrees of deterioration that typically included peeling paint and corrosion; isolated compartments at the forward and aft portions of the vessel were observed to be in a state of severe deterioration. Several compartments at this level were flooded to unknown depths and were inaccessible.

While not structural in nature, potential environmental and/or health hazards were observed in a number of compartments throughout the vessel, including asbestos, "red lead" primer, and oil/fluid spills or leaks. As noted above, an environmental assessment of the vessel was performed by The Shaw Group (Shaw) in 2013 during which a cursory review of the structural condition of the reviewed tanks was performed. There were 311 tanks located within the scope of Task 5 of this assessment. Of these 311 tanks, 106 were inaccessible, 139 exhibited minor deterioration, 50 exhibited moderate deterioration; and 16 exhibited significant deterioration.

2.6. Task 6: Estimation of Rates of Corrosion and Development of Ongoing Maintenance Plan

The information generated from Tasks 1 through 5 was used to determine the rate of corrosion and percentage of section loss for the critical structural elements of the vessel. The corrosion rates of the hull are greatest in the splash zone. Corrosion rates in this area typically are estimated to be approximately 0.002-in. to 0.007-in. per year. However, in localized areas there is already a metal loss of 70% to 80%, with a handful of isolated areas with up to 100% loss of section. Corrosion in the tidal and submerged zones has been estimated at approximately 0.00062-in. to 0.0015-in. per year. Corrosion in the mud zone could not adequately be estimated as the majority of the compartments with shell plate in contact with the mud zone are the outside tanks and the double bottom tanks which were not included in the scope of the assessment.

The observed internal corrosion is primarily the result of compartments being currently and/or previously flooded. Where evident, corrosion was typically observed on the deck plate, lower walls and lower portions of structural members.

Repairs for areas that exhibit significant deterioration are recommended in Task 7. In conjunction with these repairs, to prevent ongoing internal corrosion and an increase in corrosion rates, watertight integrity must be restored/maintained, resources must be committed to maintaining the coating systems in all compartments, and the cathodic protection system must function with maximum effectiveness. Regular daily, weekly, and long-term maintenance and inspection schedules should also be established to monitor the structural condition of the vessel.

Note that a number of the ongoing maintenance tasks recommended in Task 6 are already performed by PPDA staff. For example, the engineering staff conducts weekly visual inspections of all accessible compartments and a corrosion engineer performs quarterly inspections of the cathodic protection system.

2.7. Task 7 - Interpretation of the Structural Assessment and Repair Recommendations

Following is the order-of-magnitude cost estimate for the structural repairs for the portions of the vessel assessed in Tasks 1 through 5. This order-of-magnitude estimate is based on the team's experience with similar projects. Construction costs vary and Collins does not provide any warranty, express or implied, for construction costs. A permanent or semi-permanent/portable cofferdam offers the best choice to allow 'below waterline' repairs to the vessel's shell plating; the cost of either a portable or permanent cofferdam is not included in this estimate.

BOW TO FRAME 50

1) MOBILIZATION & DEMOBILIZATION		$4,119,510.00
2) EXTERIOR SHELL PLATING	Total Repair Cost	$5,955,000.00
3) BULKHEADS	Total Repair Cost	$3,641,600.00
4) FRAMES	Total Repair Cost	$730,000.00
5) 4th DECK	Total Repair Cost	$722,400.00
6) 1st Platform	Total Repair Cost	$3,037,570.00
7) 2nd Platform	Total Repair Cost	$3,444,550.00
8) Hold	Total Repair Cost	$1,193,650.00
9) VERTICAL KEEL	Total Repair Cost	$735,000.00
10) PAINTING	Total Repair Cost	$1,640,736.00

Total Estimated Repair Costs	$25,220,016.00
15% Contingency	$3,783,002.00
Total Cost	$29,003,018.00

FRAME 50 TO STERN

1) MOBILIZATION & DEMOBILIZATION		$2,570,329.00
2) 1st PLATFORM	Total Repair Cost	$751,200.00
3) 2ND PLATFORM	Total Repair Cost	$775,400.00
4) HOLD	Total Repair Cost	$1,342,880.00
5) WIND/WATERLINE PORT	Total Repair Cost	$2,822,000.00
6) WIND/WATERLINE STARBOARD	Total Repair Cost	$509,000.00
7) SHAFT ALLEYS	Total Repair Cost	$876,000.00
8) PAINTING	Total Repair Cost	$315,000.00

Total Estimated Repair Costs	$9,961,809.00
15% Contingency	$1,494,271.00
Total Cost	$11,456,081.00

SUMMARY OF REPAIR COSTS

Total Estimated Repair Costs	$40,459,099.00

4th Deck

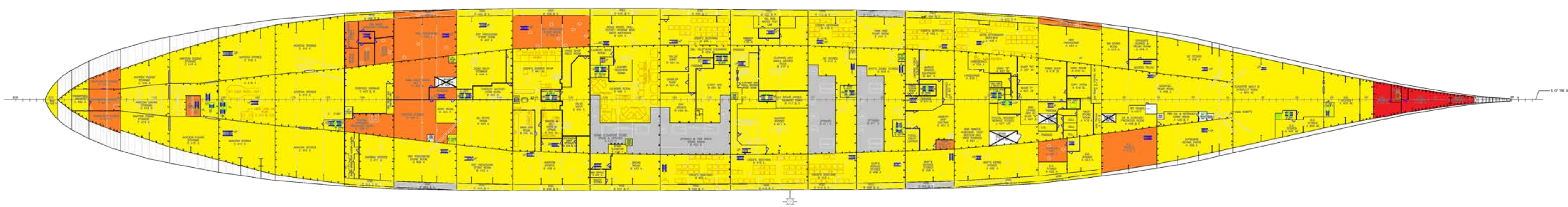

Figure 2.1 Overall view of 4th Deck

1st Platform

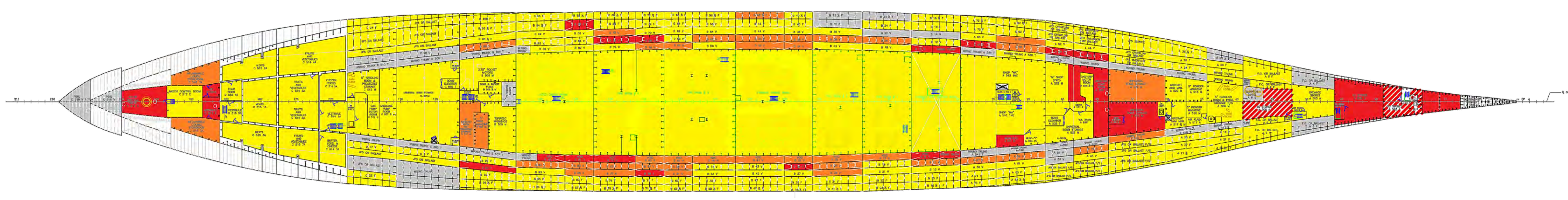

Figure 2.2 Overall view of 1st Platform

- Minor deterioration - long-term concern
- Moderate deterioration - monitoring recommended
- Significant deterioration - near-term repair recommended
- Inaccessible / not inspected

2nd Platform

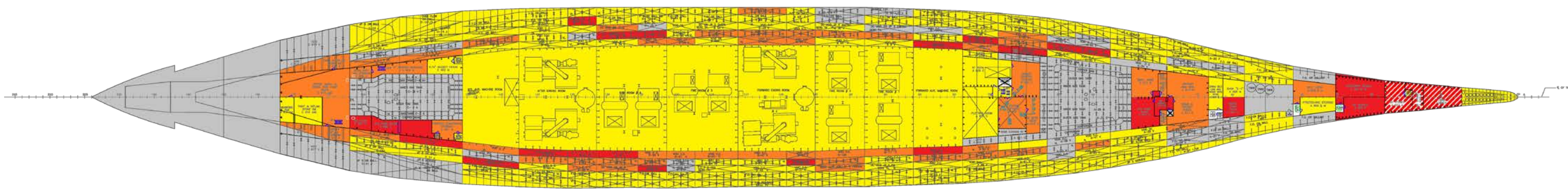

Figure 2.3 Overall view of 2nd Platform

Hold

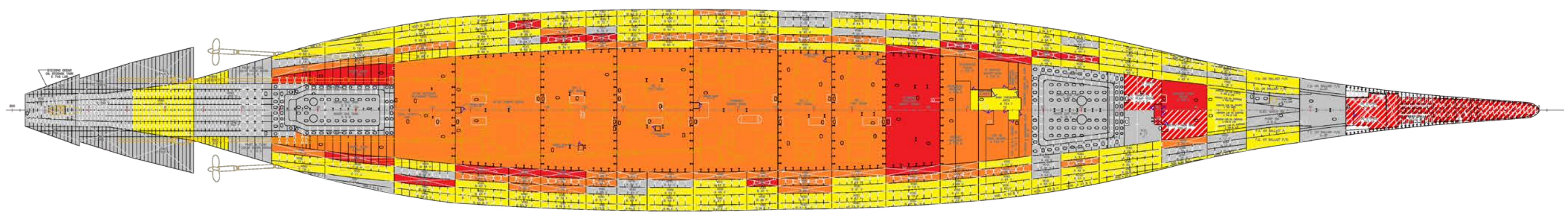

Figure 2.4 Overall view of Hold

- Minor deterioration - long-term concern
- Moderate deterioration - monitoring recommended
- Significant deterioration - near-term repair recommended
- Inaccessible / not inspected

USS YORKTOWN

Task 1: Assessment of Exterior Hull Above the Mud Line
&
Task 3: Assessment of Exterior Hull Below the Mud Line Based on Inspection

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1. EXECUTIVE SUMMARY

Collins Engineers, Inc. (Collins) was engaged by the Patriots Point Development Authority (PPDA) to perform a structural condition assessment of the USS Yorktown. Task 1 of the assessment included the performance of a general underwater condition assessment of the accessible portion of the hull aft of Frame 50 above the mud line. Task 3 of the assessment included the performance of a detailed underwater condition assessment of the hull aft of Frame 50 at seven specific locations below the channel bottom.

Collins observed typical minor pitting and pack corrosion along the exposed portions of the hull and also observed one major deficiency within the inspection area. Due to the large amount of marine growth along the entire hull of the vessel and limited underwater visibility during our review of the hull, some deficiencies may not have been evident at the time of inspection.

The channel bottom was located approximately five to six feet below Mean Low Water (MLW) on the port side and approximately zero to one foot below MLW on the starboard side. The channel bottom elevation was much deeper at the bow, measuring -10.1 feet MLW. The most likely cause for this is dredging along the channel for ship traffic. See the Channel Bottom Profile located in Appendix A for all soundings.

Assessment of the hull forward of Frame 50 was not performed as Collins was informed by PPDA that PPDA was aware of significant structural deterioration of the hull plate at the forward approximately 200-ft of the vessel and that the hull plate in this region was known to require replacement. Collins recommends that any tanks containing hazardous materials along the hull plate in this region be remediated to prevent the risk of environmental contamination.

Collins' typical observations and most notable deficiencies are as follows:

<u>General Observations</u>

- Heavy pack rust was observed on the hull within the splash zone. The pack rust extended along the full length of the vessel on the port side and at the forward approximately 150-ft and the aft approximately 100-ft of the starboard side. The pack rust was encompassed within an approximately 6-ft tall band within the splash zone that was approximately two-to-four feet tall. The thickness of the pack rust varied, with a maximum thickness of up to 1/2 in. The band was located approximately 10.5-11 feet above MLW, typically corresponding with the upper portion of the 1st Platform and the lower portion of the 4th Deck. Pitting corrosion, typically 1/8 inch to 1 inch diameter with up to 1/16 inch of penetration, was observed on all areas of all Level II cleaning locations. Due to the typical observation of pitting at each inspection location, Collins assumes the pitting extends along the entire hull below the splash zone.
- Marine growth, typically approximately 1/2 in. thick, was observed along the entire hull at both the port and starboard sides of the ship from the tidal zone to the channel bottom. The layer of marine growth prevented Collins from visually observing the steel-plated hull, preventing us from being able to observe typical minor deficiencies.
- Pitting corrosion, typically 1/8 inch to 1 inch in diameter with up to 1/16 inch of penetration, was observed at each of the twelve locations exposed for Level II inspection. The pitting corrosion, which is localized corrosion that leads to small areas with section loss, was observed to have a uniform concentration.
- Level III inspection data obtained during Task 1 indicated a maximum loss of section of up to 6.06% with an average loss of section of 2.48% and Level III inspection data obtained during Task 3 indicated a

maximum loss of section of up to 5.60% with an average loss of section of 3.57%; this corresponds to relatively minimal corrosion and loss of section at the inspection locations.

- Based on the consistency of the thickness readings and visual observations at the exposed inspection areas in both Tasks 1 and 3 – which were at locations aft of Frame 50 that appear most likely to exhibit higher corrosion rates – it is likely that the typical uninspected portions of the vessel aft of Frame 50 will exhibit a similar degree of section loss.

Notable, Specific Observations

- A corrosion hole, approximately 4 in. in diameter, was observed on the port side approximately 0.9 feet above MLW and approximately 30 ft aft of the bow. This location appears to correspond to the upper portion of the 2nd Platform and appears to be in the approximate vicinity of the port-side S.D. Stores. The hole was observed to allow water infiltration into the interior of the vessel, potentially causing deterioration inside the vessel.
- Significant corrosion with isolated locations with up to 100% loss of section were observed along the splash zone along the entire port side and the forward approximately 150-ft and the aft approximately 100-ft of the starboard side of the vessel.
- An approximately 1/2 in. diameter cable was observed to exit the hull just below the waterline at each of the port and starboard sides. The penetration through the hull was located approximately 50 ft aft of the bow. An approximately 2 in. diameter hole was observed at each location that allowed water infiltration into the vessel. The locations of the holes appear to be below the 2nd Platform and appear to be in the approximate vicinity of the S.D. Stores and the Incendiary Bomb Room. The cables extended into the channel bottom at each side of the vessel.
- A portion of a large steel pipe was observed on the channel bottom. The pipe, which measured approximately 2 feet long by 1-1/2 inches in diameter, appeared to be correlate to a missing section of corroded pipe from the vessel located directly above.

Repair recommendations for the deteriorated conditions observed above are provided in the Task 7 report. Based on Collins' observations and the galvanic potential readings performed by Ocean Technical Services, LLC (OTS), the cathodic protection system generally appears to be functioning properly. Please refer to Appendix C for a summary of the cathodic protection readings provided by OTS.

2. INTRODUCTION

2.1. Purpose and Scope

Collins Engineers, Inc. (Collins) was engaged by the Patriots Point Development Authority (PPDA) to perform a structural condition assessment of the USS Yorktown, which is located at Patriots Point in Mount Pleasant, SC. Task 1 of the assessment included the performance of a general underwater condition assessment of the accessible portions of the hull of the Yorktown aft of Frame 50 from the splash zone to the channel bottom, including detailed assessments at 12 specific locations along the hull. Task 3 of the assessment included the performance of a detailed underwater condition assessment at seven locations along the hull aft of Frame 50below the channel bottom.

The Task 1 assessment was conducted by three engineer-divers on February 18th through February 20th, 2014. The Task 3 assessment was conducted by two engineer-divers and a team member on March 24th through March 26th, 2014. This report provides a summary of Collins' observations of the exterior hull from the splash zone to the channel bottom and the specified Task 3 locations below the channel bottom.

2.2. Task 1

Task 1 of the Assessment consisted of four phases:

- A galvanic survey of the existing impressed current cathodic protection system
- A corrosion survey of the exposed portions of the USS Yorktown's hull with limited non-destructive testing
- A visual below water inspection of the exterior hull above the mud line
- A visual assessment of the exterior of the hull above the waterline from a Jon boat

Collins conducted Level I, Level II, and Level III examinations along the hull of the vessel. The Level I inspections consisted of visual and tactile examination of accessible surfaces from the splash zone to the channel bottom. The Level II inspections consisted of visual and tactile examination of localized portions of the vessel surfaces that were exposed via removal of the marine growth at 12 locations around the ship. These locations were specified as the highest priority locations by Ocean Technical Services (OTS), based on their years of experience with similar vessels and the results of the galvanic survey, and were considered representative samples for determination of the condition of the hull.

The 12 Level II and Level III inspection locations were concentrated toward the stern of the vessel, as PPDA already was aware of significant deterioration of the hull at the forward approximately 200 feet of the vessel. Because repair of this section was already anticipated, all inspection locations were performed aft of this section.

Where possible at each of the 12 locations, an approximately 2 ft x 2 ft area was cleaned at two elevations: 1) at the waterline, and 2) at the channel bottom. Level III inspections were also performed at these 12 locations. The Level III inspections consisted of non-destructive testing of the cleaned portions of the hull via an ultrasonic thickness (UT) gauge to obtain thickness measurements of the hull plate. These measurements were then compared to the original hull plate thickness specified on the original construction drawings to determine the extent of section loss of the hull plate.

2.3. Task 3

During Task 3, Collins conducted Level I, Level II, and Level III examinations (refer to Task 1 for description of these terms) below the channel bottom at seven locations along the hull. Jetting of the mud at these locations was performed to remove the silt and mud up to approximately six feet below the original channel bottom at locations specified by OTS. These locations were selected based on OTS's experience and literature research performed as part of Task 2 of the Structural assessment and summarized in the Task 2 report. The jetting was performed by Standard Diving Marine Contractors, in coordination with Collins' dive team.

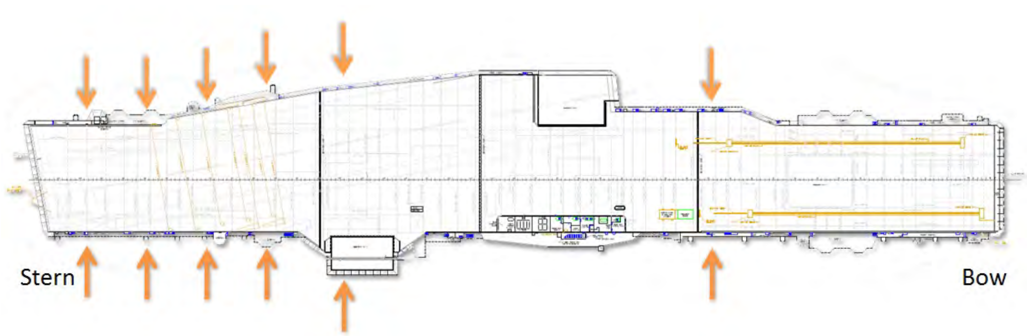


Figure 2.1 Underwater Inspection Locations

2.4. Project Team

The underwater condition assessment for Task 1 was performed by a three-person engineering dive team that consisted of one licensed professional engineer-diver registered in the state of South Carolina and two engineer-divers. The Task 3 underwater condition assessment was performed by a three-person dive team that consisted of two engineer-divers and one additional team member.

2.5. Inspection Procedure

The Task 1 and Task 3 underwater assessments were performed from a 22-foot C-Dory boat using surface-supplied air diving equipment. For surface-supplied diving, a diver will wear a helmet that fully encloses his head, a wetsuit, fins, and a harness with a backup tank. The diver can carry all necessary inspection tools such as a scraper, UT, and dive knife with him. Air is supplied to the diver through the helmet via an air hose within an umbilical. The umbilical also contains communication lines which are wired to the diver's helmet, allowing the diver to communicate with team members on the surface. Collins' divers were thus able to inspect the accessible portions of the hull while remaining in constant communication with the team members on the surface, ensuring any areas of interest could be described to members at the surface during the dive inspection.

Task 1

The Task 1 structural condition assessment included a Level I visual and tactile examination of the accessible exterior surfaces of the hull from the splash zone to the channel bottom. The general condition of the visible, accessible portions hull was noted, along with any observed deficiencies. Level I assessments are typically used to discover larger, more significant deficiencies. Marine growth is typically found on underwater inspections and a heavy layer of marine growth along the entire hull typically prevented Collins from seeing the condition of the hull.

Because it is not practical to remove all marine growth along the hull to comprehensively inspect a vessel the size of the Yorktown, Level II assessments were performed to expose a portion of the hull for detailed inspection. If consistent, the observations recorded at these locations may be reasonably extrapolated for typical conditions along the remainder of the ship. The Level II inspections of the Yorktown were performed at 12 locations specified by OTS as high priority locations and shown in Figures 2.1-1 and 2.1-2. At each location, Collins' engineer-diver cleaned an approximately 2 foot by 2 foot area of the hull, scraping and removing marine growth, to reveal the steel plated hull at each location. Visual and tactile assessments were then performed on the cleaned portion of the hull. Along the port side, two areas were cleaned at each inspection location, one at the waterline and one at the channel bottom. Along the starboard side, only one area was cleaned between the waterline and the channel bottom at each location due to the low water level, as there is only approximately zero to one foot of hull exposed between the Mean Low Water (MLW) and the average channel bottom depth.

Level III assessments were performed in conjunction with the Level II assessments. The Level III assessments included obtaining measurements of the thickness of the steel hull plate with an ultrasonic thickness (UT) gauge (Photo 5). The ultrasonic thickness gauge uses the pulse-echo principle to determine the thickness of metals. The probe is made to vibrate for a very short period, creating a pulse of ultrasound which enters the test piece. The probe waits for returned echoes and converts them into electrical signals which are processed into digital outputs. By using multiple echoes, the probe is able to determine the thickness of the metal exclusive of the paint, couplant, dirt, etc. See Figure 2.3 below.

Collins performed multiple thickness measurements at each cleaned area to ensure that an accurate thickness reading was obtained for each cleaned area. Collins then compared the thickness measurements obtained in the field to the original hull plate thicknesses shown on the original drawings from the National Archives to determine the amount of section loss of the hull plating at each location. Table 3.3-1 provides a summary of the thickness readings for results and Figures 3.3-1 and 3.3-2 provide graphic representations of the data. The original thicknesses were obtained by locating each approximate assessment location on "Shell Plating and Framing" sheets Bu. No. 305607 and 305608 from the construction documents on file at the National Archives. A diagram of the original plate thicknesses has been provided by Collins and is included in Appendix A.

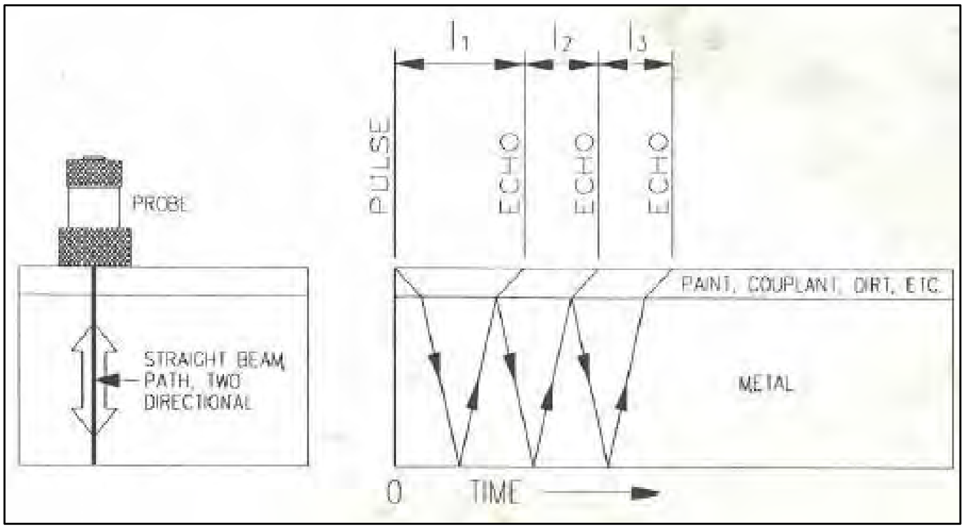


Figure 2.2 Ultrasonic Thickness Gauge

Following are the 12 locations selected for the Level II and Level III assessments:

Starboard locations:

1. Located approximately 20 feet forward of the third mooring bitt from the bow.
2. Located approximately 20 feet forward of the ninth mooring bitt from the bow.
3. Located approximately 28 feet forward of the tenth mooring bitt from the bow.
4. Located approximately 16 feet aft of the tenth mooring bitt from the bow.
5. Located approximately 2 feet forward of the last mooring bitt, or 11th from the bow.
6. Located 52 feet aft of the last mooring bitt.

Port locations:

1. Located approximately 20 feet forward of the third mooring bitt from the bow.
2. Located approximately 2 feet aft of the tenth mooring bitt from the bow.
3. Located approximately 40 feet aft of the tenth mooring bitt from the bow.
4. Located approximately 20 feet aft of the last mooring bitt, or 11th from the bow.
5. Located approximately 40 feet aft of the last mooring bitt, or 11th from the bow.
6. Located approximately 60 feet aft of the last mooring bitt, or 11th from the bow.

Task 3

During Task 3, Collins performed inspections of the hull at seven locations below the channel bottom. The inspections were performed at the locations shown on Figure 2.1-1 and 2.1-2 and typically correspond to locations outlined in Section 4.0 of the Task 2 report and the locations inspected during Task 1.

The seven locations were as follows:

Starboard locations:

1. Located approximately 20 feet forward of the third mooring bitt from the bow.
2. Located approximately 20 feet forward of the ninth mooring bitt from the bow.
3. Located approximately 28 feet forward of the tenth mooring bitt from the bow.
4. Located approximately 16 feet aft of the tenth mooring bitt from the bow.

Port locations:

1. Located approximately 20 feet forward of the third mooring bitt from the bow.
2. Located approximately 2 feet aft of the tenth mooring bitt from the bow.
3. Located approximately 40 feet aft of the tenth mooring bitt from the bow.

These locations correspond to seven of the Task 1 locations shown in section 2.4.1. Standard Diving Marine Contractors were retained to remove the silt and mud along the specified areas of the hull up to approximately six feet below the channel bottom via jetting. The jetting of the silt and mud by commercial divers allowed Collins' engineer-divers to enter the hole to perform Level II and III assessments. Level I assessments did not apply to Task 3 because the only below-channel-bottom hull locations exposed were the ones cleaned by Standard Diving for Collins' Level II and Level III inspections. The thickness measurements from the Level III assessments are included in Table 3.3-1 below.

Following the Task 3 inspections, soundings were performed with a digital boat-mounted sounder and confirmed with the diver's pneumofathometer to determine the channel bottom profile. The results of soundings are included in Appendix A: Channel Bottom Profile. Based on the soundings, it appears that the vessel is buried up to approximately 20 feet in the mud. According to Section 2.0 of the Task 2 report, the layer of soil in which the USS Yorktown is buried extends to a depth of approximately 46 feet below the mud line. Because the vessel is buried entirely within this layer, corrosion due to abrupt changes in soil type should not be present (See Task 2 report Section 11.0).

2.6. Definitions

Exposure Zones – the five zones along the hull as shown in Figure 3 in Appendix A: Atmospheric, Splash, Tidal, Submerged, and Mud.

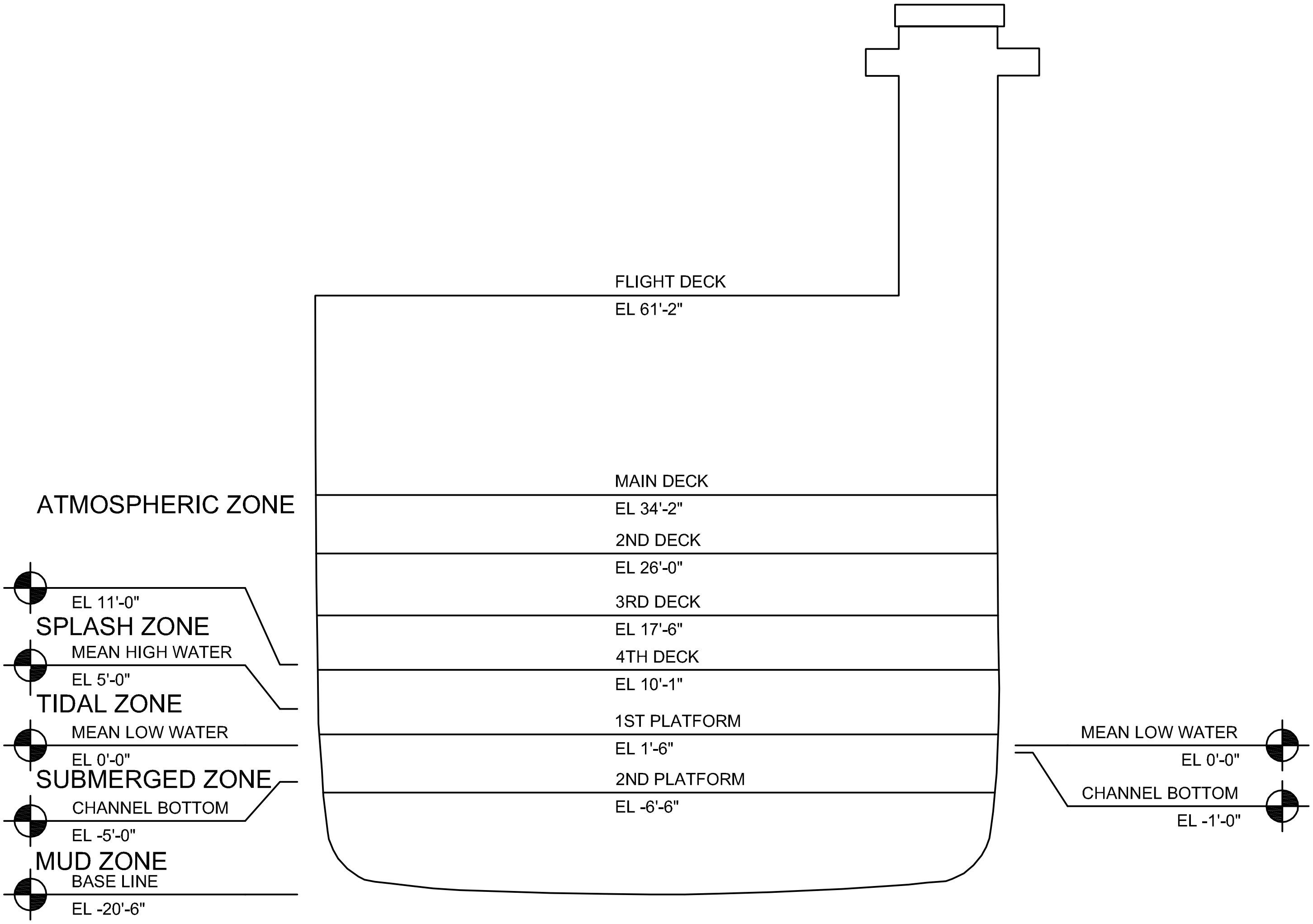
<u>Atmospheric Zone</u> – Located above all zones. Exposed to regular atmospheric conditions.

<u>Splash Zone</u> – Tidal zone to approximately 6 feet above tidal zone. Exposed to splashing from wave action and experiences multiple wet/dry cycles. Some marine growth occurs at the lower end of this zone.

<u>Tidal Zone</u> – Area between Mean Low Water (MLW) and Mean High Water (MHW). Exposed to cycles of wet/dry during tide swings. Typically largest amount of marine growth.

<u>Submerged Zone</u> – Area between MLW and the channel bottom. Constant wetness. Marine growth throughout.

<u>Mud Zone</u> – Area below the channel bottom. Refer to Figure 2.5-1 below.



USS YORKTOWN DECKS AND EXPOSURE ZONES

N.T.S. LOOKING FORWARD

PATRIOTS POINT
• HOME OF THE USS YORKTOWN •

USS YORKTOWN INSPECTION
UNDERWATER ASSESSMENT
DECK AND EXPOSURE ZONES

DRAWN BY: TWR	COLLINS ENGINEERS P.C.	225 SEVEN FARMS DR. STE. 200	DATE: MARCH 2014
CHECKED BY:		CHARLESTON, SC 29492	SCALE: NO SCALE
CODE: 40-8311		(843) 884-2027	SHEET NO.: 1

3. CONDITION ASSESSMENT OF USS YORKTOWN

3.1. Task 1

Level I Assessment

Collins observed an approximately 1/2 in. thick typical layer of marine growth along the entire hull at both the port and starboard sides of the ship from the tidal zone to the channel bottom (Photos 6 and 7). The layer of marine growth prevented Collins from visually observing the steel-plated hull, preventing us from being able to observe typical minor deficiencies. However, some larger deficiencies could be seen through the marine growth.

Heavy pack rust was observed on the hull within the splash zone. Pack rust is a form of corrosion in which the metal is observed to have layers of rust form on top of one another creating a bubbled look. The pack rust extended along the full length of the vessel and was typically up to 1/2 in. thick in a one to two foot high section. It was typically located approximately 8.9 feet above MLW just below the level of the 4th Deck (Photos 6 and 7). Readings of section loss with a UT gauge at pack rust locations are typically inaccurate due to the uneven pack rust surface. Thickness measurements taken at the pack rust locations typically were similar to the readings taken at other locations.

During the Level I inspection, a 4 in. diameter hole was observed on the port side approximately 30 feet aft of the bow and approximately 8 feet below the black stripe (approximately 0.9 feet above MLW). The hole is visible above the waterline at low tide (Photos 8 and 9). The location of the hole appears to correspond to the upper portion of the 2nd Platform and appears to be in the approximate vicinity of the port-side Boatswain's Stores or S.D. Stores. The hole was observed to allow water infiltration into the interior of the vessel. Refer to Appendix A: Structural Tanks – Second Platform.

Approximately 50 feet aft of the bow on both the port and starboard sides, a 1/2 inch diameter cable was observed that exited the hull near the waterline and extended on an angle away from the vessel into channel bottom. The cable was observed at approximately the same location on both sides of the vessel. A small hole, up to two inches in diameter, that may allow water to infiltrate into the interior of the vessel was observed where the cables entered the hull. The locations of the holes appear to be between the 2nd Platform and the 1st Platform and appear to be in the approximate vicinity of the S.D. Stores and Incendiary Bombs Room. The holes may allow water infiltration into the interior of the vessel. However, because the cable was assumed to be intentionally placed, there may be a waterproofing measure that has been installed to prevent water from infiltrating the vessel.

During the additional inspection of the splash zone performed on July 9th, 2014, numerous local areas of heavy-to-severe corrosion with up to 1/16" loss of section were observed in the splash zone. The significant corrosion was most typically observed along the entire port side of the ship and along the forward approximately 150-ft and aft approximately 100-ft of the starboard side of the vessel. Within this corroded portion of the splash zone, Collins observed several holes in the steel hull of the ship. These holes were initially obscured by pack rust, and were exposed by removing the pack rust accumulated on the outer surface of the hull. One hole was observed on the starboard side of the ship, approximately 80 feet aft of the bow of the ship, and three holes were observed on the port side of the ship in an area approximately 75 feet aft of the bow of the ship. Several previously patched holes were observed on the port side of the ship in the general vicinity of these holes. During this inspection a UT measurement was performed in the splash zone, on the starboard side of the ship, approximately 120 feet aft of the bow; this measurement found the thickness of the steel hull plating in this location to be approximately 0.445in.

Collins did not observe any other holes along the inspected areas of the hull; however, it is possible that additional holes are present along the hull that are covered with marine growth and were thus not observed during this inspection. To fully review the condition of the outer surface of the hull from the splash zone to the channel bottom, removal of flaking rust and all the marine growth from all surfaces of the hull would be required.

Approximately 300 feet aft of the bow on the port side, an approximately 2 foot long by 1-1/2 inch diameter section of steel conduit cover was observed to be broken off and protruding vertically from the channel bottom. The conduit section appears to have corroded off of the conduit located above the noted location at approximately the level of the 3rd Deck (Photos 10 and 11).

Level II Assessment

The Level II assessment was performed at the 12 locations along the hull shown in Figures 1.1-1 and 1.1-2. Pitting corrosion, typically 1/8 inch to 1 inch diameter, with up to 1/16 inch of penetration was observed on all areas of all Level II cleaning locations. Pitting is localized corrosion that forms small areas of section loss on the surface of the metal. As described in Section 9.0 of the Task 2 report, "Denser areas of pits will tend to have deeper penetration." The pitting observed by Collins was noted to have a uniform concentration at each inspection location, which indicates that the corrosion observed was likely limited to surface corrosion. Due to the typical observation of pitting at each inspection location, Collins assumes the pitting extends along the entire hull below the splash zone. While the pitting observed was up to 1/16 inch, the thickness measurements obtained during the Level III measurements may not show this localized section loss.

Level III Assessment

The Level III assessments, measuring the hull thickness with the UT gauge to determine loss of section, were performed each of the 12 locations where the Level II inspections were performed.

The original thickness of the hull at each of the Level III locations was determined from the "Shell Plating and Framing" sheets obtained from the National Archives by OTS and included in Appendix A. Inspection locations were matched to the sheets, and hull thicknesses were determined from the drawings as follows: a designation of 40# approximates to a 1 inch thick plate and a designation of 20# approximates to a 1/2 inch thick plate. The summary of the data recorded in the field is located in Table 3.3-1 below. Approximate locations of the readings can be seen in Figure 1.1-1 and 1.1-2 above.

A maximum loss of section of up to 4.67% was determined from the data. The average loss of section is 2.48% and corresponds to relatively minimal corrosion and loss of section at the inspection locations. By extrapolating the data, Collins assumes the typical uninspected locations of the vessel will have approximately the same amount of section loss. Figures 3.3-1 and 3.3-2 below relate the original thickness of the hull plating to the measured hull thicknesses obtained during Collins' Task 1 and Task 3 inspections. The original thickness of the hull plate at the inspected areas ranged from 1/2 inch to 1-1/2 inch. Pitting is especially important at thinner plated areas of the hull because corrosion holes are more likely to form at localized portions of the thinner hull plate.

3.2. Task 3

Level II Assessment

The Task 3 Level II assessments below the channel bottom were performed at each of the seven locations along the hull including Starboard locations 1, 2, 3, and 4, and port locations 1, 2, and 3 and are listed in Table 3.3-1 below. The remaining locations were not included during Task 3 because no portion of the vessel was buried below the mud line at those locations.

Crevice corrosion, as defined in Section 8.0 of the Task 2 report, was not observed during the Task 3 assessment. It is possible that areas of crevice corrosion exist below the mud line but were not apparent during the assessment due to lack of visibility and small percentage of hull inspected.

Pitting corrosion, typically 1/8 inch to 1 inch diameter, with up to 1/16 inch of penetration was noted on all areas of all Level II cleaning locations. As described in Section 9.0 of the Task 2 report, "Denser areas of pits will tend to have deeper penetration." The pitting observed by Collins was noted to have a uniform concentration at each inspection location, similar to Task 1. Due to the typical observation of pitting at each inspection location, Collins assumes the pitting extends along the entire hull at similar elevations below the channel bottom. While the pitting observed was up to 1/16 inch, the thickness measurements obtained during the Level III inspections may not show this localized section loss. Collins was unable to verify if any coating material remained during the assessment due to poor visibility and typical surface corrosion.

Level III Assessment

The Level III assessments, measuring the hull thickness to determine loss of section, were performed each of the seven locations where the Level II inspections were performed.

As with Task 1, the original thicknesses of the hull plates at the Level III locations were determined from the "Shell Plating and Framing" sheets obtained from the archives by OTS and included in Appendix A, the inspection locations were matched to the sheets, and the hull thicknesses were determined from the text of the drawings. The summary of the data recorded in the field is located in Table 3.3-1 below. Approximate locations of the readings can be seen in Figure 1.1-1 and 1.1-2.

A maximum loss of section of up to 5.60% was determined from the data. Average percentage loss of section is 3.57% and corresponds to relatively minimal corrosion and loss of section at the inspection locations. By extrapolating the data, Collins assumes the uninspected locations of the vessel will have approximately the same amount of section loss throughout. Figures 3.3-1 and 3.3-2 below relate the original thickness of the hull plating to the measured hull thicknesses obtained during Collins' Task 1 and Task 3 inspections. The original thickness of the hull plate at the inspected areas ranged from 1/2 inch to 1-1/2 inch.

3.3. Condition Assessment Summary

All of the Level II and Level III inspection locations were located aft of the approximately 200 foot forward section previously determined to be in need of repair by PPDA, with one location forward of the center of the vessel on each side and all other locations aft of the center. The inspection locations on the port and starboard sides exhibited similar loss of section and extent of pitting corrosion. Collins did not perform any Level II or Level III inspections along the forward approximately 200-ft to determine if the condition of the bow was different than that at the rest of the vessel. Based on the consistency of the thickness readings and visual observations at the exposed inspection areas in both Tasks 1 and 3 – which were at locations aft of Frame 50 that appear most likely to exhibit higher corrosion rates – it is likely that the typical uninspected portions of the vessel aft of Frame 50 will exhibit a similar degree of section loss.

Pack rust in the splash zone was typically observed in an approximately 2-to-4-ft band along the entire port side and the forward and aft portions of the starboard side of the vessel. Areas of maximum section loss were typically found at the splash zone or below the channel bottom. Such areas of differential aeration, as described in Section 6.0 of the Task 2 report, are most susceptible to corrosion.

Pitting in localized areas can eventually form corrosion holes, especially at thinner plated areas of the hull. While Collins observed one corrosion hole in the tidal zone and four corrosion holes in the splash zone, it is possible there are more corrosion holes beneath the marine growth and pack rust that were not observed.

Additionally, corrosion influencing bacteria are assumed to be present below the waterline as described in Section 10.0 of the Task 2 report. Bacteria may concentrate around iron coating products at coating defects above and below the mud line. According to the Task 2 report, the concentration of bacteria is expected to be less "in areas with operational and effective cathodic protection". The maintenance of the impressed current cathodic protection system can reduce the effects of corrosion influencing bacteria.

Table 3.3-1: Level III Ultrasonic Thickness Measurements

Side	Location ID	Elevation	Measured Thickness (in.)	Original Thickness (in.)	% Loss of Section
Port	1	TZ	1.475	1.500	1.67%
		CB	0.510	0.500	0.00%
		BCB (Task 3)	0.590	0.625	5.60%
	2	TZ	1.220	1.250	2.40%
		CB	1.240	1.250	0.80%
		BCB (Task 3)	0.790	0.825	4.24%
	3	TZ	0.985	1.000	1.50%
		CB	0.745	0.750	0.67%
		BCB (Task 3)	0.960	1.000	4.00%
	4	TZ	0.775	0.825	6.06%
		CB	0.725	0.750	3.33%
	5	TZ	0.715	0.750	4.67%
		CB	0.715	0.750	4.67%
	6	TZ	0.500	0.500	0.00%
		CB	0.715	0.750	4.67%
Starboard	1	TZ	1.470	1.500	2.00%
		BCB (Task 3)	1.470	1.500	2.00%
	2	TZ	1.490	1.500	0.67%
		BCB (Task 3)	0.620	0.625	0.80%
	3	TZ	1.445	1.500	3.67%
		BCB (Task 3)	0.710	0.750	5.33%
	4	TZ	0.995	1.000	0.50%
		BCB (Task 3)	0.970	1.000	3.00%
	5	TZ	0.730	0.750	2.67%
	6	TZ	0.715	0.750	4.67%

TZ=Tidal Zone; CB=Channel Bottom; BCB=Below Channel Bottom

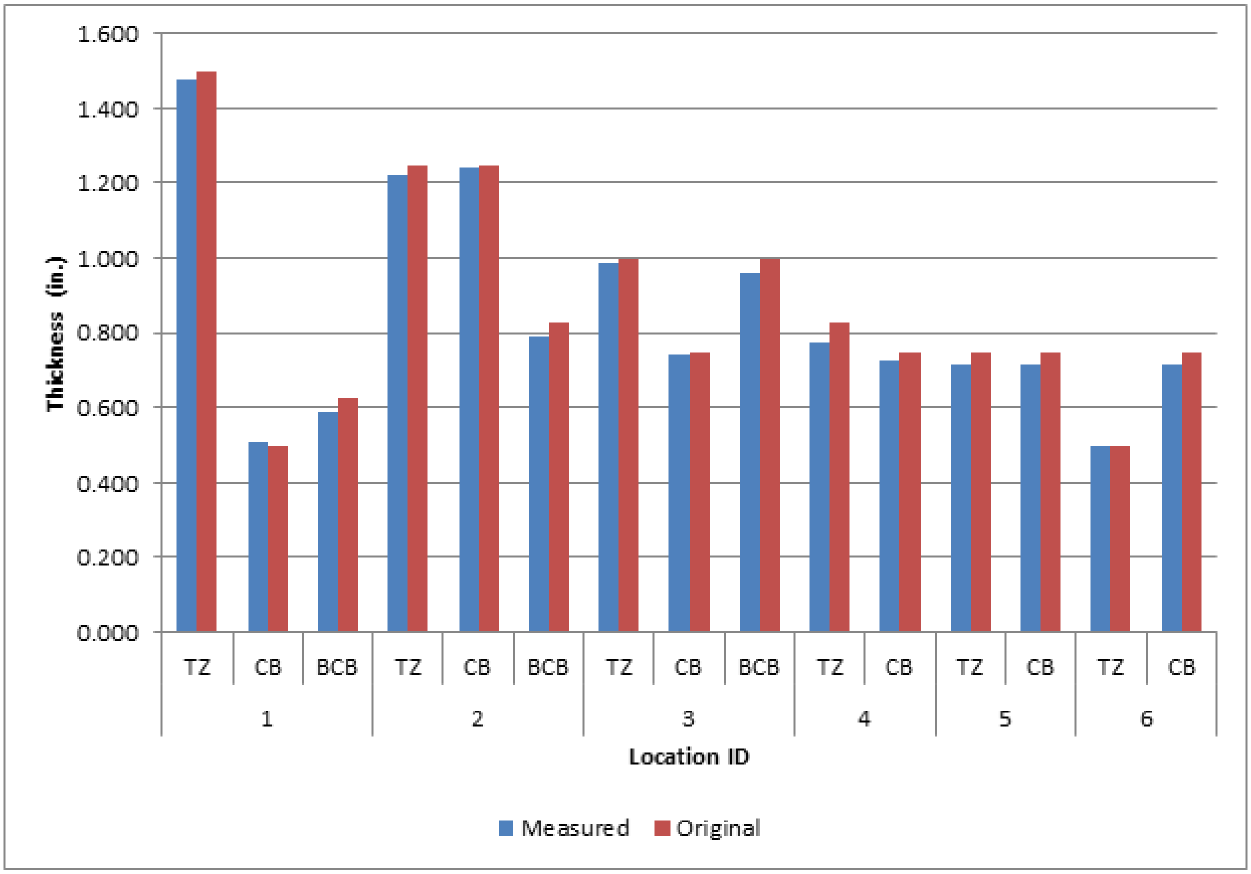


Figure 3.1 Level III Ultrasonic Thickness Measurements – Port

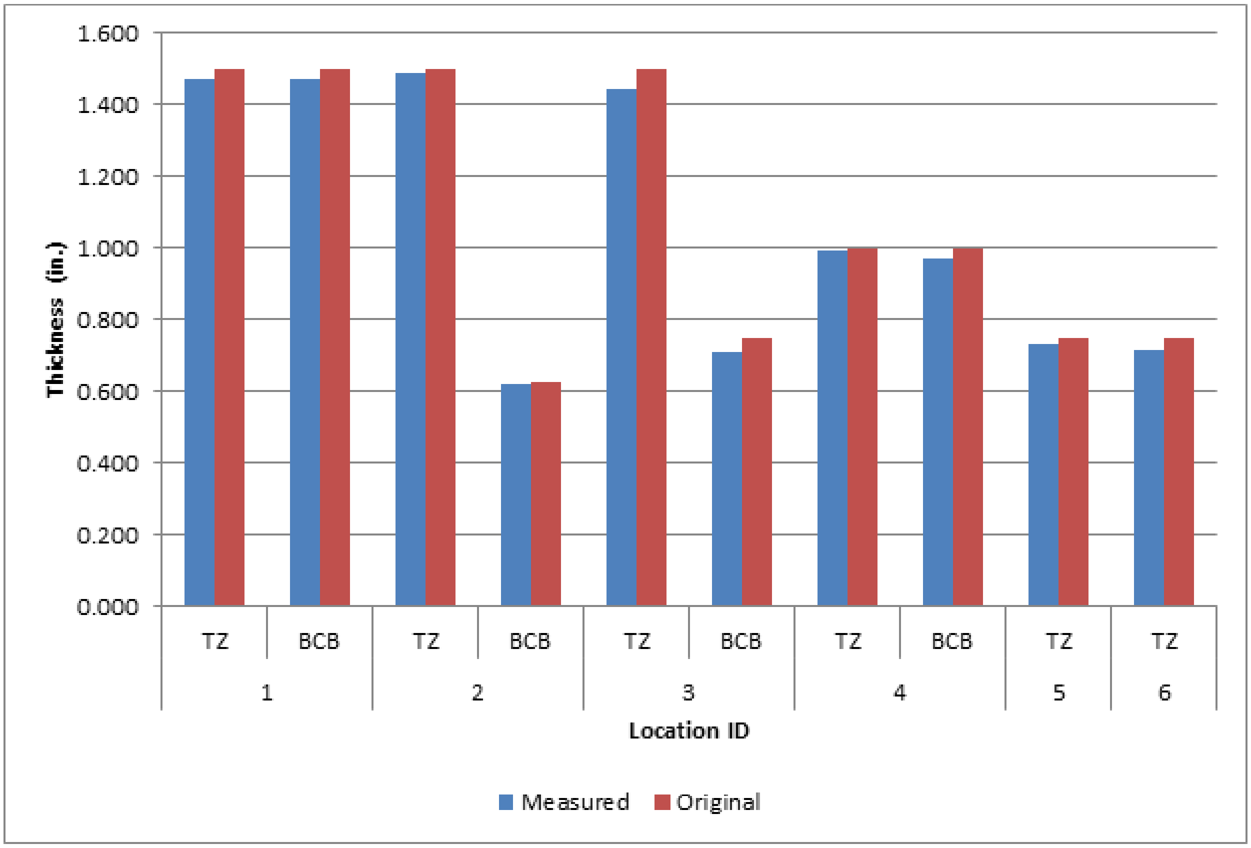
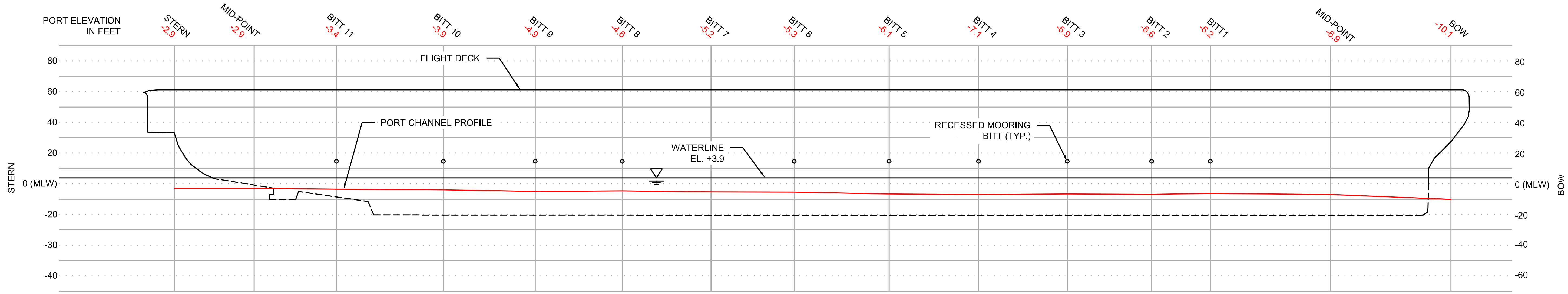
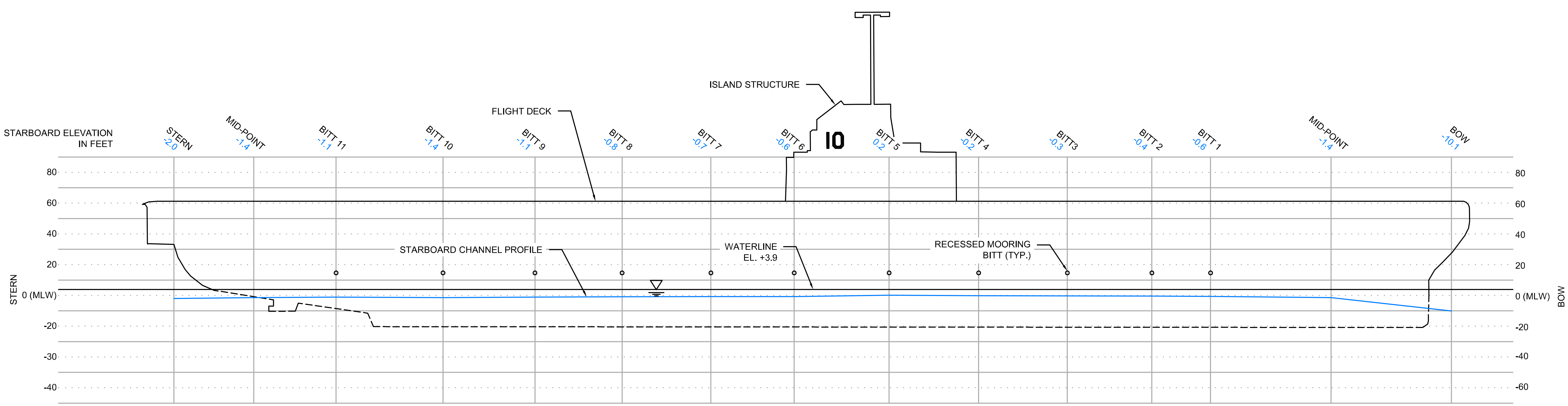


Figure 3.2 Level III Ultrasonic Thickness Measurements – Starboard

APPENDIX A: FIGURES



PORT CHANNEL BOTTOM PROFILE



STARBOARD CHANNEL BOTTOM PROFILE

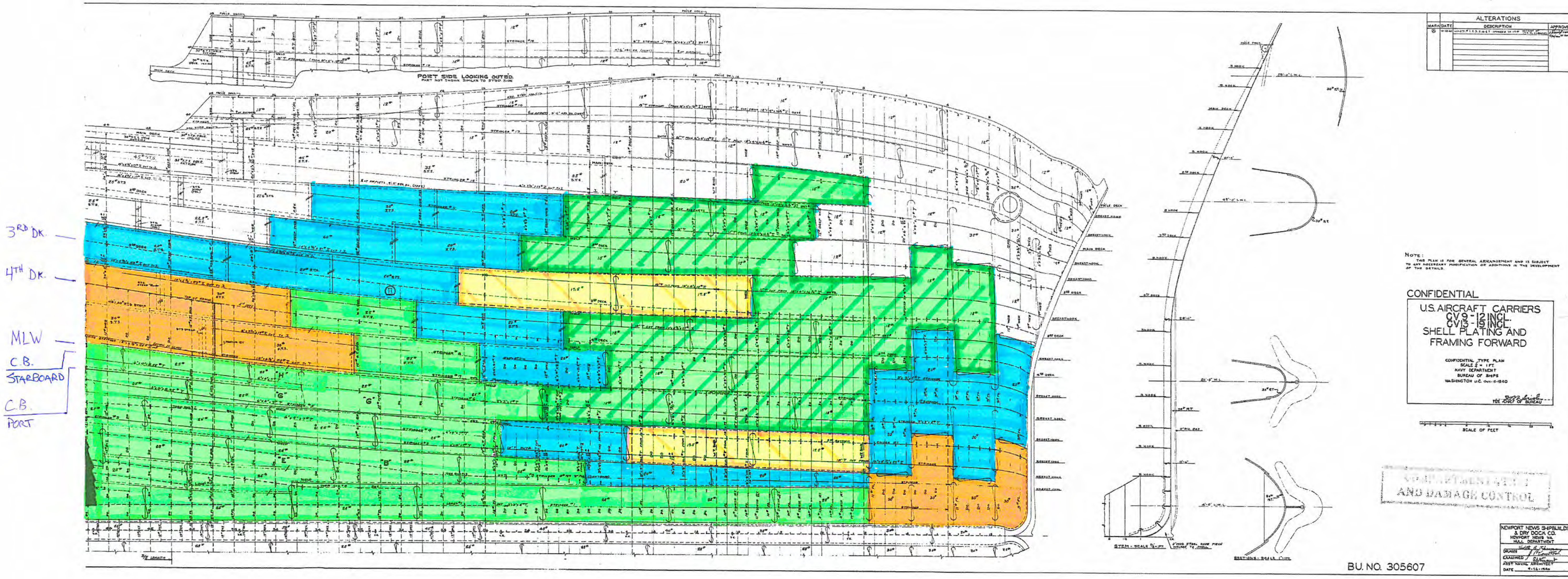
PATRIOTS POINT
• HOME OF THE USS YORKTOWN •

USS YORKTOWN INSPECTION

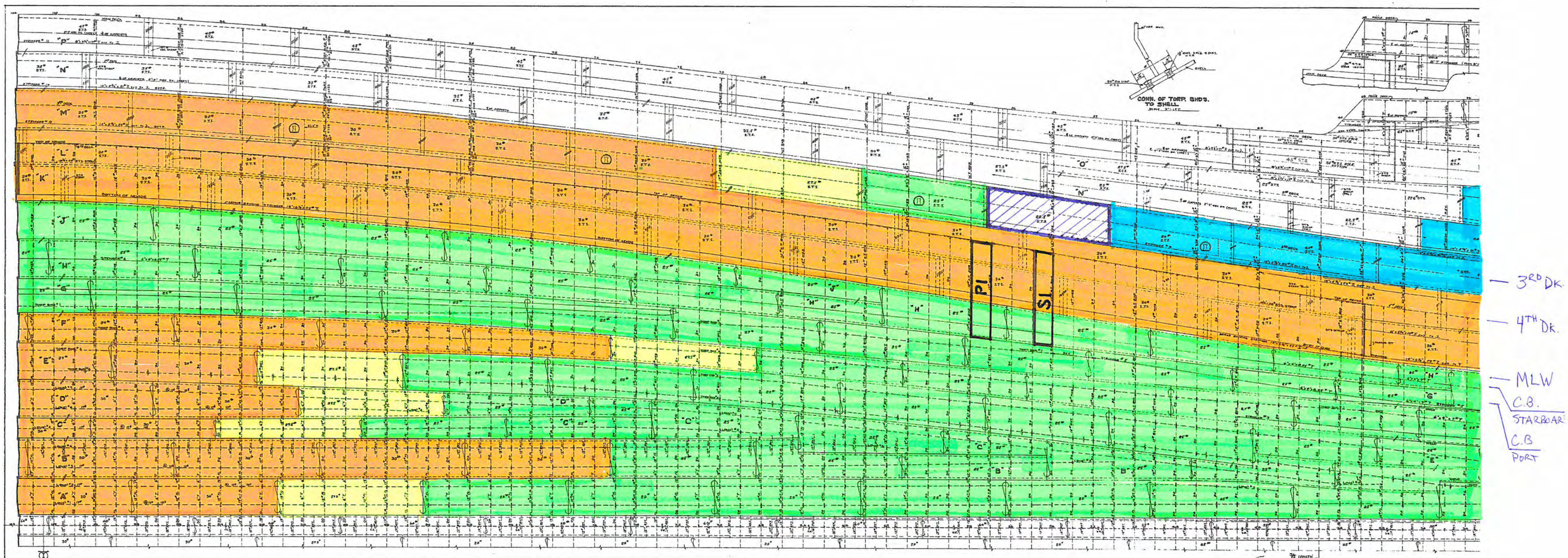
UNDERWATER ASSESSMENT

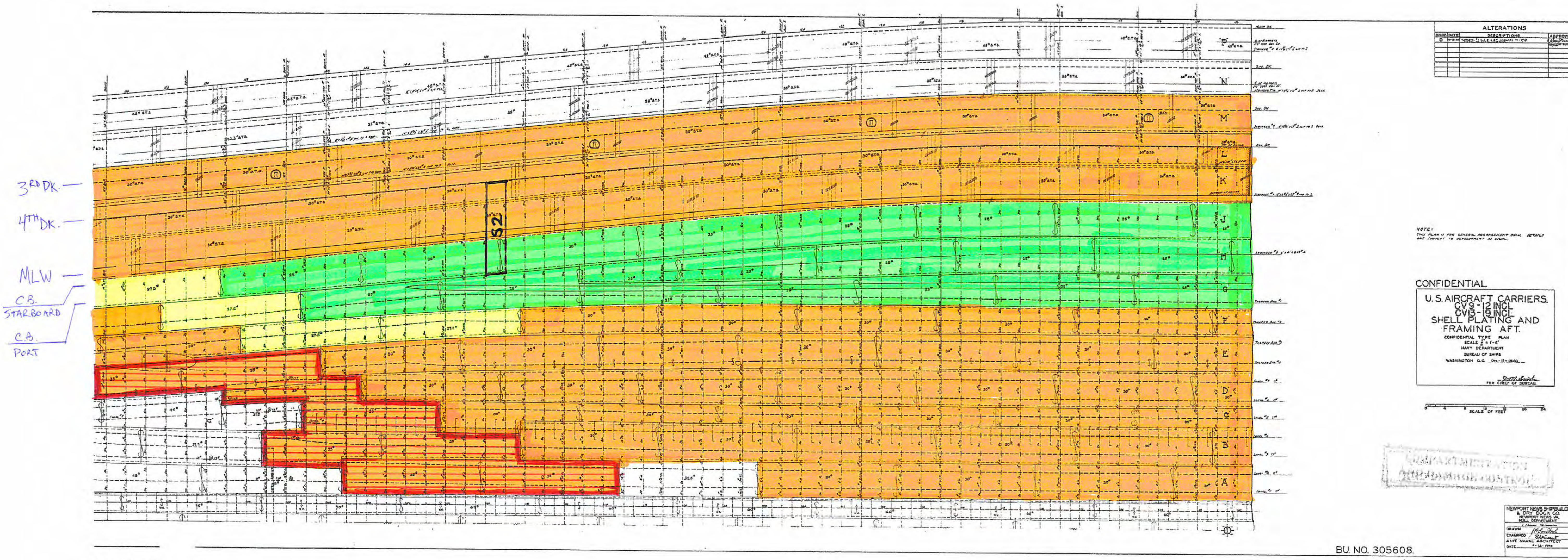
CHANNEL BOTTOM PROFILE

DRAWN BY: TWR	COLLINS ENGINEERS INC.	225 SEVEN FARMS DR. STE. 200	DATE: MARCH 2014
CHECKED BY:		CHARLESTON, SC 29492	SCALE: NO SCALE
CODE: 40-8311		(843) 884-2027	SHEET NO.: 1



3RD DK.
4TH DK.
MLW
C.B. STARBOARD
C.B. PORT
PORT SIDE LOOKING OUTBD.
ALTERATIONS
CONFIDENTIAL
U.S. AIRCRAFT CARRIERS
CV9 - 12 INCL.
CV13 - 19 INCL.
SHELL PLATING AND
FRAMING FORWARD
AND DAMAGE CONTROL
BU. NO. 305607
NEWPORT NEWS SHIPBUILDING & DRY DOCK CO.


CONN. OF TORP. BHD'S. TO SHELL
P1
S1
3RD DK.
4TH DK.
MLW
C.B. STARBOARD
C.B PORT



3RD DK.
4TH DK.
MLW
C.B. STARBOARD
C.B. PORT
S2
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D
E
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G
H
J
K
L
M
N
P
ALTERATIONS
MARK
DATE
DESCRIPTIONS
APPROVED
NOTE:
THIS PLAN IS FOR GENERAL ARRANGEMENT ONLY. DETAILS ARE SUBJECT TO DEVELOPMENT AS USUAL.
CONFIDENTIAL
U.S. AIRCRAFT CARRIERS.
CV9-12 INCL.
CV13-19 INCL.
SHELL PLATING AND
FRAMING AFT.
CONFIDENTIAL TYPE PLAN
SCALE 1/4" = 1'-0"
NAVY DEPARTMENT
BUREAU OF SHIPS
WASHINGTON D.C. DEC. 13. 1940
FOR CHIEF OF BUREAU.
0
4
8
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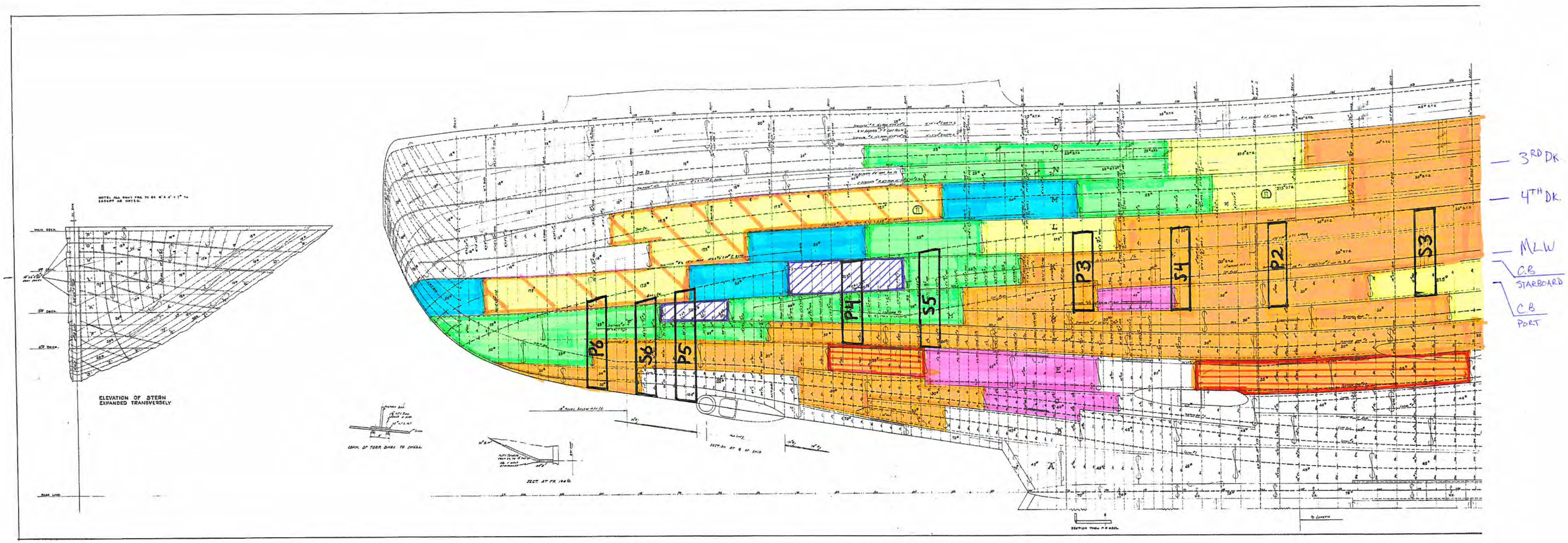
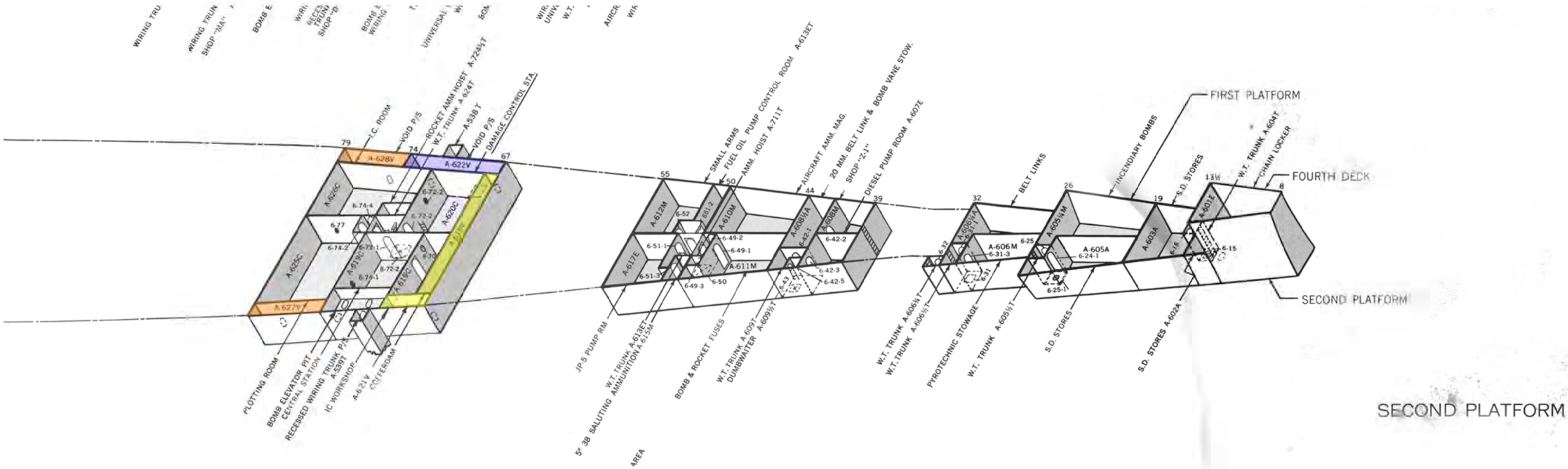
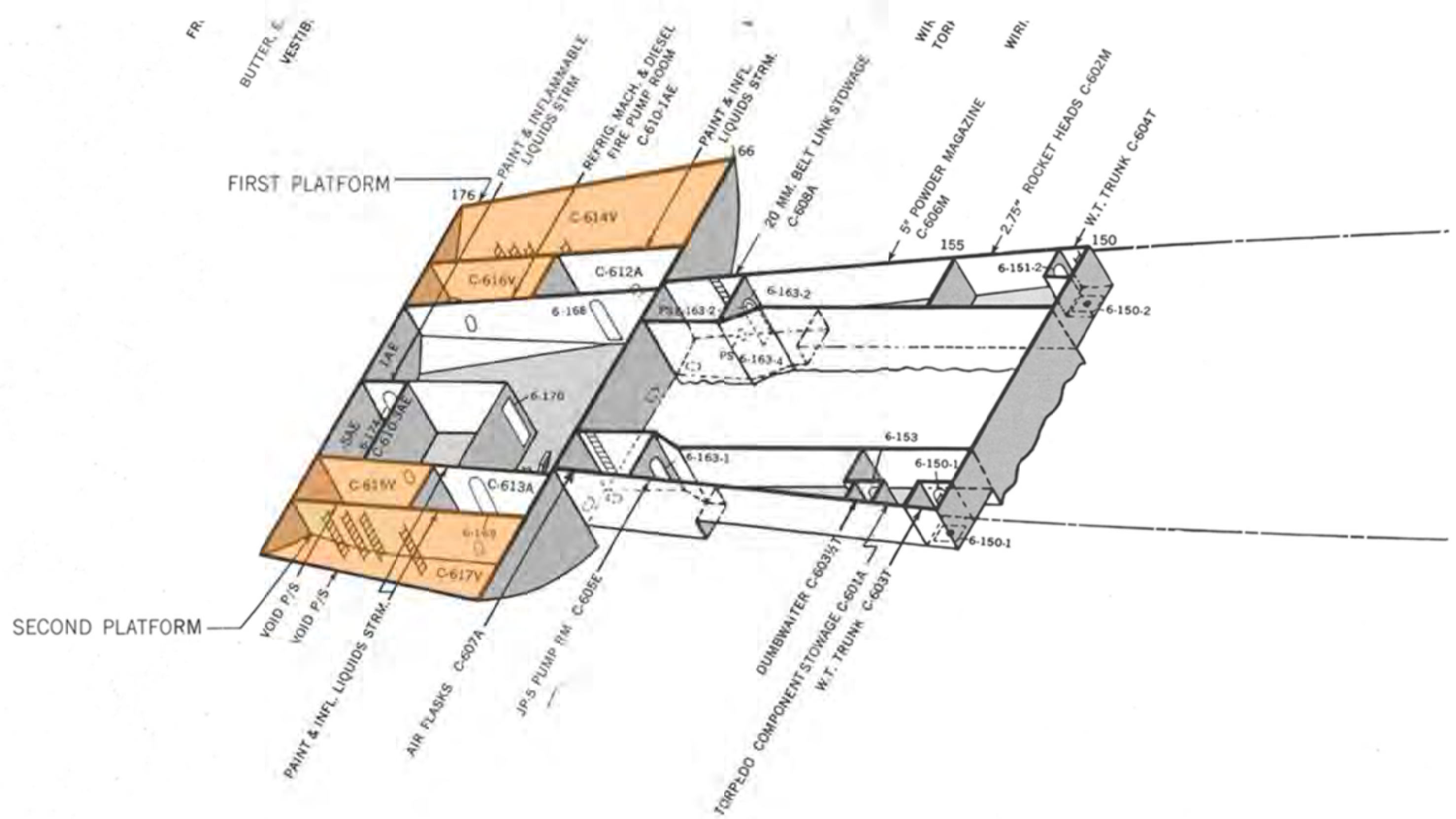
SCALE OF FEET
NEWPORT NEWS SHIPBUILDING & DRY DOCK CO.
NEWPORT NEWS VA.
HULL DEPARTMENT
DRAWN
EXAMINED
ASST. NAVAL ARCHITECT
DATE 9-26-1946
BU. NO. 305608.


ELEVATION OF STERN
EXPANDED TRANSVERSELY
P6
S6
P5
P4
S5
P3
S4
P2
S3
3RD DK.
4TH DK.
MLW
C.B
STARBOARD
C.B
PORT





(pink)	TANK CONTAINS OIL (2012)
(green)	TANK CONTAINS OIL AND WATER (2012)
(blue)	TANK CONTAINS WATER (2012)
(orange)	TANK IS DRY (2012)
(yellow)	TANK IS INACCESSIBLE (2012)
(red square)	TANK CONTAINED OIL PRE-BALLASTING (1975)
(black dot)	TANK FILLED DURING BALLASTING (1975)

0 30 60

APPROXIMATE SCALE IN FEET

Shaw

3 INDEPENDENCE POINTE
SUITE 107
GREENVILLE, SC 29615
(864) 254-9285 (TEL)
(864) 254-9286 (FAX)

OFFICE:	DRAWING DATE:	ACAD FILE:
Greenville	4/12/13	FILE NAME

USS YORKTOWN
ENVIRONMENTAL ASSESSMENT
STRUCTURAL TANKS - SECOND PLATFORM

CLIENT:	PM:
PATRIOTS POINT DEVELOPMENT AUTHORITY	RK
LOCATION: MT. PLEASANT SOUTH CAROLINA	CHECKED: LM

DESIGNED:	DETAILED:	PROJECT NO.:	FIGURE:
RS		147519	**3-3**

APPENDIX B: PHOTOGRAPHS

Figure 3.3 **Overall view of USS YORKTOWN port side.**

Figure 3.4 **Overall view of USS YORKTOWN starboard side.**

Figure 3.5 **Overall view of bow.**

Figure 3.6 **Overall view of stern.**

Figure 3.7 Diver using ultrasonic thickness gauge.

Figure 3.8 View of typical marine growth and pack rust on hull.

Figure 3.9 Close-up of typical marine growth and pack rust on hull.

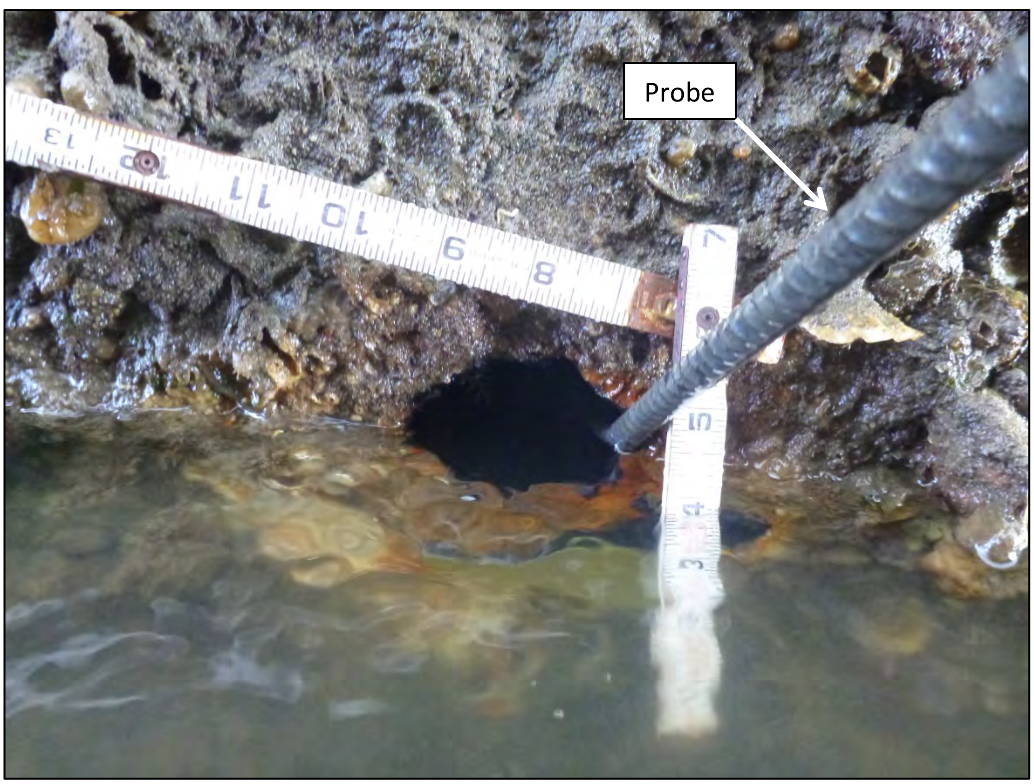


Figure 3.10 View of corrosion hole in port side hull.

Figure 3.11 View of corrosion hole in port side hull.

Figure 3.12 View of failed conduit cover, section was protruding vertically from the channel bottom.

Figure 3.13 Close-up of corroded conduit cover.

Figure 3.14 Hole in hull in splash zone, starboard side.

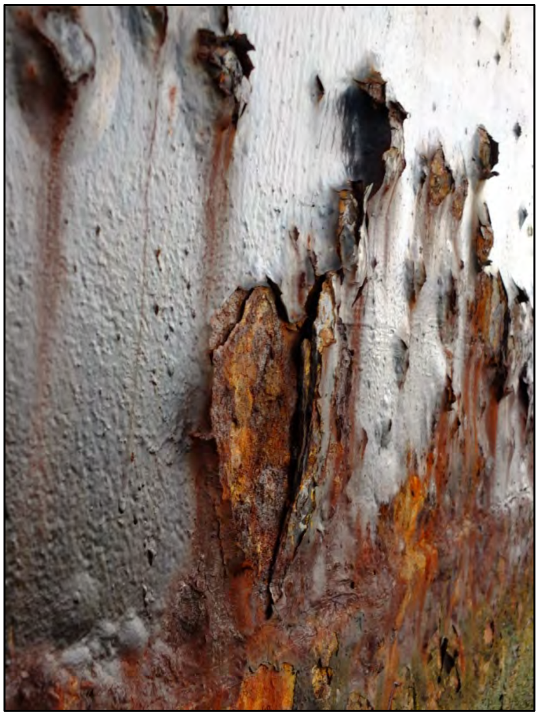


Figure 3.15 **Detail of pack rust in splash zone, port side.**

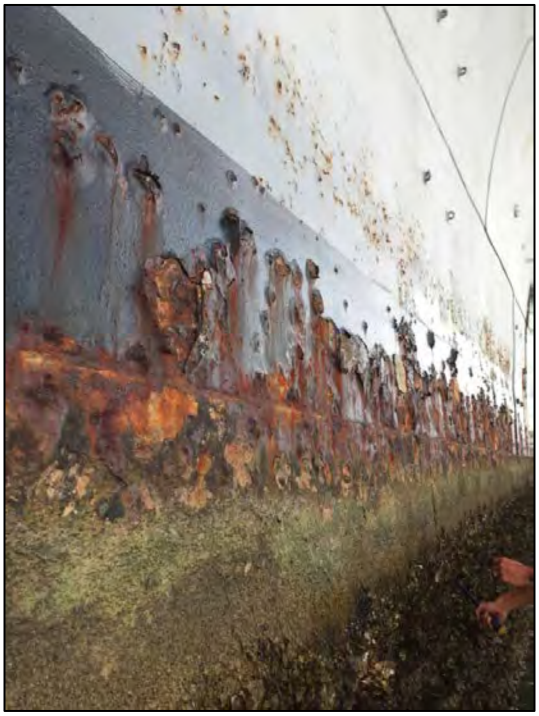


Figure 3.16 **Heavy corrosion and pack rust in splash zone, port side.**

Figure 3.17 Pack rust and hole in hull in splash zone, port side.

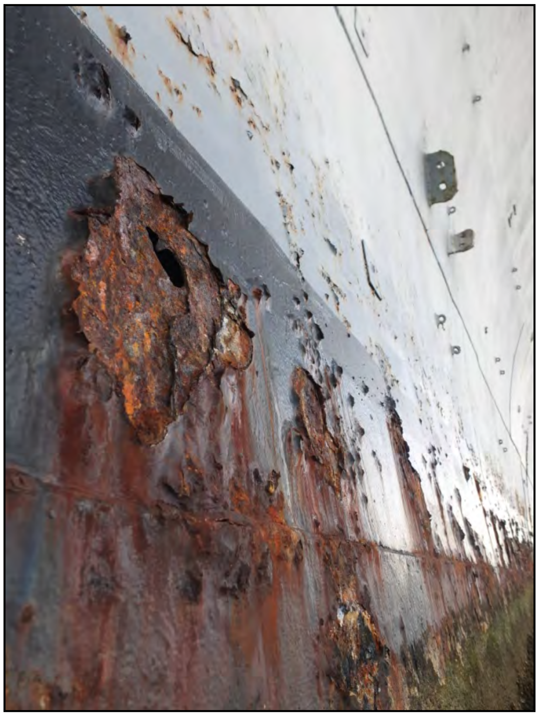


Figure 3.18 Hole in hull in splash zone, port side.

Figure 3.19 Severe corrosion and pack rust in splash zone, port side.

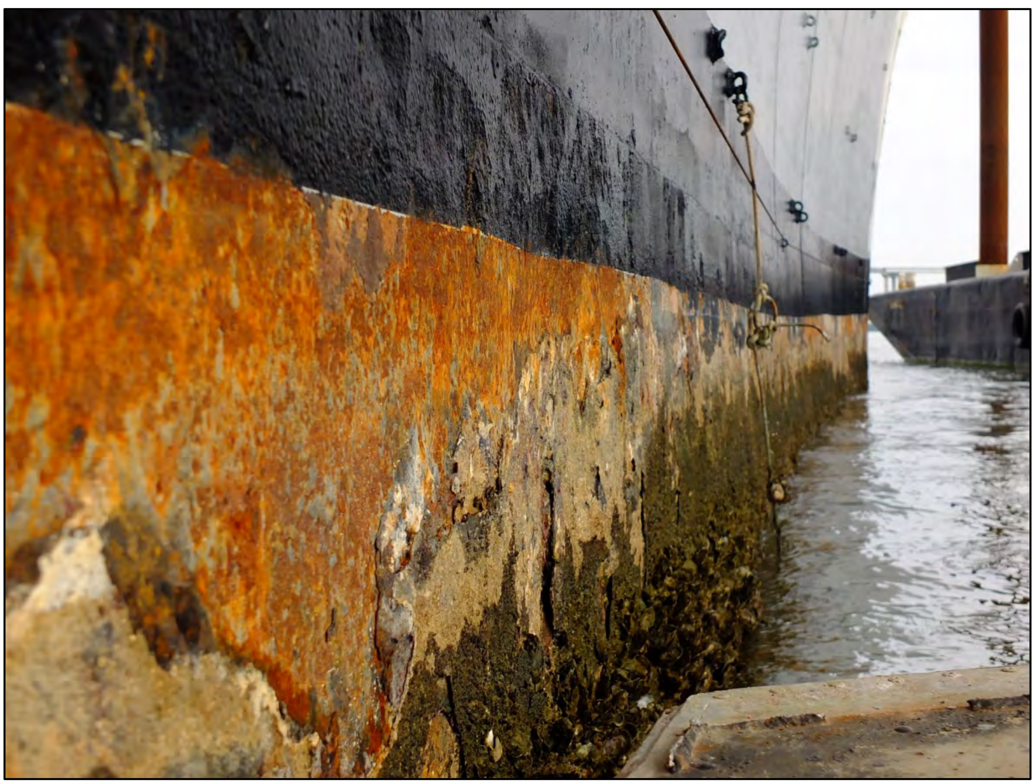


Figure 3.20 Recently cleaned and painted areas of splash zone, starboard side.

Figure 3.21 Interior view of patches and damage control plug below waterline.

Figure 3.22 Interior view of hole in hull above waterline.

Figure 3.23 **Interior view of patched hole above waterline.**

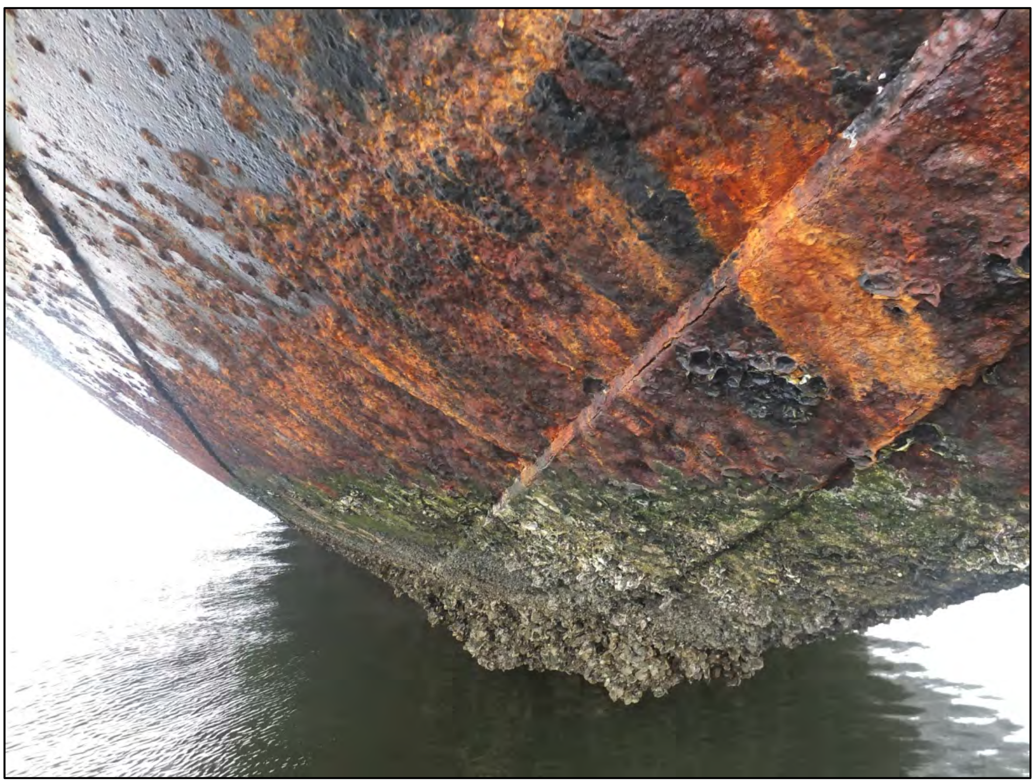


Figure 3.24 **Heavy corrosion and pack rust in splash zone, stern area.**

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17 March 2014

Task #1

Scope of Task– Assessment of Hull Above Mud Line

OTS will develop a Work Plan and a Health and Safety Plan for the project that will be coordinated with Collins Engineering.

During the introductory phase of the survey to be conducted on the U.S.S. YORKTOWN, a corrosion analysis will be performed by OTS to assess the rate at which the underwater steel is eroding as a result of electrolytic action. From the readings, which will be taken on or around 50 - 125 foot centers along the sides of the ship, there may be apparent "hot spots" that can be targeted for further inspection as part of this tasking. These readings may only point to possible trouble spots on the hull; indeed, the area between the twin skegs is suspect, but was not observed by recent galvanic readings.

The subset of this phase's tasks will be performed as follows:

1.) The perimeter of the ship will be inspected at high water with the impressed cathodic system remaining in the 'on' position. Inspection equipment will consist of a multi meter grounded to the ship's side and the use of a MILLER silver/silver chloride probe to test the water and obtain the mV readings.

2.) Upon completion of the initial recording of readings, the impressed cathodic system will be turned to the 'off' position so the waters around the ship can go back to their normal state. On the 2nd day a new round of readings will be taken with the use of the MILLER silver/silver chloride probe to test the water and obtain the mV readings.

Both sets of readings will then interpolated to provide clues for the team conducting the above and below mudline inspection of the hull.

OTS will prepare a brief report summarizing the results of this testing and will provide input for specific dive inspection locations for the underwater inspection.

Task #1

The YORKTOWN has an installed impressed cathodic protection system and is monitored on a systematic basis by a corrosion engineer hired by Patriots Point. The basis of this system is below:

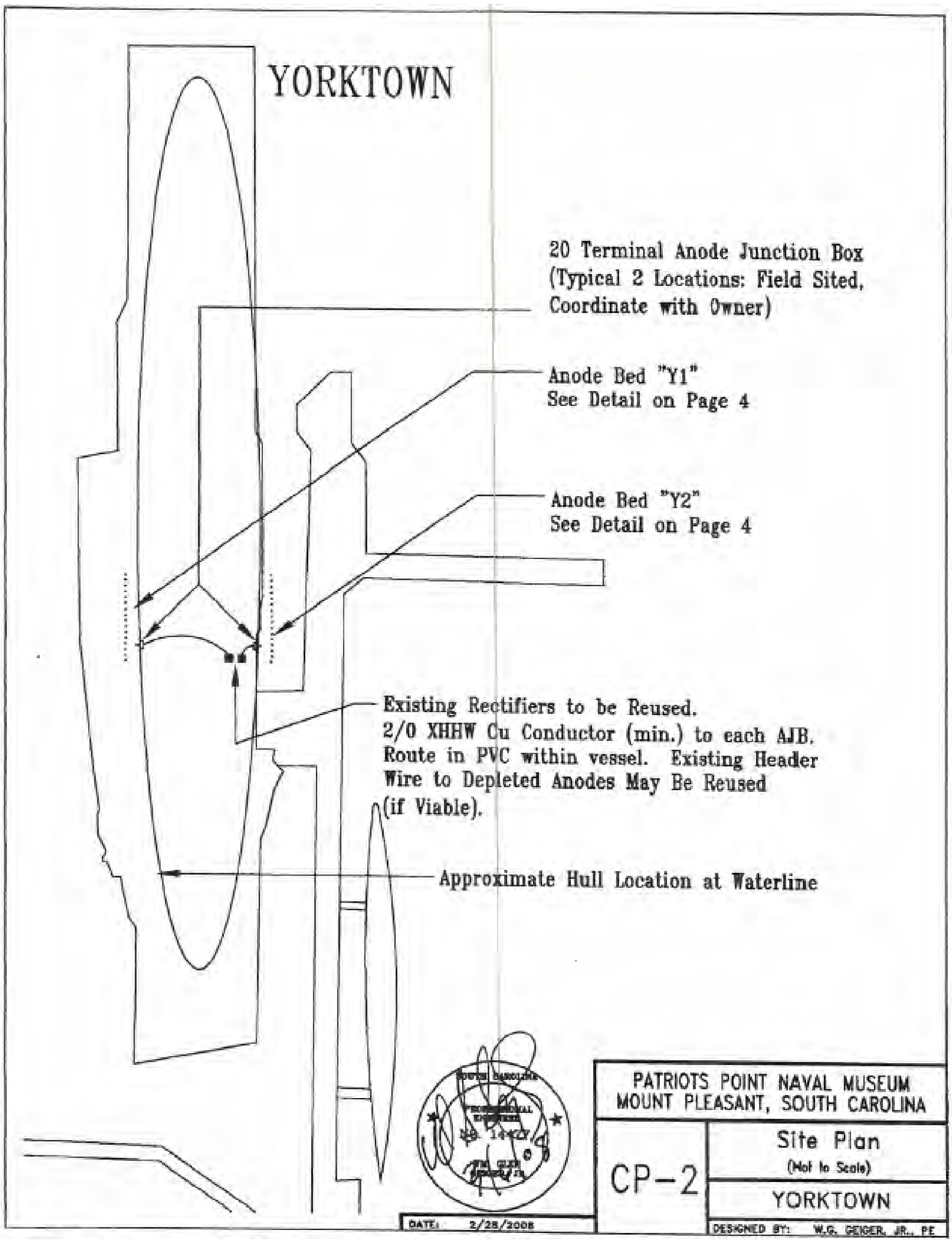

Fig. 1. General Arrangement of existing cathodic protection system for YORKTOWN.

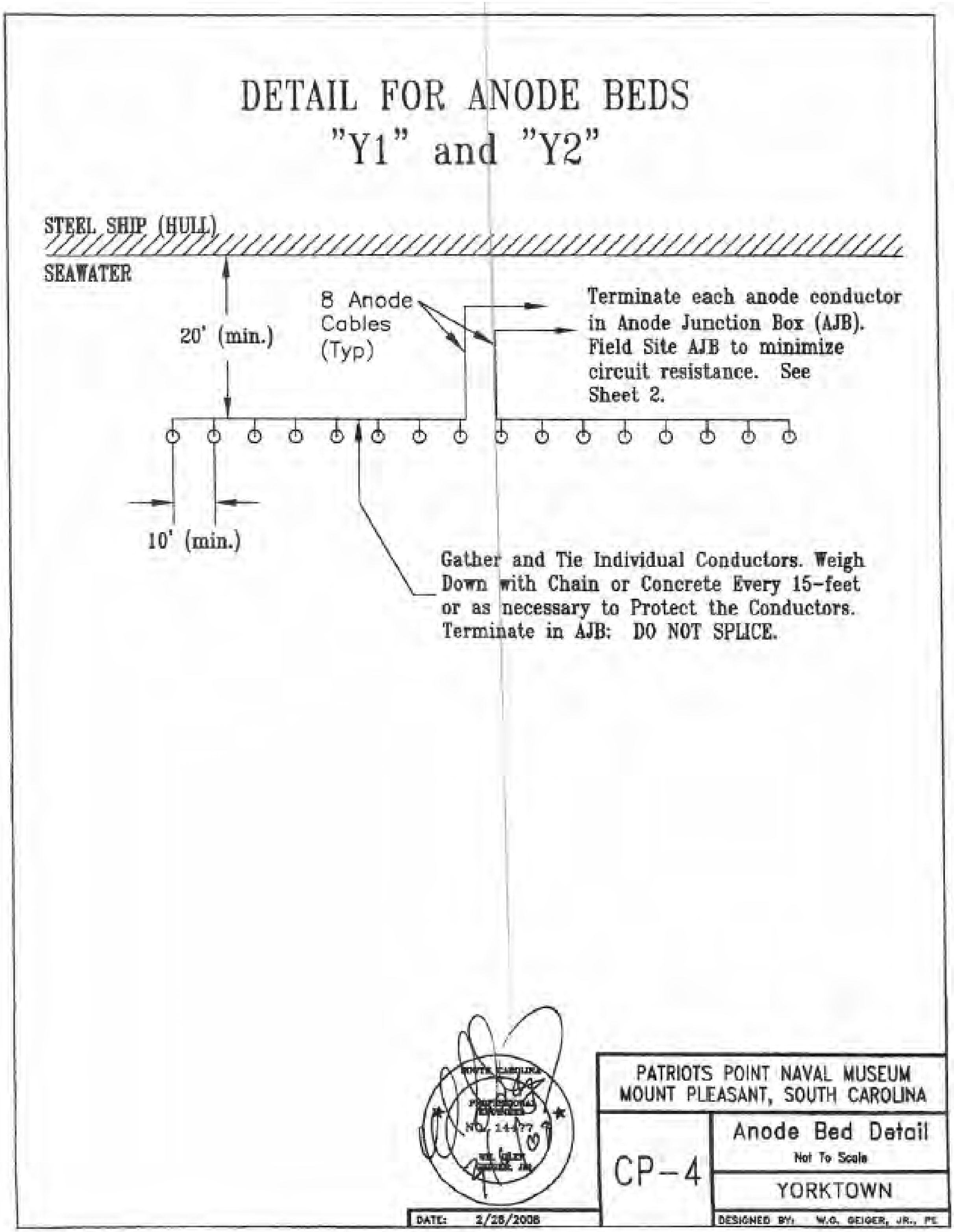

Fig. 2. Details for cathodic anode beds for TORKTOWN.

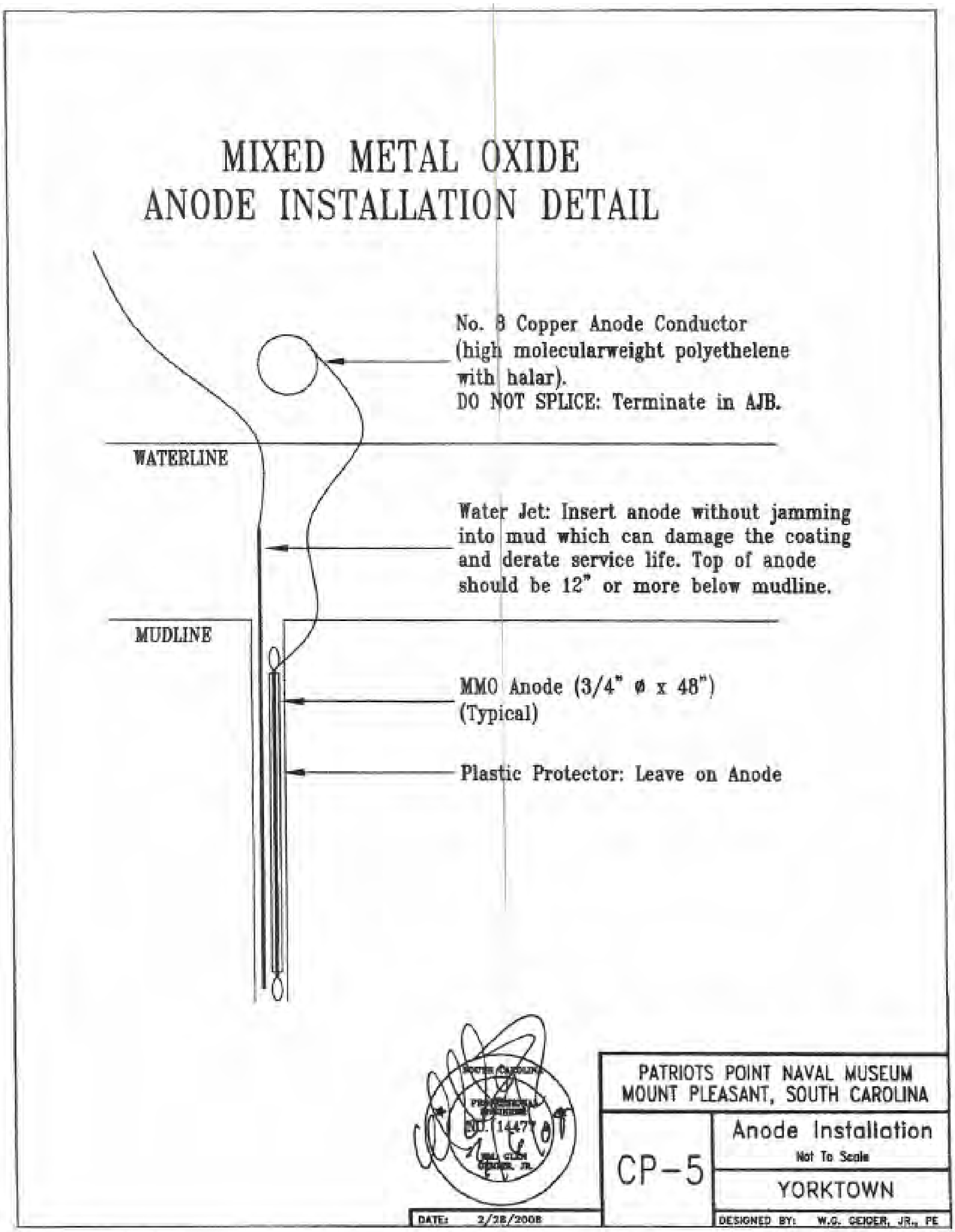

Fig. 3. Mixed metal oxide anode installation detail currently used for YORKTOWN..

OTS inspected the berth site on 12 February 2014 with the impressed cathodic system in the "on" position and then re-inspected the berth site on 15 February with the impressed cathodic system in the "off" position for the amount of galvanic potential surrounding YORKTOWN .

<u>CORROSION ANALYSIS</u>

U.S.S. YORKTOWN

Readings Taken: 12 February 2014

Location: Patriots Point, Mt. Pleasant, SC

Conditions: Air temperature 39 degrees (F), Water temperature 49 degrees (F),

Instrumentation: M.C. Miller Silver: Silver chloride half cell operating through a ceramic salt bridge and connected to a digital multi meter set to millivolt (mV) scale.

System 'ON'. Readings taken on 50' centers along the 820' waterline.

STEM
0.845

0.990	1.030
0.955	0.910
0.921	0.895
1.005	1.050
0.972	0.911
1.100	0.978
0.956	0.900
1.000	.0879
0.945	0.899
0.877	0.938
1.040	1.079
0.929	0.958
0.977	0.925
0.822	1.079
0.721	0.875
0.695	0.821

0.995
STERN

Readings Taken: 15 February 2014

Location: Patriots Point, Mt. Pleasant, SC

Conditions: Air temperature 46 degrees (F), Water temperature 50 degrees (F),

Instrumentation: M.C. Miller Silver: Silver chloride half cell operating through a ceramic salt bridge and connected to a digital multi meter set to millivolt (mV) scale.

System 'OFF'. Readings taken on 50' centers along the 820' waterline.

STEM
0.722

0.802	0.731
0.695	0.810
0.723	0.901
0.693	0.721
0.711	0.822
0.840	0.698
0.735	0.811
0.795	0.800
0.811	0.768
0.674	0.755
0.645	0.799
0.745	0.800
0.645	0.811
0.575	0.755
0.543	0.769
0.575	0.800

0.995
STERN

Summary

As part of the inspection conducted on the aircraft carrier U.S.S. YORKTON, a corrosion analysis was performed on 12 February 2014 with the system "on" and on 15 February with the system "off".

The hull at and below the waterline has no protective paint system and may be considered 'freely eroding'.

Detail of wind/waterline at stern/counter.

This situation, coupled with the long period of time since her last drydocking has allowed the breakdown of the bottom paint system and exposure to salt water. The underwater anodes and sensors are, reportedly, cleaned annually..

From the readings, which were taken on or around 50 foot centers along the sides of the ship, there have been "hot spots" where the ship had little or no cathodic protection from the vessel's cathodic protection system. Reportedly, several anodes on the vessel's port side, aft, are inoperable. Readings obtained bear this out, particularly when the system is off. It appears that the impressed cathodic system for CLAMAGORE mat be a positive influence at the stern of YORKTOWN.

A schedule of cleanings of the underwater arrays should take place on an annual basis.

Additionally, testing of the galvanic potential surrounding the ship should be accomplished on at least a bi-annual basis.

An overview of corrosion as it relates to the millivolt scale follows. Wrought iron and mild steel has a base voltage in an electrolyte of around .500 V; however, depending on the alloy and/or purity of the steel it can range from around .790 V for mild steel with no coating or protection to well below .500 mV for stainless steel. The lower the number the more noble the metal and hence the less corrosion. Gold for example is less than 0. To protect the hull the most common technique is to provide a "sacrificial" anode such as zinc or aluminum. This has the effect of driving the voltage well above the scale where it is eroding, hence protecting the metal. Wrought iron and steel are well protected if the readings are between .800 V and 1.000 V. It is possible to damage metal by over protecting it. Steel is over protected at around 1.100 V and at 1.200 V damage to coatings and the metal is quite likely.

When measuring for corrosion, the survey also measures wide differences in voltages from one part of the vessel to another. When we see discrepancies in excess of .100 V, there is possibly stray current effecting the vessel or widely dissimilar metals being used in close proximity to each other. Either case is the worst possible situation and requires immediate attention. The greater the discrepancy in readings, the faster the metal is being corroded and the sooner failure will occur.

Port bow at wind/waterline.

The underwater paint system has totally failed aboard U.S.S. YORKTOWN; she is freely eroding.

It should be recognized that other factors can influence the rate of plate corrosion, such as water current and chemical contamination in the water or in the vessel's bilge. These conditions were observed on the YORKTOWN.

Based on visual and galvanic potential readings obtained the following areas on the hull were prioritized for the ‘under the mudline’ inspections. The color key for these drawings (attached) depicts yellow for the starboard side and blue for the port side. The drawings utilized are the ‘as built’ Shell Plate Expansion Plan for the Essex Class Short Hull obtained at the National Archives.

USS YORKTOWN

Task 2: Assessment of Exterior Hull Below the Mud Line Based on Literature

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1. Introduction

The aircraft carrier USS Yorktown (CV-10) is decommissioned and is currently moored at Patriots Point, Charleston, SC as a museum ship. Based on soundings performed by Collins Engineers, Inc., the keel appears to be embedded approximately 15.5 feet into the harbor bottom on the port side and approximately 19.5 feet into the harbor bottom on the starboard side. This report identifies the operative corrosion mechanisms which are active on the hull below the mud line and provides recommendations for in-situ assessments to be performed below the mud line. In the preparation of this report, corrosion literature was searched to identify corrosion mechanisms and rates which have occurred on steel in marine environments and are applicable to the conditions present at the USS Yorktown. This information was compared with the data provided on the vessel, its environment, and its current condition.

2. Current Environment of USS Yorktown Hull

The USS Yorktown lies in soft marine bottom silt to a depth of approximately 15-to-20 feet. It has been in this location in Charleston harbor since 1975. Charleston harbor water temperature ranges from 40°F to 85°F throughout the year and averages 65°F. Salinity in the harbor basin is approximately 23,000 ppm at the bottom and 29,000 ppm at the surface and dissolved oxygen content fluctuates from 5- 10 mg/l with an annual average 7 mg/l (Reference 1). Natural sea water pH is generally approximately 8, but can become more acidic in isolated stagnant areas (Reference 2). Geotechnical and environmental soil analysis has been conducted as part of study to support the design of a cofferdam at the USS Yorktown site. The soil profile around the USS Yorktown was identified as “very loose to loose silty sands and very soft to soft silty clays” that extend to a depth of approximately 46 feet below the mud line (Reference 3).

3. Material of Construction

All carbon steel materials generally have similar corrosion resistance in marine environments (Reference 2). Shell plating is fabricated from either mild steel (A-36) or special treatment steel (S.T.S). A36 grade steel is basically carbon steel. STS contains approximately 1.75-2% by weight chromium, 3-3.5% nickel, and 0.35-0.4% carbon and was used as the structural steel for shell plating aboard the U.S.S. YORKTOWN. This material has higher toughness than carbon steel.

The armor belt was removed during the vessel's conversion to an angled flightdeck carrier in the 1950s.

4. Cathodic Protection

Currently the USS Yorktown has an installed cathodic protection system which is monitored on a systematic basis by a corrosion engineer. The system includes anode beds of 16 mixed-metal oxide anodes buried in the mud on either side of the vessel. Ocean Technical Services performed corrosion potential surveys on February 12, 2014 along the waterline with the cathodic protection system on and on February 15, 2014 after the system had been deactivated for 72 hours to determine the unprotected corrosion potential. The results identified locations where no cathodic protection has been applied to the vessel. The Ocean Technical Services survey report indicates that differences in potential of 100 mV are indicative of corrosion. Readings obtained with the cathodic protection system on ranged from 695 to 1,100 mV. With the cathodic protection system off, readings ranged from 543 mV to 995 mV (Reference 4). Steel is protected at a potential of 800 mV under aerobic conditions, (NACE Standard RP0388). Under anaerobic conditions such as the portion of the vessel below the channel bottom, a potential of 900 mV is needed (Reference 5) to obtain corrosion protection. Figure 1 presents the results of the corrosion potential survey. Locations where the potential changes by more than 100 mV within 50 ft. and potentials at or below 900 mV are likely locations where corrosion is occurring in the buried zone. This includes the bow and the following locations along the waterline:

- 200 ft. on the starboard side, 300 ft. on the port side
- 550 ft. on the port and starboard sides
- 700 ft. and 800 ft. on the starboard side
- The sternmost 150 ft. on the port side

These locations should be inspected for corrosion and the cathodic protection system adjusted to insure adequate corrosion protection at these regions.

Figure 1 Corrosion Potential Survey Readings (Cathodic Protection System On)

The corresponding vessel frame numbers are presented below:

Side of vessel	Position (distance from bow)	Frame number
Port	300 ft.	75
Port	550 ft.	137
Port	Sternmost 150 ft.	166 and aft
Starboard	200 ft.	50
Starboard	550 ft.	137
Starboard	700 ft.	175
Starboard	800 ft.	200

5. Protective Coating

According to the Ocean Technical Services corrosion potential survey, the hull of the USS Yorktown at and below the waterline has no protective coating and may be considered “freely eroding” (Reference 4). A recent painting project was undertaken to paint the entire starboard side of USS Yorktown, from waterline to flight deck, bow to stern. The coating applied was Rustoleum ROC-100 heavy rust metal primer epoxy amine-adduct, followed by Rustoleum Metal Max acrylic urethane enamel, and top coated with Rustoleum Metal Max Plus. The condition of the hull coating below the mudline is unknown.

6. Corrosion Mechanisms

Materials in marine environments are categorized in the corrosion literature into different exposure zones. These zones include the atmospheric zone, splash zone, tidal zone, immersion zone, and mud zone. The zones differ by moisture, oxygen, chloride, and microbiological content. The corrosion mechanisms applicable to carbon steel in this marine environment include general corrosion, crevice corrosion, pitting corrosion, as well as microbiologically influenced corrosion (MIC). The corrosion rates for each of these mechanisms can be highly variable based on environmental conditions. Corrosion cells of partially buried steel have been identified in the corrosion literature. Steel pile corrosion in seawater has exhibited two maxima based on testing at Kure Beach, NC. Corrosion rates are maximum in the splash zone above high tide level and below the low-tide level at the tidal zone interface with the immersion zone due to well-aerated areas becoming strongly cathodic to metal just below water (Reference 2). The different exposure zones and expected corrosion rates are represented in Figure 2. The splash zone on the hull of the USS Yorktown has experienced extensive corrosion with significant through-hull penetration, and other differential aeration areas on the USS Yorktown may exhibit a similar pattern. The most suceptible areas are locations where pitting, crevice and microbiological corrosion can occur. This region of higher susceptibility is at the water line and in regions of deaeration where corrosion influencing bacteria can be present.

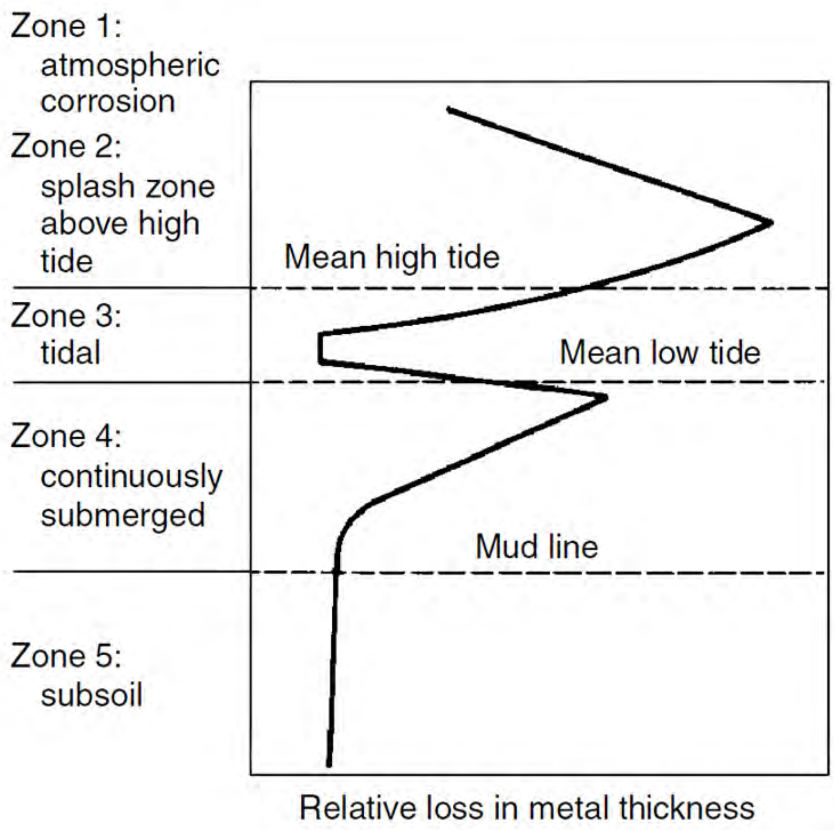

Figure 2 Exposure Zones for Marine Environments (Reference 6)

7. General Corrosion

General corrosion of carbon steel is the oxidation of the metal into iron oxide corrosion products. This process is dependent on oxygen content in the surrounding environment and varies with temperature and pH of the system. If no oxygen is present then general corrosion cannot occur. In seawater immersion, pH ranges from approximately 7.5 to 8.3. Changes within this range have no effect on corrosion of carbon steel, so corrosion testing in seawater is generally representative of most seawater conditions of similar temperature and dissolved oxygen content. In the buried environment, carbon steel exposure to oxygen is limited. Trace oxygen may be present in coarse granular soil materials, where carbon steel would corrode at a slow and uniform rate (Reference 7). In the very loose to loose silty sand identified in the geotechnical soil analysis performed at the USS Yorktown, oxygen content is likely very low. In the very soft to soft silty clay, conditions are likely anaerobic. BS6349-1, British Standard Code of Practice for Maritime Structures, indicates a maximum steel general corrosion rate in the embedded (below seabed) zone of less than 1 mil per year. In anaerobic clay or polluted mud, general corrosion can be regarded as negligible unless the soils are acidic or contain sulfate-reducing bacteria (Reference 7).

The average general corrosion rate of carbon and low-alloy steels in marine immersion environments ranges from 2 to 5 mils per year (Reference 6), but rates of 7 mils/year have been reported in the first year of steel exposure. This rate tends to decrease over time to 1 mil per year as corrosion product creates a barrier to mitigate further corrosion. Comprehensive compilation of corrosion rates of iron and steel in sea water immersion suggest that 5 mils/year may be taken as a reasonable estimate in any part of the world (Reference 2). Most of this compiled data was obtained from testing performed on small isolated panels. The estimated 5 mils/year general corrosion rate does not take into account the effects of differences in corrosion potential across a large structure. General corrosion rates on the immersed exposed area of the USS Yorktown may be assumed to be greater than this estimate due to the large variation in conditions for different areas of the hull. In areas of large differential oxygen concentrations (aerated and deaerated areas), the associated corrosion potential difference on carbon steel is approximately 60 mV (Reference 6). As stated in the USS Yorktown cathodic protection assessment, local differences in corrosion potential can develop accelerated localized corrosion mechanisms such as pitting and crevice (under deposit) corrosion. Differential aeration cells may exist at the water line, between immersed areas and buried areas, or between buried areas in loose silty sand and silty clay on the vessel hull. Interfaces between these areas, if revealed during in-situ assessment, should be inspected for more rapid corrosion.

The protective effect of any corrosion product or other deposits should be determined. Exposed iron in a marine environment is susceptible to colonization by marine organisms. Coralline algae, silicaceous diatoms, foraminifer and bivalve mollusks generate a layer of calcium carbonate on the surface of iron. This layer may slow corrosion rates, but does not passivate the material (Reference 8).

8. Crevice Corrosion

Carbon steel is susceptible to crevice corrosion in the marine environment. Crevice corrosion is dependent on an occluded crevice geometry which maintains a local environment such that the steel within the crevice becomes anodic to the cathodic exposed surface. Crevices can form at weld beads, under corrosion product, and under deposits or other surface discontinuities.

Attachment of marine organisms can also result in severe crevice corrosion. An example of localized corrosion under a sediment deposit is presented in Figure 3.

The development of a concretion layer composed of deposited carbonates on marine shipwreck sites has been noted in the corrosion literature. Underneath the concretion layer an isolated environment of high chloride, low pH conditions can develop (Reference 9). If this layer is uniform, it will slow corrosion of the underlying steel by slowing the rate of oxygen transport to the bare metal surface. If areas of deposits exist adjacent to areas of bare metal exposed to aerated conditions, crevice corrosion cells are likely to develop under the deposit. The rate of crevice corrosion in these conditions can be slowed in areas of effective cathodic protection.

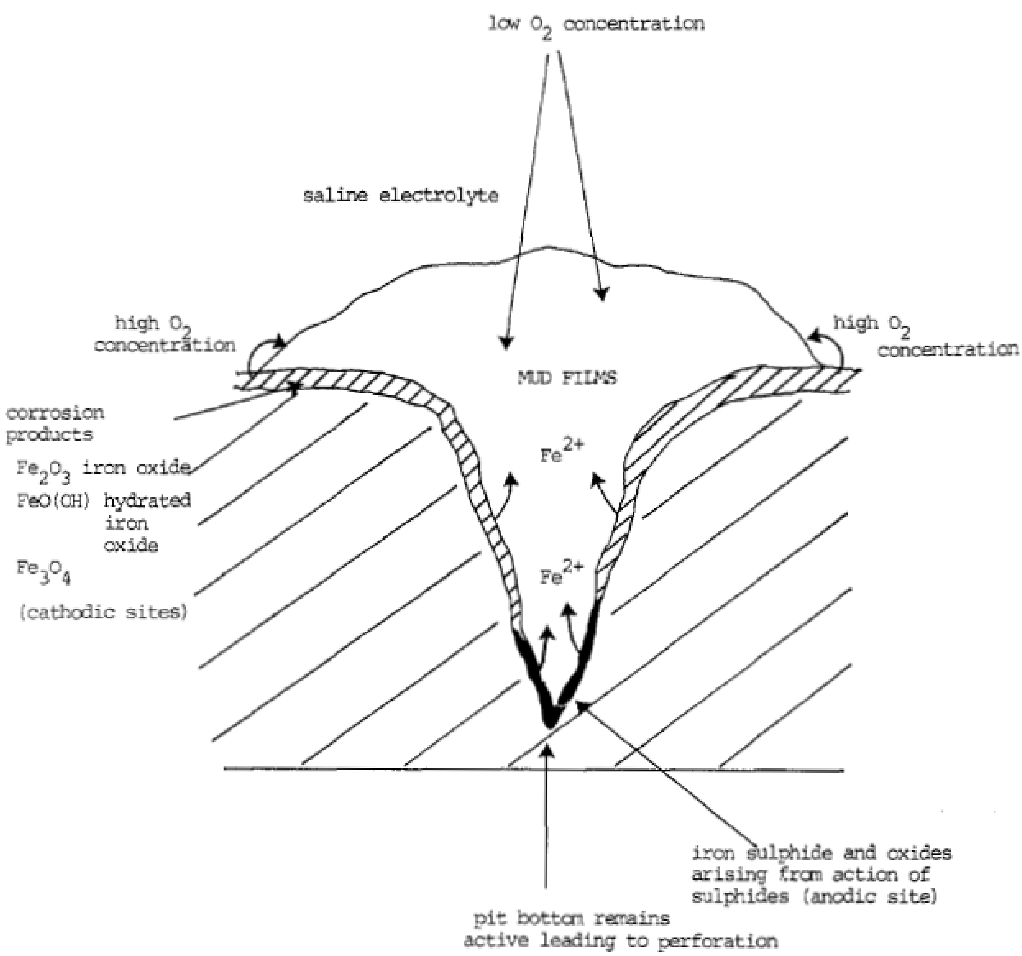

Figure 3. Carbon Steel Corrosion Under A Mud Deposit In Aerated Seawater (Reference 10)

Penetration rates of crevice corrosion can be an order of magnitude greater than corrosion of the surface material. Rates of crevice corrosion are difficult to predict as they depend on the localized environment within the crevice and the anode-to-cathode ratio of the exposed surface to the internal crevice environment. Because crevice corrosion rates are difficult to predict, estimation depends on laboratory and in-situ corrosion testing of materials in multiple representative environments or actual inspection of the component. If deposits are identified during below-the-mudline assessment of the USS Yorktown, the deposit should be removed to determine if crevice corrosion is occurring beneath and the depth of penetration noted.

9. Pitting Corrosion

Pitting corrosion of carbon steel occurs by a similar mechanism to crevice corrosion. Pitting corrosion rates are also difficult to predict and their estimation depends on laboratory and in-situ corrosion testing of materials in multiple representative environments or by actual inspection. Pitting corrosion rates can be an order of magnitude greater than the general corrosion rate on the surface of the material.

Pitting corrosion rates are generally quoted around 9 to 15 mils/year for bare steel in seawater immersion. Pitting rates for extended periods of exposure in tropical sea water have been observed as high as 39 mils/year in the first year of exposure. In this case the average rate of penetration over 16 years was 3 mils/year, indicating a reduction in penetration rate with time (Reference 2). For carbon steel pipe tested in aggressive marine mud at Hayling Island, UK, pitting and general corrosion was observed. Pit depths of 25 mils were found after five years as a result of microbiologically influenced corrosion. The average pitting rate observed was 3.3mils/year, (Reference 11). The deepest pits in low-carbon steel panels in polluted seawater containing sulfides in San Diego harbor was recorded as well as the average penetration rate. For an average 2.2 mils/year penetration rate, the five deepest pits after one year were 20-53 mils deep (Reference 6). Because penetration rates vary in a given environment and vary over time, below-the-mud line inspections on the USS Yorktown should identify the extent of pitting by measuring the concentration of pits in a given area. Denser areas of pits will tend to have deeper penetration.

10. Microbiologically Influenced Corrosion

Microbiologically influenced corrosion (MIC) occurs as a result of a corrosive environment developed due to microbiological activity. Sulfate-reducing bacteria (SRB) bacteria are the most common cause of MIC of steel in a marine environment. Sulfate-reducing bacteria generate sulfide, which cause corrosion by oxidizing the iron in steel to iron sulfide. These bacteria are also present in soils and must be identified in soil analysis. Environmental sulfate and sulfide content can indicate bacterial activity level. This data is lacking in the soil analysis performed for the area surrounding the USS Yorktown. Aggressive SRB content is about 10^7cells/ml. SRB are also present in seawater and steel exposed to the marine environment can develop a bacterial slime film which creates anaerobic conditions and encourages localized attack. Variations in bacterial content and activity in biofilms can produce anaerobic areas of high sulfide content in close proximity to aerated areas. The resulting difference in corrosion potential can be as high as 500 mV (Reference 6). Cathodic protection will not prevent microbiological corrosion.

Published microbiologically influenced corrosion rates of carbon steel in seawater immersion vary significantly. Steel pilings have been corroded by MIC in the low-water zone at rates far exceeding the expected rate of general corrosion. Corrosion rates from 11-55 mils/year were recorded for steel pilings in various tidal zones in the UK in the presence of sulfate-reducing and other bacterial species. Comparatively, the corrosion rate in sterile seawater was measured to be less than 1 mil/year (Reference 10). Bare carbon steel pilings immersed in seawater in Buzzard's Bay, MA were determined to have corroded at 12.5 mils/year over 20 years. This may indicate microbiologically influenced corrosion. When sacrificial zinc anodes were attached to the pilings, the corrosion rates were reduced to zero (Reference 5). Microbiologically influenced corrosion rates of 2-4 mils/year have been measured for carbon steel in testing in marine mud in Hayling Island, UK. The rate identified does not include pit penetration (Reference 11). For the above referenced corrosion rates, average water temperatures are significantly lower than in Charleston Harbor. Because of the higher environmental temperature, MIC rates on the hull of the USS Yorktown are expected to be greater in both the immersed and mud zones, depending on the microbiological content.

For coated steel, it has been observed that the distribution of bacteria is influenced by the presence of iron corrosion products regardless of the coating composition. Bacteria were consistently observed to concentrate around iron corrosion products at coating defects (Reference 12). It has also been observed that coating defects were covered with calcareous deposits and few bacterial cells when cathodic protection was used. Depending on the condition of the hull coating below the mudline, sulfate-reducing bacteria may concentrate in areas of iron corrosion products at coating defects on the USS Yorktown. In areas with operational and effective cathodic protection, the concentration of bacteria would be expected to be less. Soil analyses, while beneficial in identifying specific bacteria and activity, is not necessary if local biocide additions with cathodic protection is implemented. One can correctly assume corrosion influencing bacteria are present.

11. Conclusions and Recommendations

- General corrosion rates on the USS Yorktown below the mudline are likely to be low due to the anaerobic environment. The governing corrosion mechanisms below the mudline are localized crevice, pitting, and microbiological corrosion. These mechanisms are dependent on multiple variables within a localized environment and the rate of localized corrosion by these mechanisms on the USS Yorktown cannot be determined.
- It is recommended that below-the-mudline inspections be performed at locations identified by the cathodic protection potential survey. Locations where sharp changes in corrosion potential and limited cathodic protection effectiveness are present are likely locations for degradation. As identified in Figure 1, these locations include the bow and measured from the bow along the waterline: 200 ft. on the starboard side, 300 ft. on the port side, 550 ft. on the port and starboard sides, 700 ft. and 800 ft. on the starboard side, and the sternmost 150 ft. on the port side.
- The immersion zone/mud zone interface and other likely locations of differential aeration cells should be assessed. This includes any locations which may be identified during the assessment where the soil type changes abruptly from clay to sand. If localized deposits are found on the hull, an example deposit should be removed to determine if localized corrosion is occurring underneath. If severe corrosion is evident under a removed deposit, a sacrificial anode may be installed to protect the exposed metal. This has been used successfully to protect submerged iron objects uncovered at archaeological sites (Reference 8). The color of corrosion product identified may be indicative of the type of corrosion occurring. General corrosion produces red and orange rust in the presence of oxygen. Black corrosion product may be indicative of microbiologically influenced corrosion.
- Additionally, the assessment should identify the condition of the hull coating below the mudline. Localized corrosion may occur at coating defects in areas where cathodic protection is ineffective.

12. References

1. A Physical and Ecological Characterization of the Charleston Harbor Estuarine System, Marine Resources Division, South Caroline Wildlife and Marine Resources Department. May, 1990.

2. Corrosion, 3rd Edition, Shreir, L.L.; Jarma, R.A.; Burstein, S.A.; 1994

3. Geotechnical & Environmental Data Report, USS Yorktown Soil Borings and Sediment Sampling, Project No. EN105075, Mt. Pleasant, SC., WPC, December, 2010

4. Ocean Technical Services, LLC. Corrosion Analysis and Cathodic Protection Survey, Joseph Lombardi, USS Yorktown, Task 1, 16 March 2014

5. NACE Report 06303, Thirty-three Year Study of Steel Pilings in Seawater, Ashok Kumar and L.D. Stephenson, 2006

6. ASM Handbook, Volume 13C Corrosion: Environments and Industries, Cramer, Stephen D.; Covino, Bernard S., Jr. ASM International, 2006.

7. NACE Paper 05221, Accelerated Low Water Corrosion of Steel Pilings in Seawater, Ashok Kumar and Larry D. Stephenson, 2005

8. H.L. Hunley Site Assessment, National Park Service, Naval Historical Center, and SC Institute of Achaeology and Anthropology, 1999

9. The Application of Corrosion Science to the Management of Maritime Archaeological Sites, Ian Donald MacLeod, Department of Materials Conservation, Western Australian Maritime Museum

10. A Practical Manual on Microbiologically Influenced Corrosion, John G. Stoecker, NACE International, 2001

11. NACE Paper 99313, Corrosion of Some Stainless Steels in a Marine Mud, R Francis, G Byrne, Weir Materials & Foundries; HS Campbell, University of Surrey, 1999

12. NACE Paper 99183 Marine Bacteria and Localized Corrosion on Polymer Coated Steel: Cause and Effect, Brenda J. Little, Richard I. Ray, Patricia A. Wagner, Naval Research Laboratory; Joanne Jones-Meehan, Naval Research Laboratory; C.C. Lee and Florian Mansfield, Dept. of Materials Science, University of Southern California, 1999

USS YORKTOWN

Task 4: Visual Assessment of Accessible Compartments in the Bow Region

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1. Executive Summary

Collins Engineers, Inc. (Collins) and Ocean Technical Services, Inc. (OTS) were engaged by the Patriots Point Development Authority (PPDA) to perform a structural condition assessment of the USS Yorktown located at the Patriots Point Naval and Maritime Museum in Mount Pleasant, South Carolina. Task 4 of the Assessment consisted of a cursory visual assessment of the accessible interior compartments of the ship's bow area from the forward perpendicular to Frame 50, from the 4th Deck down through the 1st and 2nd Platforms and Hold. Collins/OTS did not perform detailed assessments from which repair drawings and/or specifications could be compiled. All easily accessible spaces were visually reviewed with notation made as to the overall structural condition, condition of easily accessible major structural members, bulkheads, floors, and condition of foundations of components where applicable. No destructive testing or materials sampling was performed. Collins/OTS did not enter any confined spaces or perform any inspections at the interior of any tanks. The inspections were performed between June and August 2014.

Following are Collins' and OTS's typical observations and most notable deficiencies:

Observations

- Significant deterioration was observed in this section of the ship. All spaces forward of Frame 19 from the 4th Deck down are flooded and/or exhibit severe deterioration for which near term repair is recommended.
- Severe deterioration for which near term repair is recommended was also observed at the 1st and 2nd Platforms forward of Frame 26.
- Flooding was observed at the 1st Platform between frames 32 and 39 for which near term repair is recommended.
- Severe deterioration was observed at the 2nd Platform between frames 38 and 42 for which near term repair is recommended.
- Flooding and/or severe deterioration were observed in all spaces forward of Frame 26 and between Frames 44 and 50 on the Hold level for which near term repair is recommended.
- The other spaces in this section of the ship were generally found to be in structurally sound condition with varying degrees of minor deterioration that typically included peeling paint and light surface corrosion.
- Potential environmental and/or health hazards were observed in a number of compartments, including asbestos, "red lead" primer, and oil/fluid spills or leaks.

4th Deck

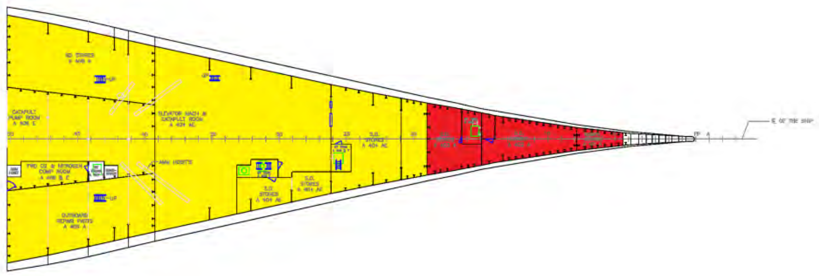

Figure 1.1 Overall view of 4th Deck

1st Platform

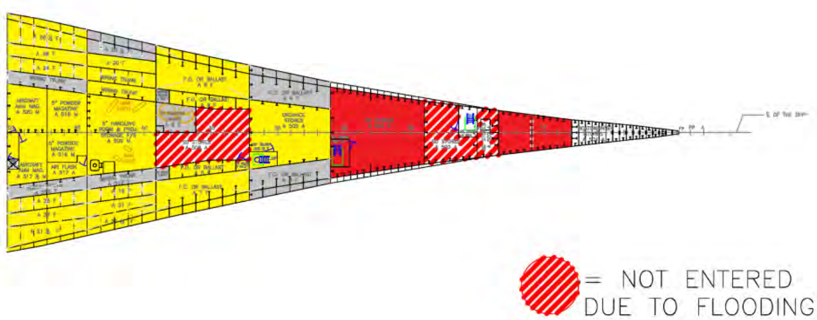

Figure 1.2 Overall view of 1st Platform

- Minor deterioration - long-term concern
- Moderate deterioration - monitoring recommended
- Significant deterioration - immediate repair recommended
- Inaccessible / not inspected

2nd Platform

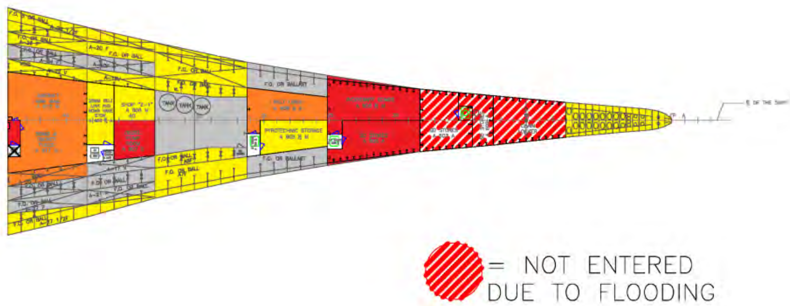

Figure 1.3 Overall view of 2nd Platform

Hold

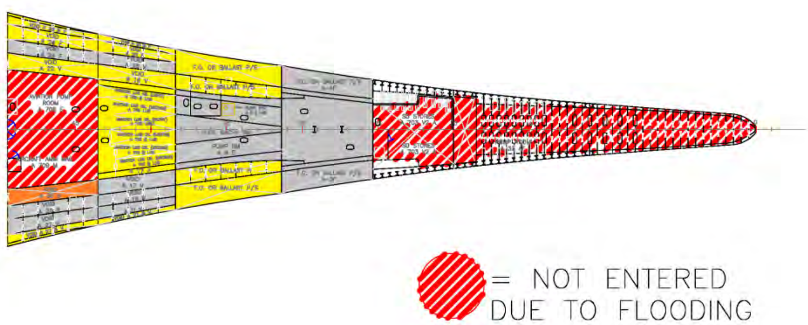

Figure 1.4 Overall view of Hold

- Minor deterioration - long-term concern
- Moderate deterioration - monitoring recommended
- Significant deterioration - immediate repair recommended
- Inaccessible / not inspected

2. Purpose and Scope

Collins Engineers, Inc. (Collins) and Ocean Technical Services, Inc. (OTS) was engaged by the Patriots Point Development Authority (PPDA) to perform a structural condition assessment of the USS Yorktown located at the Patriots Point Naval and Maritime Museum in Mount Pleasant, South Carolina. Task 4 of the Assessment consisted of a cursory visual assessment of the accessible interior compartments of the ship's bow area from the forward perpendicular to Frame 50, from the 4th Deck down through the 1st and 2nd Platforms and Hold. Easily accessible representative spaces were inspected with notation made as to the general structural condition and the condition of major structural members, bulkheads, and floors.

The Task 4 assessment was conducted between June and August, 2014. This report provides a summary of Collins' observations of the interior compartments inspected. The inspections were purely visual in nature; no destructive sampling or material testing was performed. Observations reflect the conditions observed at the time of inspection; areas, especially those with water and oil, will continue to deteriorate if left unrepaired.

The observations summarized in this report have been organized by level, beginning with the 4th Deck and proceeding down through the 1st and 2nd Platforms and Hold. **Significant structural observations are noted in bold print**; safety issues are noted in red print. Conceptual repair recommendations and a cost estimate for the conceptual repairs are provided in the Task 7 section.

Readily evident environmental conditions, such as peeling paint, red lead primer, oil, and potential asbestos were observed during the Task 4 assessment. A complete environmental assessment was performed by the Shaw Group in 2013 and a summary of Shaw's findings and recommendations was provided in Shaw's report dated April 12, 2013.

Please refer to the "Construction" section for a description of the vessel's original construction and subsequent modifications.

3. 4th Deck

3.1. A-401A, Boatswain's Stores, Frames 4 – 8

Structural Observations

- **Moderate to heavy rust/scale on overhead, side shell plating and deck. Shell plate thickness loss 70% or greater. Deck plate loss is 70% or greater. Fore and aft bulkheads and all scantlings in good condition.**
- Space is cosmetically and structurally poor and will need repair. Space is relatively dry.
- Ultrasonic thickness measurements were taken of the side shell plating and sampling of deck. The balance of the shell plating is sized 20# (1/2"). The following shell plate thicknesses were observed:

PORT Side, bow - stern				STARBOARD Side, stern – bow			
.219	.165	.315	.199	.179	.125	.208	.201
.187	.122	.219	.163	.105	.201	.185	.124
.109	.142	.202	.135	.212	.208	.132	.188
.155	.149	.222	.159	.225	.157	.299	.211

Additional Observations

- Heavy flaking and peeling of coatings. Red lead throughout space.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

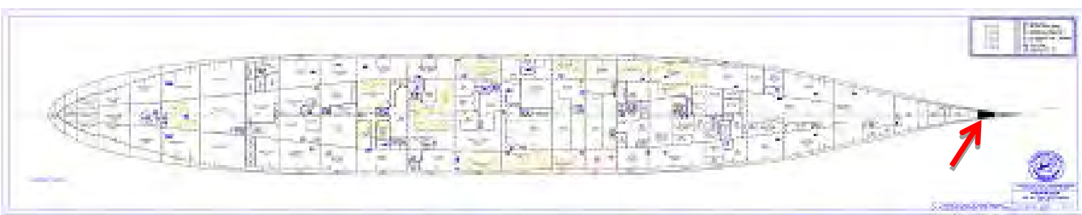

Figure 3.1 Location of compartment A 401 A

Figure 3.2 A-401A, Boatswain's Stores, looking aft.

3.2. A-402A, Storeroom, Frames 8 – 15

Structural Observations

- **Moderate to heavy rust/scale on overhead, side shell plating and deck. Shell plate thickness loss 50% or greater. Deck plate loss is 50% or greater. Fore and aft bulkheads and all scantlings in good condition.**
- Space is cosmetically and structurally poor and will need repair. Space is relatively dry.
- Ultrasonic thickness measurements were taken of the side shell plating and sampling of deck. The balance of the shell plating is sized 15# (3/8"). The following shell plate thicknesses were observed:

PORT Side, bow - stern				STARBOARD Side, stern – bow			
.320	.215	.241	.208	.200	.210	.228	.206
.191	.225	.232	.209	.179	.312	.269	.195
.180	.158	.192	.164	.199	.155	.147	.190
.167	.151	.242	.164	.200	.175	.176	.222

Additional Observations

- Heavy flaking and peeling of coatings. Red lead throughout space.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 3.3 Location of compartment A 402 A

Figure 3.4 A-402A, looking forward showing anchor hawse pipes leading to flooded chain lockers below.

3.3. A-403A, Electrical Storeroom, Frames 15 – 19

Structural Observations

- **Moderate to heavy rust/scale on overhead, side shell plating and deck. Shell plate thickness loss 60% or greater. Deck plate loss is 60% or greater. Fore and aft bulkheads and all scantlings in good condition.**
- **Space is cosmetically fair/good and structurally poor and will need repair. Space has standing water from DC plugs to port.**
- Ultrasonic thickness measurements were taken of the side shell plating and sampling of deck. The balance of the shell plating is sized 15# (3/8"). The following shell plate thicknesses were observed:

PORT Side, bow - stern	STARBOARD Side, stern – bow
.192 .164 .115 .155	.317 .142 .231 .200
.242 .164 .200 .175	.192 .164 .139 .155
.232 .209 .179 .312	.210 .193 .145 .206
.158 .192 .164 .199	.131 .127 .269 .169

Additional Observations

- Heavy flaking and peeling of coatings. Red lead throughout space.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 3.5 Location of compartment A 403 A

Figure 3.6 A-403A, showing badly corroded deck and standing water from DC plugs to port.

Figure 3.7 Failed patch and open hole in outer hull, compartment A 403 A

3.4. A-404 AE, Elevator Machinery & Catapult Pump Room and SD Stores, Frame 19 – 39

Structural Observations

- Minor rust/scale on overhead, side shell plating and deck. Shell plate thickness loss 20% or less. Deck plate loss is 20% or less. Fore and aft bulkheads and all scantlings in good condition.
- Space is cosmetically and structurally good. Space has standing hydraulic oil from catapult & pump components.
- Ultrasonic thickness measurements were taken of the side shell plating and sampling of deck. The balance of the shell plating is sized 15# (3/8”). The following shell plate thicknesses were observed:

PORT Side, bow - stern	STARBOARD Side, stern – bow
.299 .315 .323 .331 .311	.239 .303 .297 .300 .324
.320 .289 .294 .298 .300	.299 .311 .309 .300 .302

Additional Observations

- Minor flaking and peeling of coatings.

Due to the observed deficiencies, this space classifies as a long term concern. Be aware the weight of this and other machinery above will impact seriously degraded spaces below.

Figure 3.8 Location of compartment A 404 E

Figure 3.9 Overall view of compartment A 404 E

Figure 3.10 **Motor generator for hydraulic pump.**

Figure 3.11 Heavy machinery located within this space for the elevator and auxiliary equipment.

3.5. A-406E, Catapult Pump Room, Frames 39 – 58

This space comprises the heavy catapult machinery foundations, machinery and supporting auxiliary machinery.

Structural Observations

- Minor rust/scale on overhead, side shell plating and deck. Deck plate loss is 20% or less. Fore and aft bulkheads and all scantlings in good condition. No outboard plating within this space.
- Space is cosmetically and structurally good. Space has standing hydraulic oil from catapult & pump components.

Additional Observations

- Minor flaking and peeling of coatings.

Due to the observed deficiencies, this space classifies as a long term concern. Be aware the weight of this and other machinery above will impact seriously degraded spaces below.

Figure 3.12 Location of compartment A 406 E

Figure 3.13 Overall view of compartment A 406 E

Figure 3.14 Wire reel for catapult.

Figure 3.15 Notice hydraulic oil on deck beneath components.

3.6. A-406E, Fitting Room, Frames 44 – 50

This space comprises a shop area and is in good condition.

Structural Observations

- Minor rust/scale on overhead, side shell and deck. Deck plate loss is 20% or less. Fore and aft bulkheads and all scantlings in good condition. No outboard plating within this space.
- Space is cosmetically and structurally good.

Additional Observations

- Minor flaking and peeling of coatings.

Due to the observed deficiencies, this space classifies as a long term concern.

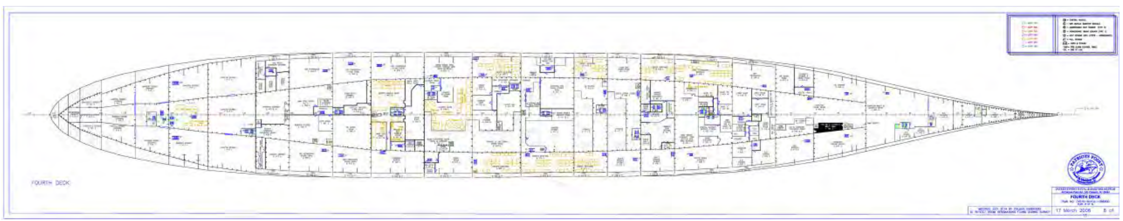

Figure 3.16 Location of compartment A 406 E

Figure 3.17 Overall view of compartment A 406 E

3.7. A 409 A, Outboard Repair Parts, Frames 39 – 50 ½

Structural Observations

- Minor rust/scale on overhead, side shell plating and deck. Shell plate thickness loss 20% or less. Deck plate loss is 20% or less. Fore and aft bulkheads and all scantlings in good condition.
- Space is cosmetically and structurally good. Space has debris & standing black oil from tank inspections.
- Ultrasonic thickness measurements were taken of the side shell plating and sampling of deck. The balance of the shell plating is sized 15# (3/8”). The following shell plate thicknesses were observed:

  STARBOARD Side, stern – bow
  .321 .315 .320 .325
  .329 .300 .342 .333
  .331 .322 .319 .329
  .327 .315 .340 .322

Additional Observations

- Minor flaking and peeling of coatings.

Due to the observed deficiencies, this space classifies as a long term concern. Be aware the weight of this and other machinery above will impact seriously degraded spaces below.

Figure 3.18 Location of compartment A 409 AE

Figure 3.19 Overall view of compartment A 409 AE

Figure 3.20 Overall view #2 of compartment A 409 AE

Figure 3.21 Overall view #3 of compartment A 409 AE

3.8. A-408A, S.D. Stores, Frames 39 ½ - 50 ½

Structural Observations

- Minor rust/scale on overhead, side shell plating and deck. Shell plate thickness loss 20% or less. Deck plate loss is 20% or less. Fore and aft bulkheads and all scantlings in good condition.
- Space is cosmetically and structurally good. Space has debris & standing black oil from tank inspections. Many tank covers removed as crew is shifting ballast/oil.
- Ultrasonic thickness measurements were taken of the side shell plating and sampling of deck. The balance of the shell plating is sized 15# (3/8”). The following shell plate thicknesses were observed:

  PORT Side, bow to stern

  .300 .292 .289 .300 .311 .300 .334 .310

Additional Observations

- Minor flaking and peeling of coatings.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 3.22 Location of compartment A 408 A

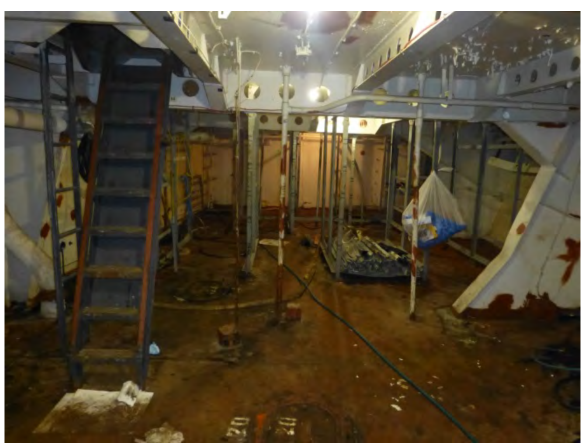

Figure 3.23 A-408A, looking aft.

Figure 3.24 A-408A, looking forward to port. Notice cut-out in bulkhead to Catapult Machinery Room forward.

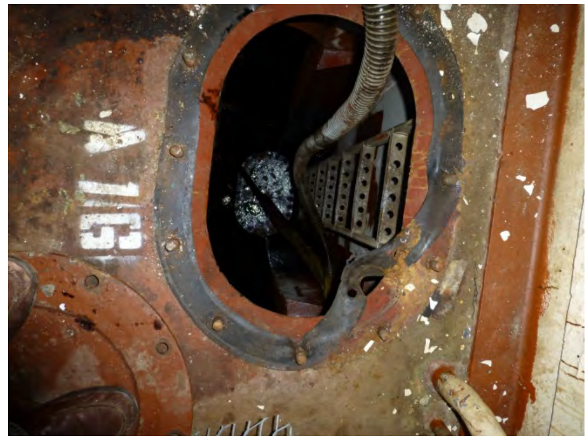

Figure 3.25 Open hatch to Tank A-16F in A-408A.

4. 1st Platform

4.1. A-501A, Bosun’s Storeroom, Frames 4 – 8

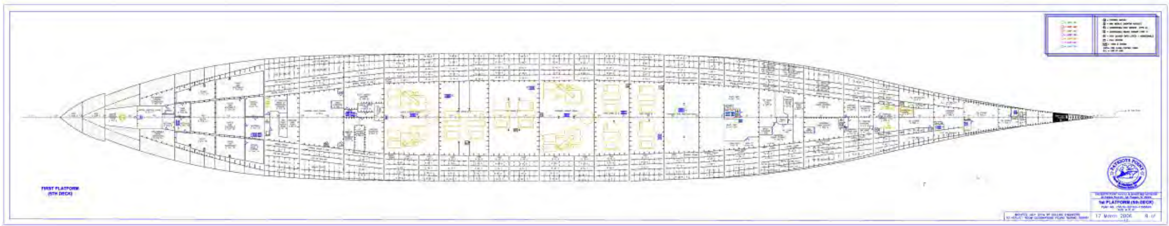

Figure 4.1 Location of compartment A 501 A Boatswain’s Stores

- Moderate to heavy rust scale on overhead, side shell plating and deck. Shell plate thickness loss 70% or greater. Deck plate loss is 80% or greater. Fore and aft bulkheads and all scantlings in fair/good repair.
- Space is cosmetically and structurally poor and will need repair. Space is relatively dry.
- U/T shots were taken of the side shell plating and sampling of deck. The balance of the shell plating is sized 15# (3/8”, 0.375”). The following shell plate thickness was observed:

PORT Side, bow - stern				STARBOARD Side, stern – bow			
.209	.131	.129	.170	.145	.132	.178	.211
.155	.167	.167	.145	.129	.097	.110	.123
.150	.101	.095	.100	.111	.147	.098	.100
.077	.055	.100	.091	.103	.077	.061	.055

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

4.2. A-502A, S.D. Stores, Frames 13-15

This compartment is flooded and structural condition is unknown.

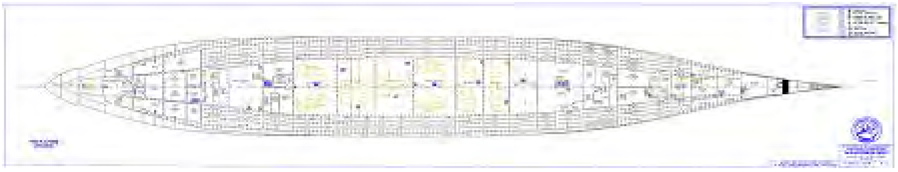

Figure 4.2 Location of compartment A 502 A

Figure 4.3 View of flooding in compartment A 502 A

4.3. A-503A, S.D. Stores, Frames 15-19

This compartment is flooded and structural condition is unknown.

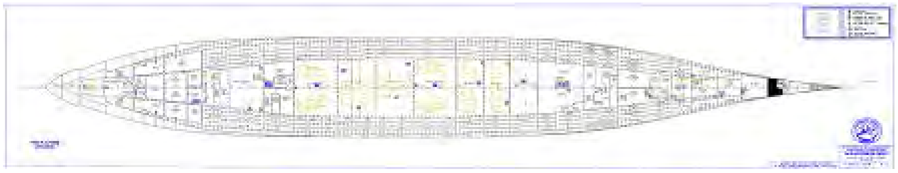

Figure 4.4 Location of compartment A 503 A

Figure 4.5 Sealed hatch leading to compartment A 503 A

4.4. A-504A, S.D. Stores, Frames 19 – 26

Structural Observations

- Damage control patches outboard to port.
- **Moderate to heavy rust/scale on overhead, side shell plating and deck. Shell plate thickness loss 70% or greater. Deck plate loss is 80% or greater. Fore and aft bulkheads and all scantlings in good condition.**
- Space is cosmetically and structurally poor and will need repair. Space is relatively dry.
- Ultrasonic thickness measurements were taken of the side shell plating and sampling of deck. The balance of the shell plating is sized 15# (3/8”, 0.375”). The following shell plate thicknesses were observed:

PORT Side, bow - stern			
.159	.145	.165	.179
.176	.143	.200	.156
.089	.112	.132	.135
.136	.198	.213	.149

STARBOARD Side, stern – bow			
.180	.139	.208	.203
.115	.195	.135	.110
.200	.158	.121	.147
.204	.135	.099	.078

Additional Observations

- Heavy flaking and peeling of coatings. Red lead throughout space. Much mildew throughout space.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 4.6 Location of compartment A 504 A

Figure 4.7 General condition of A-504A.

Figure 4.8 Heavy corrosion at forward corner to starboard.

Figure 4.9 A-504A, looking forward to port.

4.5. A-505A, Ordnance Stores, Frames 26 -32

Structural Observations

- Fore and aft bulkheads and all scantlings in good condition.
- Space is cosmetically and structurally excellent. Space is relatively dry.
- Ultrasonic thickness measurements were taken of the side shell plating (which borders outboard fuel/ballast tankage) and sampling of deck. The balance of the shell plating is sized 15# (3/8"). The following shell plate thicknesses were observed:

PORT Side, bow - stern				STARBOARD Side, stern – bow			
.359	.345	.365	.349	.320	.339	.308	.313
.299	.343	.310	.346	.325	.325	.331	.322
.319	.312	.333	.335	.312	.315	.351	.345
.336	.338	.343	.349	.314	.335	.317	.348

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.10 Location of compartment A 505 A

Figure 4.11 A-505A, showing storage bins.

4.6. A-506A. S.D. Stores, Frames 32 – 39

This compartment is flooded and structural condition is unknown.

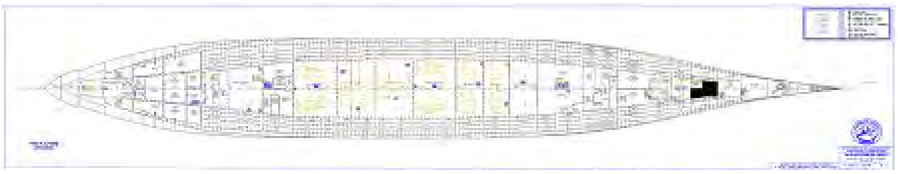

Figure 4.12 Location of compartment A 506 A

Figure 4.13 Sealed hatch leading to compartment A 506 A

4.7. A-509M, 5" Handling & Projectile Stowage Room, Frames 39 – 44 ½.

Structural Observations

- Space is in cosmetically and structurally sound condition.

Additional Observations

- Much hydraulic oil on deck from machinery.
- Loose debris on deck.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.14 Location of compartment A 509 M

Figure 4.15 A-509M, looking at 5" hoist.

4.8. A-516M, 5" Powder Magazine, Port, Frames 44 ½ - 47 ½

Structural Observations

- Space is in cosmetically and structurally sound condition.

Additional Observations

- Possible friable asbestos on deck.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.16 Location of compartment A 516 M

Figure 4.17 A-516M, 5" Powder Magazine

Figure 4.18 Possible friable asbestos on deck

4.9. A-517A, Air Flask Room, Frames 44 ½ - 47 ½

Structural Observations

- Space is in cosmetically and structurally sound condition.

Additional Observations

- Much hydraulic oil on deck from machinery.
- Loose debris on deck.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.19 Location of compartment A 517 A

Figure 4.20 A-517A, Air Flask Room, with hydraulic oil on deck.

4.10. A 520 M, Aircraft Ammunition Magazine, Frames 47-50

Structural Observations

- No major structural issues were observed.
- An approximately 10 square foot (SF) area of light corrosion was observed on the steel floor in the aft starboard corner of the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

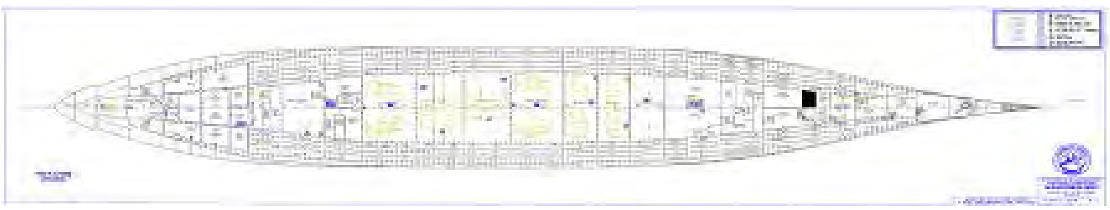

Figure 4.21 Location of compartment A 520 M

Figure 4.22 Overall view of compartment A 520 M.

4.11. A 517 ½ M, Aircraft Ammunition Magazine, Frames 47-50

Structural Observations

- No major structural issues were observed.
- Isolated areas of spotty, light corrosion were observed across the floor of the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

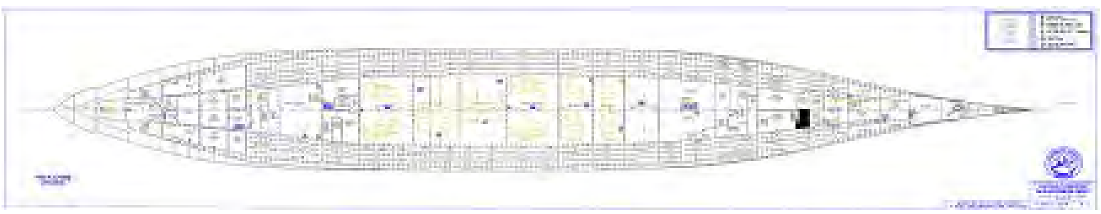

Figure 4.23 Location of compartment A 517 ½ M

Figure 4.24 Location of compartment A 517 ½ M

5. 2ND Platform

5.1. Chain Locker, Frames 7 – 12 1/2

The space is currently flooded and structural condition is unknown.

Figure 5.1 Location of Chain Locker

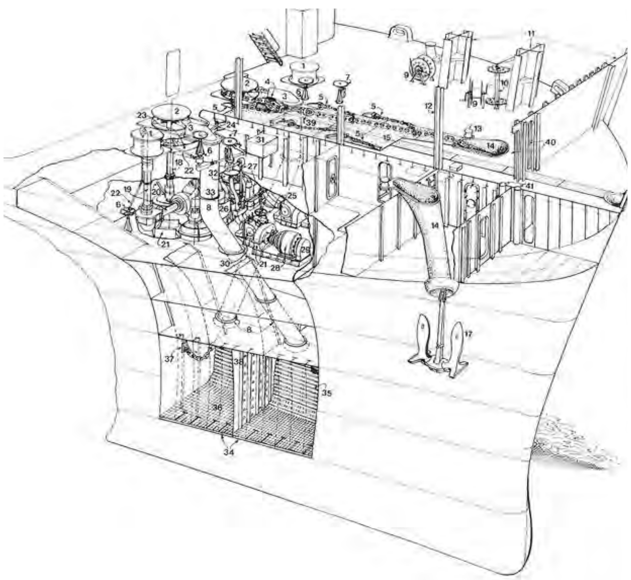

Figure 5.2 Cross-section of forward portion of ship showing Chain Locker

Figure 5.3 Flooding and hole in outer hull in Chain Locker

5.2. A-602A, S.D. Stores, Frames, 12 ½ - 15

The space is currently flooded and structural condition is unknown.

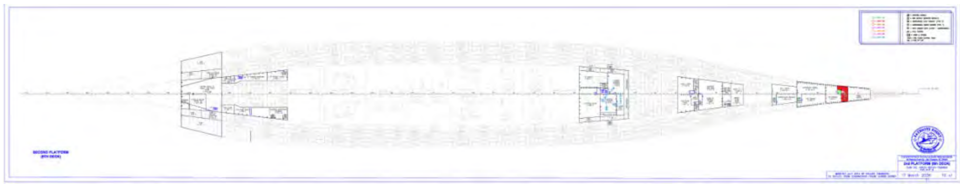

Figure 5.4 Location of compartment A 602 A

Figure 5.5 Sealed hatch leading to compartment A 602 A

5.3. A-603A, S.D. Stores, Frames 14 – 17

The space is currently flooded and structural condition is unknown.

Figure 5.6 Location of compartment A 603 A

Figure 5.7 Sealed hatch leading to compartment A 603 A

5.4. A-605 ½M, Incendiary Bomb Magazine, Frames 18 – 25, Port

This space is to port and has suffered immense degradation throughout the structure.

Structural Observations

- **Heavy corrosion of the forward bulkhead**
- **Heavy corrosion of the aft bulkhead**
- **Heavy corrosion of the overhead transverse frames and deck**
- **Heavy corrosion of the deck**
- **Heavy corrosion of the centerline bulkhead and vertical stanchions**
- **Heavy corrosion surrounding watertight dogging hatch to access trunk**

Additional Observations

- Space has damage control plugs that were leaking at time of inspection

No ultrasonic thickness readings were taken on the shell plating due to very fragile condition of plating.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

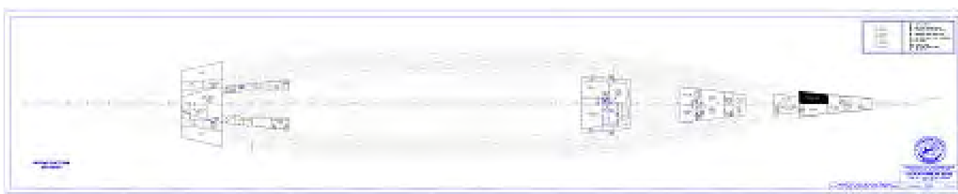

Figure 5.8 Location of compartment A 605 ½ M

Figure 5.9 A-605 ½M, looking forward.

Figure 5.12 Wated transverse frame in A-605 1/2M.

Figure 5.10 A-605 ½M,, upper corner on centerline bulkhead.

Figure 5.13 Corroded frame and watertight dogging hatch to vertical access trunk.

Figure 5.11 Typical outboard shell transverse frame.

Figure 5.14 Corroded transverse overhead deck frames in A-605 1/2M.

5.5. A-605A, S.D. Stores, Frames 18 – 25 Starboard

This space is to starboard and has suffered immense degradation throughout the structure.

Structural Observations

- **Heavy corrosion of the forward bulkhead**
- **Heavy corrosion of the aft bulkhead**
- **Heavy corrosion of the overhead transverse frames and deck**
- **Heavy corrosion of the deck**
- **Heavy corrosion of the centerline bulkhead and vertical stanchions**
- **Heavy corrosion surrounding watertight dogging hatch to access trunk**

Additional Observations

- Space has friable asbestos on deck from overhead piping

No UT readings were taken on the shell plating due to very fragile condition of plating.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 5.15 Location of compartment A 605 A

Figure 5.16 A-605A, looking forward.

Figure 5.18 Deteriorated shell plating and transverse frame in A-605A.

Figure 5.17 Friable asbestos on deck in A-605A

Figure 5.19 Overhead transverse deck frame in A-605A.

5.6. A-606 ½ M, Pyrotechnic Storage, Frames 25 – 31 ½ Starboard.

The space is in good cosmetic and excellent structural condition

Structural Observations

- Minor rust/scale on deck

Additional Observations

- Friable asbestos on deck
- Aluminum racks disintegrating against steel decks (dissimilar metals)

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.20 Location of compartment A 606 ½ M

Figure 5.21 Overall view of compartment A 606 ½ M

5.7. A-606 ½ A, Belt Links, Frames 25 – 31 ½ Starboard.

The space is in fair/good cosmetic (having been previously flooded) and excellent structural condition

Structural Observations

- Moderate rust/scale on deck
- Aft bulkhead is wavy and deflected 4"

Additional Observations

- Friable asbestos on deck
- Aluminum racks disintegrating against steel decks (dissimilar metals)
- Oil on bulkheads

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 5.22 Location of compartment A 606 ½ A

Figure 5.23 Overall view of compartment A 606 ½ A

Figure 5.24 Buckled bulkhead, deflected 4", outboard intersection of tank plating.

5.8. A-607E, Diesel Pump Room, Frames 38 1/2 – 41 ½ Starboard.

Structural Observations

- **Heavy rust/scale/corrosion on deck with plate loss exceeding 60%**

Additional Observations

- Standing oil on deck from pump gauges
- Friable asbestos on deck from overhead pipe lagging

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 5.25 Location of compartment A 607 E

Figure 5.26 Corrosion on deck in compartment A 607 E

Figure 5.27 Overall view of compartment A 607 E

5.9. A-606M, Shop Z-1 Room, Frames 38 1/2 – 41 ½ Port.

Space is in good structural condition; much debris and parts strewn on deck outside of storage bins.

Due to the observed deficiencies, this space classifies as a long term concern.

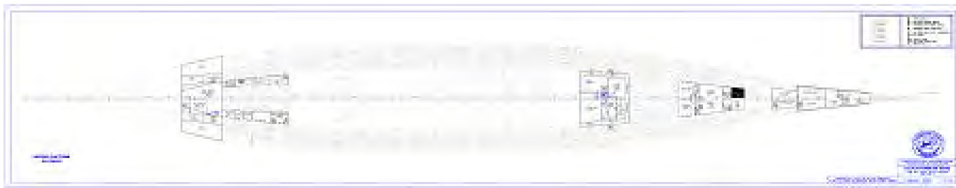

Figure 5.28 Location of compartment A 606 M

Figure 5.29 Overall view of compartment A 606 M

5.10. A-608M, Belt Link & Bomb Vane Room, Frames 41 1/2 – 43 ½ Port.

Space is in good structural condition; much debris and parts strewn on deck outside of storage bins.

No photographs for this space

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.30 Location of compartment A 608 M

5.11. A-610M, Aircraft Ammunition Magazine, Frames 44 – 50

Structural Observations

- The walls, floor, and ceiling of this compartment are covered by insulation. Based on other areas where similar corrosion was observed but portions of the structure behind the lining were exposed, it is likely that corrosion is present behind the lining of this compartment.
- Moderate corrosion was observed in a small area of exposed ceiling.
- Corrosion was observed around fittings on the forward bulkhead at Frame 44.
- Areas of light surface corrosion were observed on the floor of the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

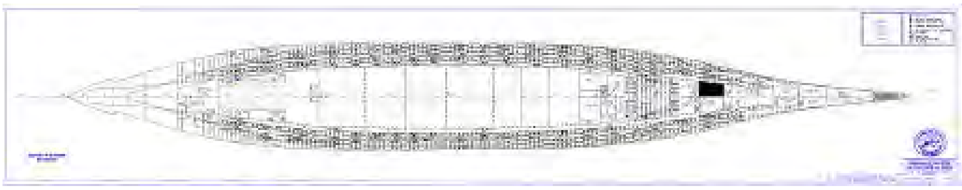

Figure 5.31 Location of compartment A 610 M

Figure 5.32 Overall view of compartment A 610 M

5.12. A-611M, Bomb & Rocket Fuses Magazine, Frames 44 – 50

Structural Observations

- The walls, floor, and ceiling of this compartment are covered by insulation. Based on other areas where similar corrosion was observed but portions of the structure behind the lining were exposed, it is likely that corrosion is present behind the lining of this compartment.
- Light corrosion was observed to a height of approximately 3-in on the lower walls, and around the edges of the floor pan.

Additional Observations

- **This compartment is flooded to a depth of approximately 12-in.**
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 5.33 Location of compartment A 611 M

Figure 5.34 Overall view of compartment A-611 M.

Figure 5.35 Flooding in compartment A-611 M.

6. Hold

6.1. A-703V2A, SD Stores, Frames 20-25

This space is flooded and structural condition is unknown.

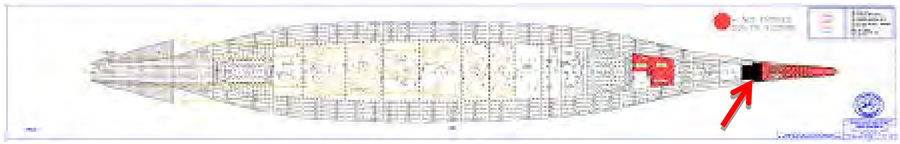

Figure 6.1 Location of compartment A 703 V2A

Figure 6.2 Sealed hatch leading to compartment A 703 V2A

6.2. A-708E, Aviation Pump Room, Frames 43 ½ - 49 ½

Structural Observations

- Corrosion is visible throughout the compartment.
- Based on conditions observed in areas of the ship which were previously flooded for extended periods, it is likely that structural components in this compartment are severely deteriorated. Near term repairs are likely warranted.

Additional Observations

- **This compartment is flooded to an unknown depth and could not be fully inspected.**

Due to the observed deficiencies, this space requires near term repair.   Refer to Task 7 for recommended repairs.

Figure 6.3 Location of compartment A 708 E

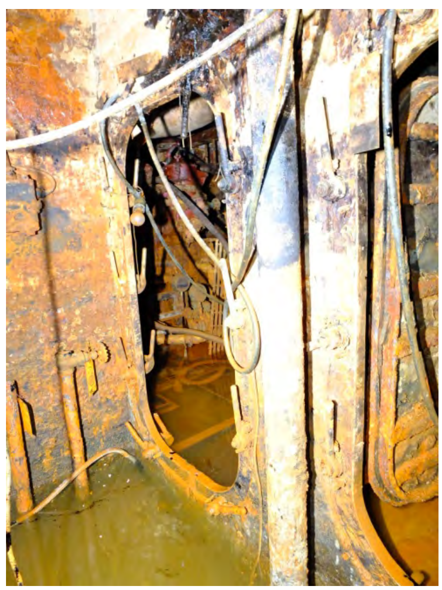

Figure 6.4 View of flooding in entry to compartment A-708E.

6.3. A-709M, Aircraft Ammunition Magazine, Frames 43 ½ - 49 ½

Structural Observations

- Corrosion is visible throughout the compartment.
- Based on conditions observed in areas of the ship which were previously flooded for extended periods, it is likely that structural components in this compartment are severely deteriorated. Near term repairs are likely warranted.

Additional Observations

- **This compartment is flooded to an unknown depth and could not be fully inspected.**

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 6.5 Location of compartment A 709 M

Figure 6.6 Overall view of flooding in compartment A-709M

6.4. A-711T, Trunk, Frames 49 ½ - 50 1/2

Structural Observations

- **Corrosion is visible throughout the compartment.**
- **Based on conditions observed in areas of the ship which were previously flooded for extended periods, it is likely that structural components in this compartment are severely deteriorated. Near term repairs are likely warranted.**
- **Heavy-to-severe corrosion was observed on walls above the flooded lower portion of the compartment.**

Additional Observations

- **This compartment is flooded to an unknown depth and could not be fully inspected.**
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 6.7 Location of compartment A 711 T

Figure 6.8 Overall view of flooding in compartment A 711 T.

7. Tanks

7.1. Condition Assessment of Structural Tanks by Shaw

On behalf of Collins Engineers, Inc., a corrosion survey for the structural tanks and compartments of the USS Yorktown, located at Patriots Point in Mount Pleasant, South Carolina was conducted by Shaw Environmental & Infrastructure (SHAW) a CB&I company during the months of November and December 2012. A visual corrosion inspection rating scale was used for the accessible compartments in the interior of the vessel. This visual corrosion was ranked as (Type 1) only minor spot rusting, paint intact or little to no deterioration, (Type 2) surface corrosion, flaking and light pitting or minor deterioration, (Type 3) moderate metal loss, severe pitting and peeling or moderate deterioration, and (Type 4) significant metal loss or significant deterioration. Only types 1, 2, and 3 were observed with no type 4 detected. Pictures were taken in each structural tank including top of deck head, sides, and bottom of tank to document the condition of the metal in the compartment. Only accessible representative spaces were inspected with notation made as to general structural condition. Shaw has found and documented 428 tanks, structures, or compartments that contain environmental contaminants or hazards. This photo documented corrosion survey includes 346 of these structural tanks and compartments that have been inspected and included in Table 1. There was no access to 119 of these tanks which included 78 that could only be accessed by sounding tubes, 31 that were water filled, and 10 compartments could not be accessed. There were 227 type 1, 2, and 3 tanks, tank structures, or compartments accessible for inspection for this survey. Tanks, tank structures, and compartments were inspected from Bow to Stern and included the fourth, fifth, sixth, and seventh decks, and the hull of the ship.

There were 32 tanks located within the scope of Task 4 of this assessment, beginning at the Forward Perpendicular and continuing aft to Frame 50. Of the 32 tanks located within the scope of Task 4, 14 were inaccessible; 16 were found to have minor deterioration; 2 were found to have moderate deterioration; and 0 were found to have significant deterioration.

7.2. Table of Tank Inspection Findings

Tank ID	Name	Frame	Condition
A-18F	Inner Ballast A-18F	41	No Access
A-19F	Inner Ballast A-19F	41	No Access
A-21F	Outer Ballast A-21F	41	No Access
A-801V	Central Lower Skin	43	No Access
A-802V	Central Lower Skin	43	No Access
A-907F	Bottom Skin	43	No Access
A-24F	Inner Ballast A-24F	47	No Access
A-25F	Inner Ballast A-25F	47	No Access
A27F	Outer Ballast A-27F	47	No Access
A709 M	Lower Inner	49	No Access
A-803V	Central Lower Skin	49	No Access
A-804V	Central Lower Skin	49	No Access
A-908.5F	Bottom Skin	49	No Access
A-909.5F	Bottom Skin	49	No Access
A-16V	Inner Void A-16V	41	1
A-512T	Upper Inner Skin	43	1
A-22V	Inner Void A-22V	47	1
A-1W	Peak Tank	3	Oil Coated (1)
A-5F	Inner Ballast A-5F	37	Oil Coated (1)
A-6F	Inner Ballast A-6F	37	Oil Coated (1)
A-7F	Outer Ballast A-7F	37	Oil Coated (1)
A-8F	Outer Ballast A-8F	37	Oil Coated (1)
A-15.5F	Inner void A-15.5F	39	Oil Coated (1)
A705.25LUB	Lower Inner LUB	39	Oil Coated (1)
A706.25LUB	Lower Inner LUB	39	Oil Coated (1)
A-20F	Outer Ballast A-20F	41	Oil Coated (1)
A-21.5F	Outer Skin A-21.5	41	Oil Coated (1)
A26F	Outer Ballast A-26F	47	Oil Coated (1)
A26.5F	Outer Skin A-26.5	47	Oil Coated (1)
A27.5F	Outer Skin A-27.5	47	Oil Coated (1)
A-2W	Peak Tank	7	2
A-23V	Inner Void A-23V	47	2

7.3. Tank Inspection Photos

Figure 7.1 "Bottom and sides of peak tank A-1W with oil coated and minor deterioration on bow section FR 3"

Figure 7.2 "Side wall of inner void A-5F with no corrosion on starboard side section FR 37"

Figure 7.3 "Front wall of inner void A-5F with oil coated and light surface corrosion on port side section FR 37"

Figure 7.4 "Front sides of outer ballast A-7F with no corrosion on starboard side section FR 37"

Figure 7.5 "Sides of outer ballast A-8F with no corrosion on port side section FR 37"

Figure 7.6 "Sides of inner void A-15.5F with no corrosion on port side section FR 39"

Figure 7.7 “Front wall of inner void A-16V with no corrosion on port side section FR 41”

Figure 7.8 “Side of outer ballast A-20F with oil coated and light surface corrosion on port side section FR 41”

Figure 7.9 “Side of outer skin A-21.5F with oil coated and light surface corrosion on starboard side section FR 41”

Figure 7.10 “Bottom and sides of inner void A-22V with minor deterioration on port section FR 47”

Figure 7.11 “Front wall of outer skin A-26.5F with oil coated and no corrosion on port side section FR 47”

Figure 7.12 “Back corner of outer ballast A-26F with oil coated and no corrosion on port side section FR 47”

Figure 7.13 “Front corner of outer skin A-27.5F with oil coated and no corrosion on starboard side section FR 47”

Figure 7.15 “Top of Anchor Chain Room A-601E with flaking and minor corrosion on bow section FR 7”

Figure 7.14 “Bottom and sides of peak tank A-2W with flaking and minor deterioration on bow section FR 7”

Figure 7.16 “Front wall of inner void A-23V with peeling paint and minor corrosion on starboard side section FR 48”

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USS YORKTOWN

Task 5: Visual Assessment of all Accessible Compartments in the Remainder of the Vessel

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1. Executive Summary

Task 5 of the Assessment consisted of a cursory visual assessment of the accessible interior compartments of the ship from Frame 50 to the stern, from the 4th Deck down through the 1st and 2nd Platforms and Hold. Assessment work was performed by Collins and OTS from April through November 2014. All assessments were purely visual in nature; no material sampling or destructive testing was performed. All easily accessible spaces were visually reviewed with notation made as to the overall structural condition, condition of easily accessible major structural members, bulkheads, floors and condition of foundations of components where applicable. Tanks, cofferdams, and other confined spaces were not visually reviewed by OTS or Collins; however, data recorded by CB&I (the Shaw Group) during their environmental assessment was included in the report for this task. Per the project scope, Collins/OTS did not perform detailed assessments from which repair drawings and/or specifications could be compiled.

The structural conditions observed during the Task 5 assessments varied greatly with level and location. A deck by deck summary of the conditions observed follows.

The compartments of the 4th Deck were generally found to be in structurally sound condition with varying degrees of minor deterioration that typically included peeling paint and light surface corrosion. Deformation of transverse bulkheads was observed at several locations on the 4th Deck, and many bulkheads have been torch-cut previously.

The compartments of the 1st Platform (5th Deck) were generally found to be in structurally sound condition with varying degrees of deterioration that typically included peeling paint and light surface corrosion; several compartments at the forward and aft portions of the vessel were observed to be in a state of severe deterioration.

The compartments of the 2nd Platform (6th Deck) were generally found to have varying degrees of deterioration that typically included peeling paint and corrosion; several compartments at the forward and aft portions of the vessel were observed to be in a state of severe deterioration.

The compartments of the Hold level (7th Deck) were generally found to have varying degrees of deterioration that typically included peeling paint and corrosion; several compartments at the forward and aft portions of the ship were observed to be in a state of severe deterioration. Several compartments at this level were flooded to unknown depths and were inaccessible.

Potential environmental and/or health hazards were observed in a number of compartments throughout the vessel, including asbestos, "red lead" primer, and oil/fluid spills or leaks. An environmental assessment of the vessel was performed by The Shaw Group (Shaw) in 2013 and was not included in the scope of this structural assessment. A summary of Shaw's findings and recommendations was provided in Shaw's report dated April 12th, 2013. During the environmental assessment, Shaw performed a visual assessment of structural tanks. There were 311 tanks located within the scope of Task 5 of this assessment, beginning at Frame 50 and continuing aft to the stern of the ship. Of the 311 tanks located within the scope of Task 5, 106 were inaccessible; 139 were found to have minor deterioration; 50 were found to have moderate deterioration; and 16 were found to have significant deterioration.

Representative photos of significantly deteriorated conditions and a deck-by-deck graphic summary of the condition of each compartment are included on the following pages.

Figure 1.1 Deformation of transverse bulkhead at Frame 50, port side

Figure 1.2 Deformation of transverse bulkhead at Frame 142, starboard side

Figure 1.3 Overall view of compartment A 523 M

Figure 1.4 Corrosion on lower scantlings in compartment A 523 M

Figure 1.5 Overall view of compartment A 525 ½ T

Figure 1.6 100% loss of section on scantlings in compartment A 541 ET

Figure 1.7 Flooding in forward section of compartment A 613 ET "WT Trunk"

Figure 1.8 Heavy corrosion of lower walls in compartment C 605 E

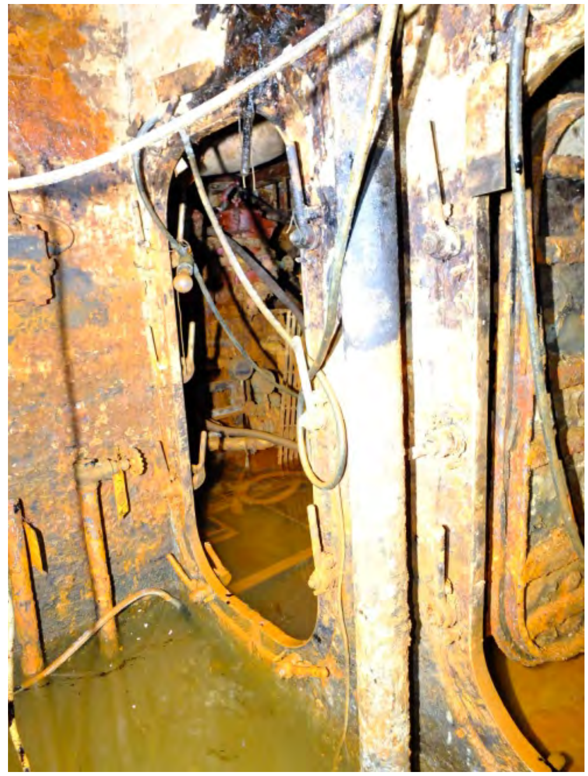


Figure 1.9 View of flooding in entry to compartment A 708 E

Figure 1.10 Overall view of flooding in compartment A 709 M

Figure 1.11 Severe corrosion of lower walls in compartment A 720 M

Figure 1.12 Moderate-to-heavy corrosion on walls in compartment A 721 M

Figure 1.13 Heavy corrosion on lower flange of ceiling beam in compartment A 721 M

Figure 1.14 Heavy corrosion on floor in compartment A 721 ½ M

Figure 1.15 Heavy-to-severe corrosion on floor in starboard end of compartment A 721 ½ M

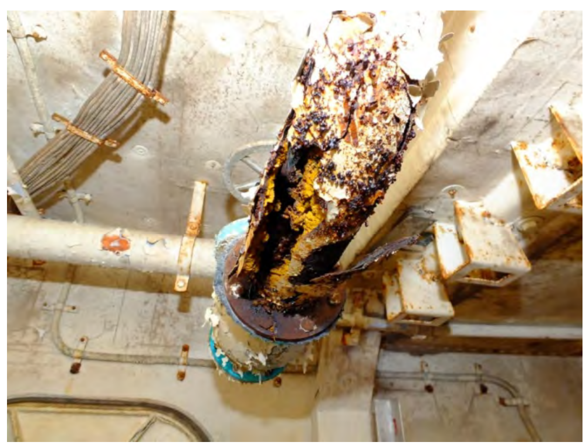


Figure 1.16 Corroded utility pipe in compartment A 725 M

4th Deck

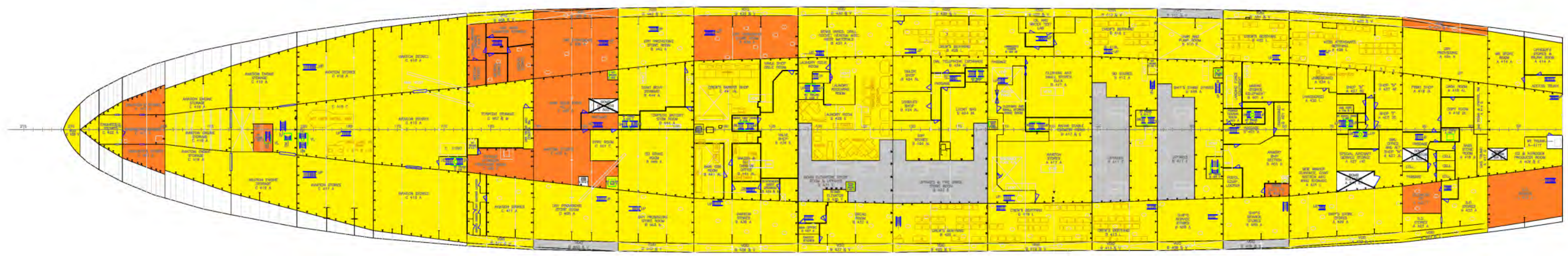


Figure 1.17 Overall view of 4th Deck

1st Platform

Figure 1.18 Overall view of 1st Platform

- Minor deterioration - long-term concern
- Moderate deterioration - monitoring recommended
- Significant deterioration - near-term repair recommended
- Inaccessible / not inspected

2nd Platform

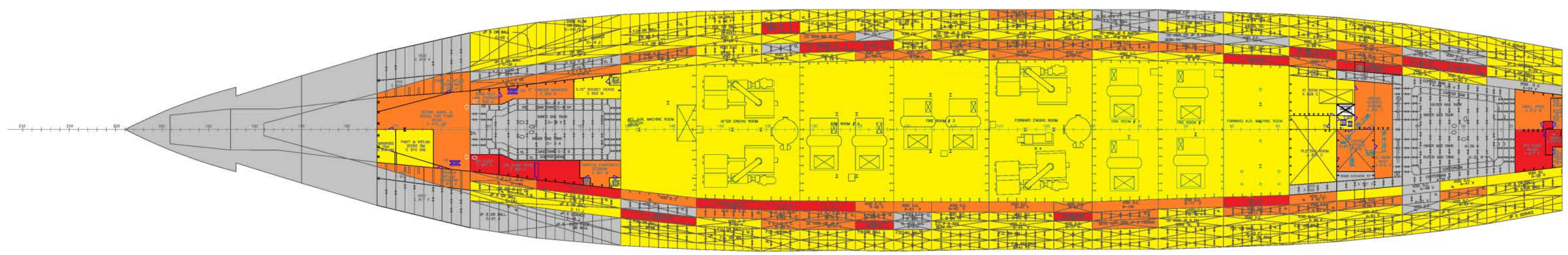


Figure 1.19 Overall view of 2nd Platform

Hold

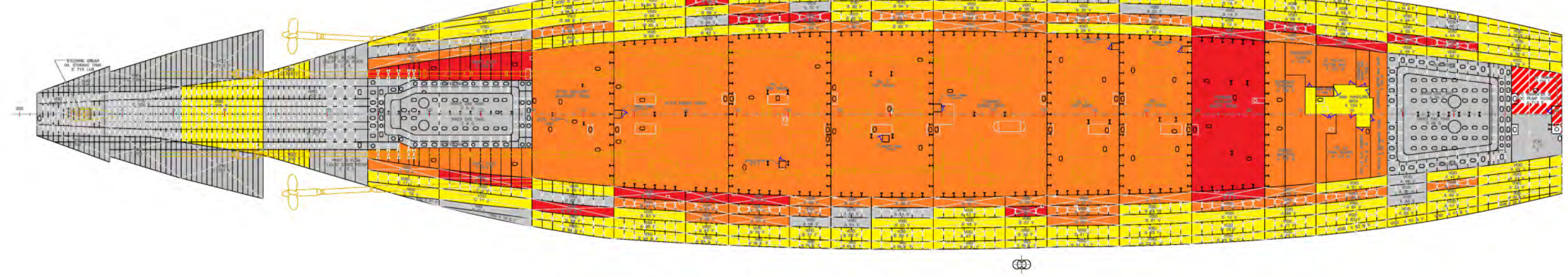


Figure 1.20 Overall view of Hold

- Minor deterioration - long-term concern
- Moderate deterioration - monitoring recommended
- Significant deterioration - near-term repair recommended
- Inaccessible / not inspected

2. Introduction

Task 5 of the Assessment consisted of a cursory visual assessment of the accessible interior compartments of the ship from Frame 50 to the stern, from the 4th Deck down through the 1st and 2nd Platforms and Hold. Assessment work was performed by Collins and OTS from April through November 2014. All assessments were purely visual in nature; no material sampling or destructive testing was performed. All easily accessible spaces were visually reviewed with notation made as to the overall structural condition, condition of easily accessible major structural members, bulkheads, floors and condition of foundations of components where applicable. Tanks, cofferdams, and other confined spaces were not visually reviewed by OTS or Collins; however, data recorded by CB&I (the Shaw Group) during their environmental assessment was included in the report for this task. Per the project scope, Collins/OTS did not perform detailed assessments from which repair drawings and/or specifications could be compiled.

3. Purpose and Scope

Collins Engineers, Inc. (Collins) was engaged by the Patriots Point Development Authority (PPDA) to perform a structural condition assessment of the USS Yorktown located at the Patriots Point Naval and Maritime Museum in Mount Pleasant, South Carolina. Task 5 of the assessment included a visual inspection of accessible compartments in the interior of the vessel aft of Frame 50. This cursory, visual structural Hull Survey was conducted aboard the USS Yorktown from the waterline 'splash' zone to the keel, aft of Frame 50 from the 4th Deck down through the 1st and 2nd Platforms and Hold. Easily accessible representative spaces were inspected with notation made as to the general structural condition and the condition of major structural members, bulkheads, and floors.

The Task 5 assessment was conducted between June 23rd and August 18th, 2014. This report provides a summary of Collins' observations of the interior compartments inspected. The inspections were purely visual in nature; no destructive sampling or material testing was performed. Observations reflect the conditions observed at the time of inspection; areas, especially those with water and oil, will continue to deteriorate if left unrepaired.

The observations summarized in this report have been organized by level, beginning with the 4th Deck and proceeding down through the 1st and 2nd Platforms and Hold. **Significant structural observations are noted in bold print**; safety issues are noted in red print. Conceptual repair recommendations and a cost estimate for the conceptual repairs are provided in the Task 7 section.

Readily evident environmental conditions, such as peeling paint, red lead primer, oil, and potential asbestos were observed during the Task 5 assessment. While outside the scope of Collins' assessment, these items are noted as "Additional Observations". A complete environmental assessment was performed by the Shaw Group in 2013 and a summary of Shaw's findings and recommendations was provided in Shaw's report dated Apr 12, 2013.

Please refer to the "Construction" section for a description of the vessel's original construction and subsequent modifications.

4. 4th Deck

<u>Typical conditions:</u> The compartments of the 4th Deck were generally found to be in structurally sound condition with varying degrees of minor deterioration that typically included peeling paint and light surface corrosion. A graphic representation of the severity of the deterioration observed at each compartment is provided on the following page. Potential environmental and/or health hazards were observed at a number of compartments, including asbestos, "red lead" primer, and oil/fluid spills or leaks. An environmental assessment of the vessel was performed by The Shaw Group (Shaw) in 2013 and was not included in the scope of this structural assessment. A summary of Shaw's findings and recommendations was provided in Shaw's report dated April 12th, 2013.

Deformation of transverse bulkheads was observed at several locations on the 4th Deck, and many bulkheads have been torch-cut previously. A summary of Collins' observations of the bulkheads is provided at the end of this section.

4.1. Overview of 4th Deck

4th Deck

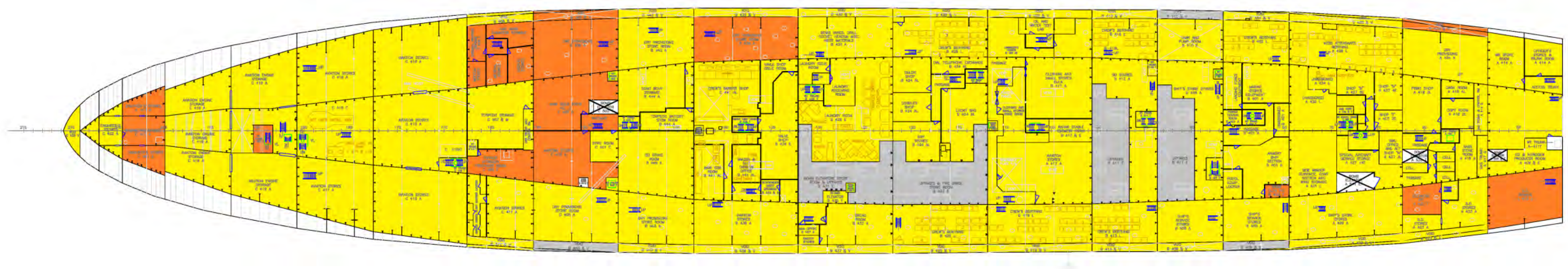


Figure 4.1 Overview of 4th Deck

- Minor deterioration - long-term concern
- Moderate deterioration - monitoring recommended
- Significant deterioration - near-term repair recommended
- Inaccessible / not inspected

4.2. A 414 A, Officer's Stores / WR Store Room, Frames 50-58

Structural Observations

- No major structural issues were observed.
- An approximately 24 square foot (SF) area of light corrosion was observed on the steel floor in the aft section of the compartment.

Additional Observations

- The access hatch to tank "A28" was covered by a loose grating.
- Peeling paint and "red lead" primer were observed.
- Evidence of a previous oil leak was observed around utility lines in the aft port corner of the compartment.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.2 Location of compartment A 414 A

Figure 4.3 Overall view of compartment A 414 A.

4.3. A 406 ½ E, Oxygen Nitrogen Producer Room, Frames 50-58

Structural Observations

- No major structural issues were observed.
- Light corrosion was observed in the corners of the compartment and along the forward floor/bulkhead interface.
- Light corrosion was observed on exposed portions of ceiling beams in the center of the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.4 Location of compartment A 406 ½ E Oxygen Nitrogen Producer Room

Figure 4.5 Light corrosion in forward corner of compartment A 406 ½ E

4.4. A 413 A, SD Stores, Frames 50-58

Structural Observations

- **A torch-cut hole which measured approximately 27¼-in W x 67-in H was observed in the 3/8in thick steel bulkhead at Frame 50. (Figure 3.7)**
- A torch-cut hole, which measured approximately 3-in in diameter, was observed in the aft starboard corner of the compartment.
- An approximately 100 square foot (SF) area of moderate corrosion was observed on the floor along the bulkhead at Frame 50 and the outboard bulkhead of the compartment.
- An approximately 20 SF area of heavy corrosion was observed on the steel floor in the aft starboard corner of the compartment. (Figure 3.6)
- A band of light-to-moderate corrosion, which measured approximately 1-ft in width, was observed along the perimeter of the steel floor of the compartment.
- Ultrasonic thickness measurements were taken of the side shell plating; the following shell plate thicknesses were observed:

Starboard Side, stern-bow:

.300	.292	.289	.300	.311	.300	. 334	.310

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 4.6 Location of compartment A 413 A

Figure 4.7 Overall view of compartment A 413 A

Figure 4.8 Heavy corrosion in aft starboard corner of compartment A 413 A

Figure 4.9 Torch-cut hole in bulkhead at Frame 50.

4.5. A 424 A, Dry Provisions, Frames 58-67

Structural Observations

- No major structural issues were observed.
- Isolated areas throughout the compartment were observed to have light-to-moderate corrosion and pitting.

Additional Observations

- 5 access hatches to tanks were covered with loose gratings.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.10 Location of compartment A 424 A

Figure 4.11 Overall view of compartment A 424 A

4.6. A 418 4L, Dark Room, Frames 59-63

Structural Observations

- No major structural issues were observed.
- An area of light corrosion was observed on the steel floor along the port bulkhead and in the aft starboard corner of the compartment. (Figure 3.11)

Additional Observations

- Peeling paint and suspected asbestos floor tile were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.12 Location of compartment A 418 4L

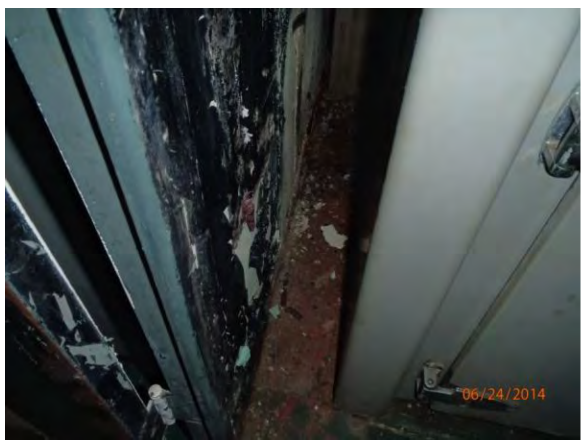


Figure 4.13 Corrosion along port bulkhead in compartment A 418 4L

4.7. A 418 2L, Copy Room, Frames 59-63

Structural Observations

- No major structural issues were observed.
- An area of light corrosion was observed on the floor in the forward port corner of the compartment.

Additional Observations

- Peeling paint and suspected asbestos floor tile were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.14 Location of compartment A 418 2L

Figure 4.15 Overall view of compartment A 418 2L

4.8. A 414 G, Gas Trunk & Control Room, Frames 58-59

Structural Observations

- No major structural issues were observed.
- An area of light-to-moderate corrosion was observed on the steel floor in the vicinity of the access hatch to compartment A 526 G.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.16 Location of compartment A 414 G

Figure 4.17 Corrosion around floor hatch in compartment A 414 G

4.9. A 417 G, Gas Trunk, Frames 58-59

Structural Observations

- No major structural issues were observed.
- Isolated corroded areas which appeared to show evidence of previous leakage were observed throughout the compartment. (Figure 3.18)

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.18 Location of compartment A 417 G

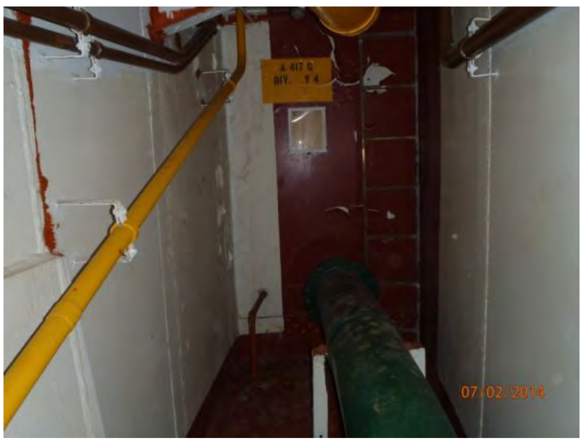


Figure 4.19 Overall view of compartment A 417 G

Figure 4.20 Corrosion and evidence of leakage in compartment A 417 G

4.10. A 423 A, SD Stores, Frames 58-67

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 24-in H x 25-in W, was observed in the 3/4-in thick steel outboard bulkhead. (Figure 3.22)
- A torch-cut hole, which measured approximately 19.5-in H x 17.5-in W, was observed in the 3/8-in thick steel bulkhead at Frame 58.
- A torch-cut hole which measured approximately 4-in in diameter was observed in the inboard bulkhead.
- An area of moderate corrosion was observed on the steel floor in the aft port corner of the compartment. (Figure 3.21)
- A band of light corrosion, which measured approximately 1-ft wide, was observed on the steel floor along the base of the outboard bulkhead.

Additional Observations

- The access hatch to tank A45 was covered by a loose grating.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.21 Location of compartment A 423 A

Figure 4.22 Overall view of compartment A 423 A

Figure 4.23 Moderate corrosion in aft port corner of compartment A 423 A

Figure 4.24 Torch-cut hole in outboard bulkhead of compartment A 423 A

4.11. A 419 A, Sass Store Room, Frames 59-61

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 8-in in diameter, was observed in the aft steel bulkhead at Frame 61.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.25 Location of compartment A 419 A

Figure 4.26 Overall view of compartment A 419 A

4.12. A 421 T, WT Trunk, Frames 61-62

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.27 Location of compartment A 421 T

Figure 4.28 Overall view of compartment A 421 T

4.13. A 418 2L, Print Shop, Frames 63-67

Structural Observations

- No major structural issues were observed.
- An area of light-to-moderate corrosion was observed on the steel floor in the aft port corner of the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.29 Location of compartment A 418 2L

Figure 4.30 Overall view of compartment A 418 2L

4.14. A 425 T, Elevator Pit, Frames 63-67

Structural Observations

- **An area of severe corrosion with 100% loss of section (LOS), which measured 16-in L x ¾-in W, was observed on the forward vertical leg of the structure supporting the deck above the elevator pit. (Figure 3.32)**
- **An area of severe corrosion with 100% LOS, which measured approximately 10-in L x 1¼-in W, was observed on the aft vertical leg of the structure supporting the deck above the elevator pit. (Figure 3.33)**
- **Moderate-to-heavy corrosion was observed on steel frame members supporting the elevator system. (Figure 3.31)**

Additional Observations

- There are open areas at the top of the shaft that allow for water infiltration. If these areas remain open, further water intrusion will occur. This will lead to continued deterioration of the structural elements in the compartment.
- Standing water was observed on the floor of the compartment. The floor showed evidence of recent painting, and the condition of the underlying surface could not be observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 4.31 Location of compartment A 425 T

Figure 4.32 Openings at top of elevator shaft above compartment A 425 T

Figure 4.33 Overall view of compartment A 425 T

Figure 4.35 Corrosion with 100% LOS on forward frame member in compartment A 425 T

Figure 4.34 Moderate-to-heavy corrosion of elevator support members in compartment A 425 T

Figure 4.36 Corrosion with 100% LOS on aft frame member in compartment A 425 T

4.15. Cells & Cell Passage, Frames 61-67

Structural Observations

- No major structural issues were observed.

Additional Observations

- This area appears to be in tour-ready condition.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.37 Location of Cells & Cell Passage

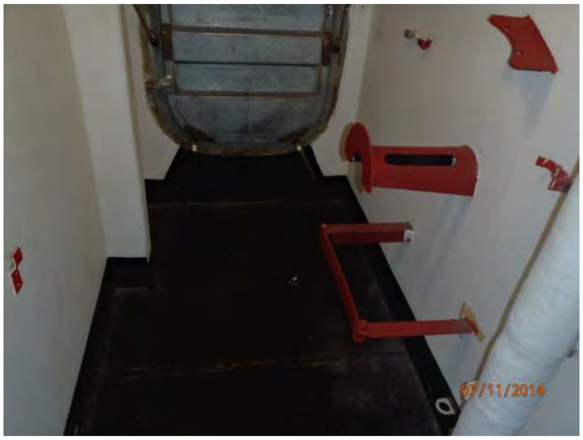


Figure 4.38 Overall view of Cells & Cell Passage

4.16. A 429 A, Ship Stores, Frames 67-79

Structural Observations

- **A torch-cut hole, which measured approximately 17½-in W x 50-in H, was observed in the 3/8-in thick steel bulkhead at Frame 67. A section of one horizontal frame member, which measured 21-in wide, was removed at the hole. The frame member was "T"-shaped with the following dimensions: Depth = 3.5-in, Flange thickness = 3/8-in, Flange & web thickness = 3/8-in. (Figure 3.38)**
- An approximately 30 square foot (SF) area of light corrosion was observed on the steel floor along the outboard wall of the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.39 Location of compartment A 429 A

Figure 4.40 Overall view of compartment A 429 A

Figure 4.41 Torch-cut hole in bulkhead at Frame 67, compartment A 429 A

4.17. A 428 L, Mess Attendants Berthing, Frames 67-79

Structural Observations

- **A torch-cut hole, which measured approximately 27-in W x 48-in H, was observed in the 3/8-in thick steel bulkhead at Frame 79. A section which measured approximately 24-in W was removed from two 2-in deep, 3/8-in thick horizontal plates at the location of the hole. (Figure 3.41)**
- Evidence of surface corrosion was observed under the floor tile throughout the compartment.
- Moderate corrosion was observed on isolated areas of exposed floor throughout the compartment.

Additional Observations

- Peeling paint, suspected asbestos tile and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.42 Location of compartment A 428 L

Figure 4.43 Overall view of compartment A 428 L

Figure 4.44 Torch-cut hole in bulkhead at Frame 79, compartment A 428 L

4.18. A 427 4E, Shop "N", Frames 67-70

Structural Observations

- No major structural issues were observed.
- Moderate corrosion was observed on the steel floor under furnishings in the forward starboard corner of the compartment. (Figure 3.44)

Additional Observations

- Peeling paint, suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.45 Location of compartment A 427 4E

Figure 4.46 Overall view of compartment A 427 4E

Figure 4.47 Moderate corrosion under counter in compartment A 427 4E

4.19. A 427 2E, Shop "I", Frames 67-70

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and suspected asbestos tile were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.48 Location of compartment A 427 2E

Figure 4.49 Suspected asbestos tile in compartment A 427 2E

4.20. A 427 3L, SWU Office & Alt. Shop "N", Frames 67-69

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and suspected asbestos tile were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.50 Location of compartment A 427 3L

Figure 4.51 Overall view of compartment A 427 3L

4.21. A 427 1AT, Special Aircraft Service Stores, Frames 67-74

Structural Observations

- No major structural issues were observed.
- Isolated areas of light corrosion were observed on many surfaces throughout the compartment.
- An approximately 3-ft x 6-ft area of moderate corrosion with 20-30% loss of section was observed on the steel floor along the port wall of the compartment. (Figure 3.51)

Additional Observations

- Peeling paint and suspected asbestos tile were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.52 Location of compartment A 427 1AT

Figure 4.53 Overall view of compartment A 427 1AT

Figure 4.54 Moderate corrosion on floor along port bulkhead in compartment A 427 1AT

4.22. A 427 5E, Shop "B", Frames 70-74

Structural Observations

- No major structural issues were observed.
- An approximately 2-ft x 6-ft area of moderate corrosion with 20% loss of section was observed on the steel floor along the starboard wall of the compartment. (Figure 3.54)

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.55 Location of compartment A 427 5E

Figure 4.56 Overall view of compartment A 427 5E

Figure 4.57 Moderate corrosion along starboard wall in compartment A 427 5E

4.23. A 426 T, Escape Trunk, Frames 71-72

Structural Observations

- No major structural issues were observed.
- Isolated areas of spotty, light corrosion were observed on the floor of the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.58 Location of compartment A 426 T

Figure 4.59 Overall view of compartment A 426 T

4.24. A 430 T, WT Escape Trunk, Frames 72-74

Structural Observations

- No major structural issues were observed.

Additional Observations

- "Red lead" primer was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.60 Location of compartment A 430 T

Figure 4.61 Overall view of compartment A 430 T

4.25. A 431 L, Side Winder Guidance Cont. Section & Wing Storage, Frames 74-79

Structural Observations

- No major structural issues were observed.
- Isolated areas of light corrosion were observed over exposed sections of the floor of the compartment.

Additional Observations

- Suspected asbestos tile was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.62 Location of compartment A 431 L

Figure 4.63 Overall view of compartment A 431 L

4.26. A 434 L, Unassigned, Frames 74-77

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.64 Location of compartment A 434 L

Figure 4.65 Overall view of compartment A 434 L

4.27. A 432 L, Unassigned, Frames 74-79

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.66 Location of compartment A 432 L

Figure 4.67 Overall view of compartment A 432 L

4.28. B 402 L, Crews Berthing, Frames 79-86

Structural Observations

- **A torch-cut hole, which measured approximately 34½-in W x 61-in H, was observed in the 5/8-in thick steel inboard bulkhead. (Figure 3.67)**

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.68 Location of compartment B 402 L

Figure 4.69 Overall view of compartment B 402 L

Figure 4.70 Torch-cut hole in inboard bulkhead in compartment B 402 L

4.29. B 405 A, Ships Service Stores, Frames 79-86

Structural Observations

- **A torch-cut hole, which measured approximately 23½-in W x 60-in H, was observed in the 3/8-in thick steel bulkhead at Frame 79. (Figure 3.70)**
- **A torch-cut hole, which measured approximately 31-in W x 75-in H, was observed in the 3/8-in thick steel bulkhead at Frame 86. (Figure 3.72)**
- **A torch-cut hole, which measured approximately 24-in W x 33-in H, was observed in the ¾-in thick steel starboard bulkhead. (Figure 3.71)**
- Light-to-moderate corrosion was observed to a height of approximately 3-ft along the lower portion of the steel bulkhead at Frame 79.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.71 Location of compartment B 405 A

Figure 4.72 Overall view of compartment B 405 A

Figure 4.73 Torch-cut hole in forward bulkhead of compartment B 405 A

Figure 4.74 Torch-cut hole in outboard bulkhead in compartment B 405 A

Figure 4.75 Torch-cut hole in aft bulkhead of compartment B 405 A

4.30. B 403 T, Bomb Elevator Pit, Frames 79-82

Structural Observations

- **Moderate-to-heavy corrosion was observed over the entire steel floor of the compartment. (Figure 3.75)**
- Light-to-moderate corrosion, with 10-25% loss of section (LOS), was observed to a height of approximately 4-in along the lower walls and scantlings.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 4.76 Location of compartment B 403 T

Figure 4.77 Overall view of compartment B 403 T

Figure 4.78 Moderate-to-heavy corrosion on floor of compartment B 403 T

4.31. B 401 A, Frames 79-86

B 401 A Unassigned Space:

Structural Observations

- No major structural issues were observed.

Additional Observations

- “Red lead” primer and suspected asbestos tile were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.79 Location of compartment B 401 A “Unassigned”

Figure 4.80 Overall view of compartment B 401 A “Unassigned”

B 401 A Armory Ship Section:

Structural Observations

- **A torch-cut hole, which measured approximately 30½-in W x 65-in H, was observed in the ¾-in thick steel starboard bulkhead. (Figure 3.80)**

Additional Observations

- Peeling paint and suspected asbestos tile were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.81 Location of compartment B 401 A "Armory Ship Section"

Figure 4.82 Overall view of compartment B 401 A "Armory Ship Section"

Figure 4.83 Torch-cut hole in starboard bulkhead of compartment B 401 A "Armory Ship Section"

<u>B 401 A Marine Stores Equip.:</u>

Structural Observations

- No major structural issues were observed.

Additional Observations

- Suspected asbestos tile and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.84 Location of compartment B 401 A “Marine Stores Equip.”

Figure 4.85 Overall view of compartment B 401 A “Marine Stores Equip.”

B 401 A Passage:

Structural Observations

- **A torch-cut hole, which measured approximately 27½-in W x 46-in H, was observed in the 1-in thick steel bulkhead which separates this compartment from compartment "WT Trunk B 404 T".**

Additional Observations

- Peeling paint and suspected asbestos tile were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.86 Location of compartment B 401 A "Passage"

Figure 4.87 Overall view of compartment B 401 A "Passage"

B 401 A Power Testing Room:

Structural Observations

- **A torch-cut hole, which measured approximately 48½-in W x 79-in H, was observed in the 1-in thick steel aft bulkhead of the compartment. (Figure 3.87)**

Additional Observations

- Peeling paint, suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.88 Location of compartment B 401 A "Power Testing Room"

Figure 4.89 Overall view of compartment B 401 A "Power Testing Room"

Figure 4.90 Torch-cut hole in aft bulkhead of compartment B 401 A "Power Testing Room"

B 401 A Landing Force Equipment:

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.91 Location of compartment B 401 A “Landing Force Equipment”

Figure 4.92 Overall view of compartment B 401 A “Landing Force Equipment”

4.32. B 404 T, WT Trunk, Frames 82-84

Structural Observations

- **A torch-cut hole, which measured approximately 48½-in W x 79-in H, was observed in the 1-in thick steel bulkhead at Frame 84.**
- The upper access hatch in this compartment, which previously opened to the 3rd deck, has been replaced with a steel plate which has been welded around its perimeter to seal the hatch opening. **Two steel members were removed from the support framing around the hatch opening, each of which measured 55-in L x 6¼-in W. (Figure 3.91)**

Additional Observations

- Suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.93 Location of compartment B 404 T

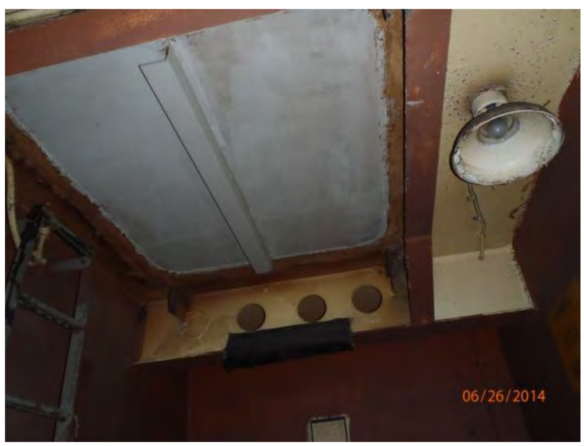


Figure 4.94 Hatch in compartment B 404 T sealed with steel plate

4.33. B 410 E, Tank & Pump Room, Frames 86-93

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured 6-in in diameter, was observed in the steel bulkhead at Frame 86.

Additional Observations

- 4 tank access hatches were open and uncovered.
- The floor, walls, and equipment in this compartment are covered in oil from an unknown source.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.95 Location of compartment B 410 E

Figure 4.96 Overall view of compartment B 410 E

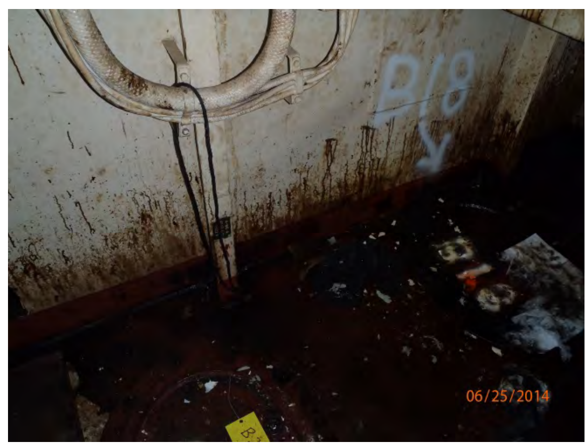


Figure 4.97 Oil on floor and walls of compartment B 410 E

4.34. B 409 A, Ships Service Stores, Frames 86-93

Structural Observations

- **A torch-cut hole, which measured approximately 23-in W x 64-in H, was observed in the steel bulkhead at Frame 93; 2 T-shaped horizontal members were cut at the location of the hole. The dimensions of the member were as follows: Depth = 5-in, Flange width = 2 5/8-in, Flange & Web Thickness = ¼-in. The member appears to be an MT5x4.5 section.**
- A torch-cut hole, which measured approximately 6-in W x 5¾-in H, was observed in the 5/8-in thick steel port bulkhead.
- Isolated areas of light surface corrosion were observed throughout the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.98 Location of compartment B 409 A

Figure 4.99 Overall view of compartment B 409 A

4.35. B 408 T, WT Trunk, Frames 86-87

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and suspected asbestos tile were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.100 Location of compartment B 408 T

Figure 4.101 Overall view of compartment B 408 T

4.36. B 406 A, Ship Store Stores, Frames 86-93

Structural Observations

- No major structural issues were observed.
- Two torch-cut holes, each of which measured approximately 8-in W x 8-in H, were observed in the 1-in thick steel bulkhead at Frame 93. (Figure 3.101)
- A torch-cut hole, which measured approximately 7-in W x 8-in H, was observed in the 1-in thick steel starboard bulkhead.
- Isolated areas of light surface corrosion were observed throughout the compartment.

Additional Observations

- Peeling paint, suspected asbestos tile and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.102 Location of compartment B 406 A

Figure 4.103 Overall view of compartment B 406 A

Figure 4.104 Torched cuts in bulkhead at Frame 93, compartment B 406 A

4.37. B 407 T, WT Trunk, Frames 86-88

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 7-in W x 8-in H, was observed in the 1-in thick steel port bulkhead.

Additional Observations

- Peeling paint, suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.105 Location of compartment B 407 T

Figure 4.106 Overall view of compartment B 407 T

4.38. B 411 E, Uptakes, Frames 89-93

- This compartment was not thoroughly inspected due to safety and health concerns. According to USS Yorktown personnel, high levels of asbestos are present in the Uptakes compartments.

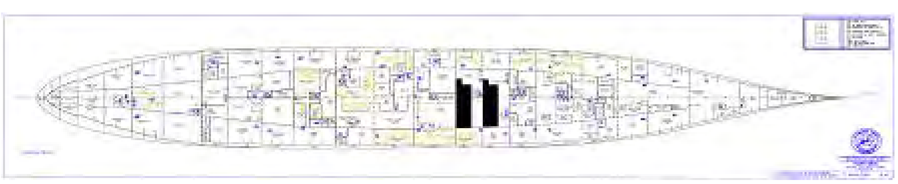


Figure 4.107 Location of compartment B 411 E

4.39. B 418 L, Crews Berthing, Frames 93-100

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 5-in W x 5-in H, was observed in the 3/8-in thick steel bulkhead at Frame 93.

Additional Observations

- 4 tank access hatches were covered with loose gratings.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.108 Location of compartment B 418 L

Figure 4.109 Overall view of compartment B 418 L

4.40. B 413 L, Crews Berthing, Frames 93-100

Structural Observations

- **A torch-cut hole, which measured approximately 29-in W x 66-in H, was observed in the ½-in thick steel bulkhead at Frame 100. Sections of 2 horizontal members, each of which measured approximately 33-in in length, were removed at the location of the hole. The dimensions of the members were as follows: Depth = 4-in, Flange width = 2¼-in, Flange & Web thickness = ¼-in. The members appear to be MT4x3.1 sections.**

Additional Observations

- Peeling paint, suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.110 Location of compartment B 413 L

Figure 4.111 Overall view of compartment B 413 L

4.41. B 412 A, SD Stores, Frames 93-100

Structural Observations

- No major structural issues were observed.

Additional Observations

- This area appears to be in good condition and is used for curator collections storage.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.112 Location of compartment B 412 A

Figure 4.113 Overall view of compartment B 412 A

4.42. B 416 T, WT Trunk, Frames 93-94

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 8-in W x 8-in H, was observed in the 1-in thick steel bulkhead at Frame 93.

Additional Observations

- Peeling paint was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.114 Location of compartment B 416 T

Figure 4.115 Overall view of compartment B 416 T

4.43. B 414 T, WT Trunk, Frames 93-95

Structural Observations

- No major structural issues were observed.

Additional Observations

- Suspected asbestos tile was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.116 Location of compartment B 414 T

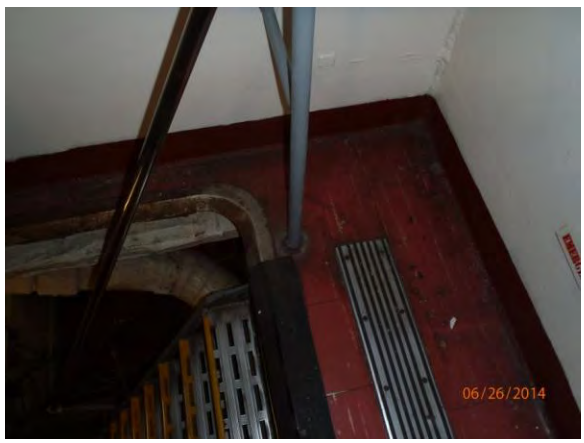


Figure 4.117 Overall view of compartment B 414 T

4.44. B 411 E, Uptakes, Frames 96-100

- This compartment was not thoroughly inspected due to safety and health concerns. According to USS Yorktown personnel, high levels of asbestos are present in the Uptakes compartments.

Figure 4.118 Location of compartment B 411 E

4.45. B 420 AE, Engineer's Stores / Oil & Water Test Lab, Frames 100-111

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 17-in W x 22-in H, was observed in the 3/8-in thick steel bulkhead at Frame 111.
- A torch-cut hole, which measured approximately 9-in W x 7-in H, was observed in the ½-in thick steel bulkhead at Frame 100.
- Isolated areas of light surface corrosion were observed throughout the compartment.

Additional Observations

- The access hatch into tank B48 was open and uncovered; this tank is filled with oil.
- Peeling paint, suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.119 Location of compartment B 420 AE

Figure 4.120 Overall view of compartment B 420 AE

Figure 4.121 Open tank "B48" filled with oil in compartment B 420 AE

4.46. B 417 A, Clothing and Small Stores Bulk, Frames 100-111

Structural Observations

- No major structural issues were observed.
- Access stairs in the rear passage, which previously led to the 3rd Deck, were previously sealed off with a welded-in plate. (Figure 3.121)
- An area of light corrosion was observed under a vent duct in the center of the compartment. Corrosion likely appears to result from a previous utility leak.

Additional Observations

- This area appears to be in good condition and is used for curator collections storage.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.122 Location of compartment B 417 A

Figure 4.123 Overall view of compartment B 417 A

Figure 4.124 Access hatch in compartment B 417 A replaced with welded-in plate

4.47. B 417 ½ E, Radar Stable Element Room, 100-105

Structural Observations

- No major structural issues were observed.
- Minor corrosion was observed on wall fittings within the compartment.
- Access doorways, each of which measured approximately 32½-in W x 72-in H, have been cut through the ½-in thick steel port and starboard bulkheads into both adjacent compartments.

Additional Observations

- This area appears to be in good condition and is used for curator collections storage.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.125 Location of compartment B 417 ½ E

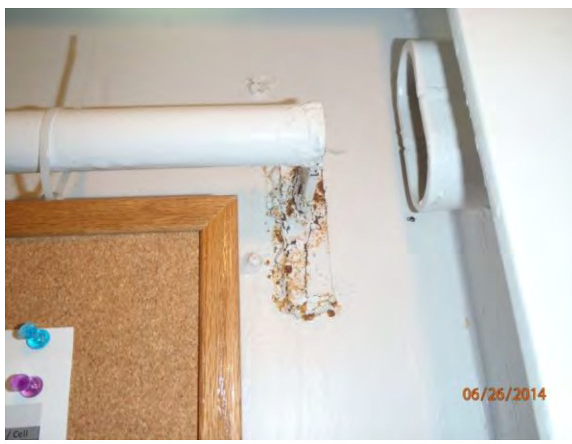


Figure 4.126 Light corrosion around fittings in compartment B 417 ½ E

4.48. A 417 A, Aviation Stores, Frames 100-111

Structural Observations

- No major structural issues were observed.

Additional Observations

- This area appears to be in good condition and is used for curator collections storage.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.127 Location of compartment A 417 A

Figure 4.128 Overall view of compartment A 417 A

4.49. B 419 L, Crews Berthing, Frames 100-111

Structural Observations

- **A torch-cut hole, which measured approximately 31-in W x 72-in H, was observed in the ½-in thick steel bulkhead at Frame 111.**
- **Two torch-cut holes, each of which measured approximately 32-in in diameter, were observed in the ceiling of the compartment**.
- Isolated areas of light surface corrosion were observed throughout the compartment.

Additional Observations

- 2 tank access hatches were open and covered with loose gratings.
- Peeling paint, suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.129 Location of compartment B 419 L

Figure 4.130 Overall view of compartment B 419 L

Figure 4.131 View from above of torch-cut holes in ceiling of compartment B 419 L

4.50. B 421 T, WT Trunk, Frames 105-107

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and suspected asbestos tile were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

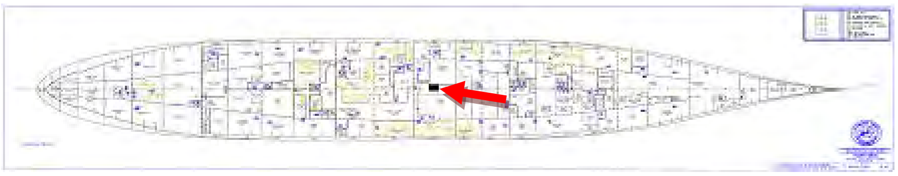


Figure 4.132 Location of compartment B 421 T

Figure 4.133 Overall view of compartment B 421 T

4.51. B 422 T, WT Trunk, Frames 110-111

Structural Observations

- This compartment is secured and was inspected from above; the compartment appears to be in good structural condition.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.134 Location of compartment B 422 T

Figure 4.135 Overall view of compartment B 422 T

4.52. B 425 L, Crews Berthing, Frames 111-121

Structural Observations

- **A torch-cut hole, which measured approximately 31-in W x 73-in H, was observed in the 3/8-in thick steel bulkhead at Frame 111. Sections of 2 T-shaped horizontal members, each of which measured 33-in in length, were removed at the location of the hole. The dimensions of the members were as follows: Depth = 2¼-in, Flange width = 3¾-in, Flange & Web thickness = ¼-in. The members appear to be MT4x3.1 sections.**

Additional Observations

- 1 tank access hatch was open and covered with a loose grating. (Figure 3.134)
- Peeling paint, suspected asbestos tile and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.136 Location of compartment B 425 L

Figure 4.137 Overall view of compartment B 425 L

Figure 4.138 Tank access hatch covered with loose grating in compartment B 425 L

4.53. B 428 L, Crews Berthing, Frames 111-121

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint, suspected asbestos tile and "red lead" primer were observed.
- Oil spills were observed around tank access hatches. (Figure 3.137)

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.139 Location of compartment B 428 L

Figure 4.140 Overall view of compartment B 428 L

Figure 4.141 Oil spill around take access hatch in compartment B 428 L

4.54. B 423 E, Uptakes & Fire Brick Stowage, Frames 111-121

- This compartment was not thoroughly inspected due to safety and health concerns. According to USS Yorktown personnel, high levels of asbestos are present in the Uptakes compartments.

Figure 4.142 Location of compartment B 423 E

4.55. B 424 AL, Frames 111-121

<u>B 424 AL Dial Telephone Exchange:</u>

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 17-in W x 19-in H, was observed in the 5/8-in thick steel bulkhead at Frame 111.
- An isolated area of light-to-moderate corrosion was observed on the steel floor in the aft section of the compartment.

Additional Observations

- Suspected asbestos tile was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

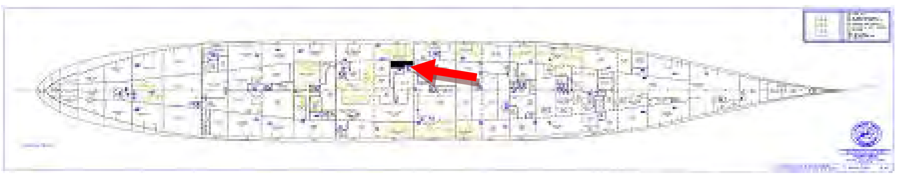


Figure 4.143 Location of compartment B 424 AL "Dial Telephone Exchange"

Figure 4.144 Overall view of compartment B 424 AL "Dial Telephone Exchange"

<u>B 424 AL Passage:</u>

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

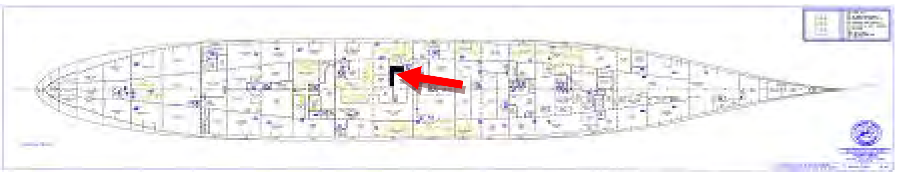


Figure 4.145 Location of compartment B 424 AL "Passage"

Figure 4.146 Overall view of compartment B 424 AL "Passage"

B 424 AL Dry Stores:

Structural Observations

- No major structural issues were observed.
- Isolated areas of light surface corrosion were observed throughout the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

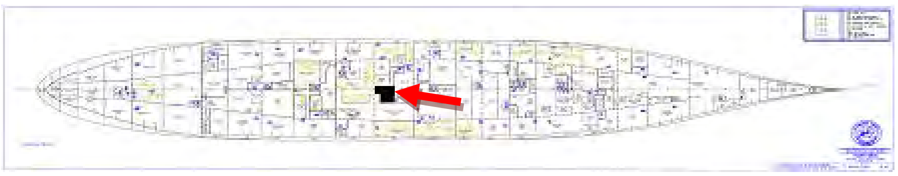


Figure 4.147 Location of compartment B 424 AL “Dry Stores”

Figure 4.148 Overall view of compartment B 424 AL “Dry Stores”

B 424 AL Tailor Shop:

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 6-in W x 6-in H, was observed in the ½-in thick steel aft bulkhead at Frame 121.

Additional Observations

- Suspected asbestos tile was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

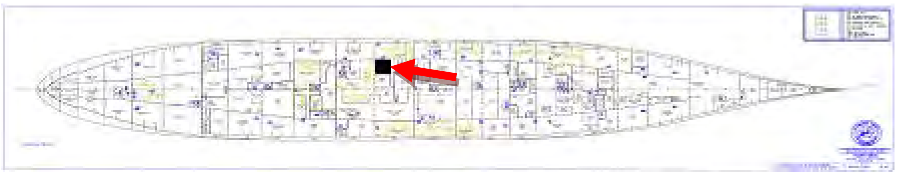


Figure 4.149 Location of compartment B 424 AL "Tailor Shop"

Figure 4.150 Overall view of compartment B 424 AL "Tailor Shop"

<u>B 424 AL Cobbler Shop:</u>

Structural Observations

- No major structural issues were observed.
- Isolated areas of light surface corrosion were observed throughout the compartment.

Additional Observations

- Peeling paint, suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

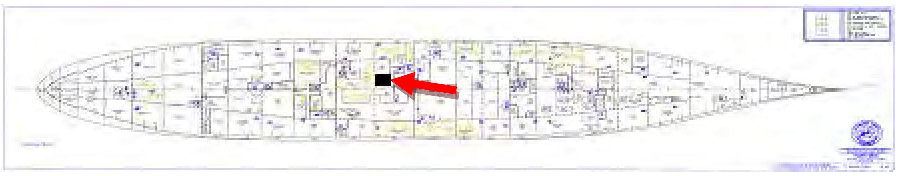


Figure 4.151 Location of compartment B 424 AL "Cobbler Shop"

Figure 4.152 Overall view of compartment B 424 AL "Cobbler Shop"

4.56. B 426 T, WT Trunk, Frames 111-113

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 15-in W x 15-in H, was observed in the 1-in thick steel port bulkhead.

Additional Observations

- Peeling paint and suspected asbestos tile were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

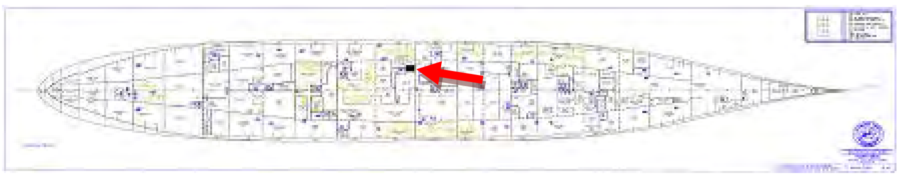


Figure 4.153 Location of compartment B 426 T

Figure 4.154 Overall view of compartment B 426 T

4.57. B 424 9L, Lucky Bag, Frames 111-116

Structural Observations

- No major structural issues were observed.
- A previously torch-cut hole which has been patched with a welded steel plate, and which measured approximately 8-in W x 7-in H, was observed in the steel bulkhead at Frame 111.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.155 Location of compartment B 424 9L

Figure 4.156 Overall view of compartment B 424 9L

4.58. B 437 A, Bread Room, Frames 121-131

Structural Observations

- **A torch-cut hole, which measured approximately 27½-in W x 70-in H, was observed in the ½-in thick steel bulkhead at Frame 121. A section of 1 horizontal member was removed at the location of the hole. The dimensions of the member were as follows: Depth = 3-in, Flange width = 1 7/8-in, Flange thickness = 3/16-in, Web thickness = ¼-in. The member appears to be an MT4x3.1 section. (Figure 3.154)**

Additional Observations

- 1 tank access hatch was open and covered with a loose grating. (Figure 3.155)
- Peeling paint, suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.157 Location of compartment B 437 A

Figure 4.158 Overall view of compartment B 437 A, incl. torch-cut hole in bulkhead at Frame 121.

Figure 4.159 Open tank access hatch in compartment B 437 A

4.59. B 429 E, Laundry Room, Frames 121-131

Structural Observations

- No major structural issues were observed; this area appears to be in tour-ready condition.
- In areas behind equipment, light-to-moderate corrosion with 15-20% loss of section was observed along the lower 4-in of the bulkhead at Frame 121. (Figure 3.158)

Additional Observations

- Suspected asbestos tile was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.160 Location of compartment B 429 E

Figure 4.161 Overall view of compartment B 429 E

Figure 4.162 Corrosion on lower walls in compartment B 429 E

4.60. B 430 A, Bomb Vanes, Drill Rocket Heads, & Misc. Inert Materials, Frames 121-131

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 12-in W x 20-in H, was observed in the 3/8-in thick steel bulkhead at Frame 121.
- A torch-cut hole, which measured approximately 16-in W x 17-in H, was observed in the 3/8-in thick steel bulkhead at Frame 131.
- An area of light-to-moderate corrosion was observed on the steel floor in the aft port corner of the compartment.

Additional Observations

- One tank access hatch was partially uncovered. (Figure 3.161)
- Splashes of oil residue were observed on the walls and floor of the compartment.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.163 Location of compartment B 430 A

Figure 4.164 Overall view of compartment B 430 A

Figure 4.165 Partially uncovered tank access hatch in compartment B 430 A

4.61. B 431 E, Bomb Elevator Store Room & Uptakes, Frames 121-131

Structural Observations

- This compartment was not thoroughly inspected due to safety and health concerns. According to USS Yorktown personnel, high levels of asbestos are present in the Uptakes compartments.

Figure 4.166 Location of compartment B 431 E

Figure 4.167 Overall view of compartment B 411 E

4.62. B 433 T, Water Tight Trunk, Frames 125-126

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

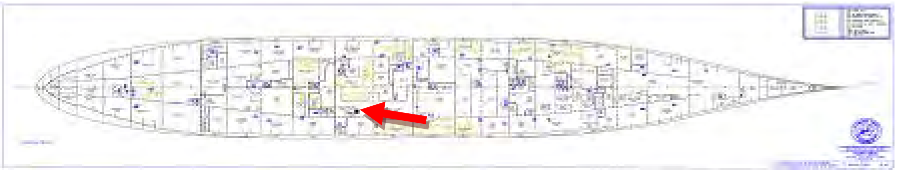


Figure 4.168 Location of compartment B 433 T

Figure 4.169 Overall view of compartment B 433 T

4.63. B 435 T, Bomb Elevator, Frames 126-129

Structural Observations

- No major structural issues were observed.
- The original bomb elevator has been replaced with a passenger elevator; the bomb elevator pit is used as the pit for the passenger elevator system.

Due to the observed deficiencies, this space classifies as a long term concern.

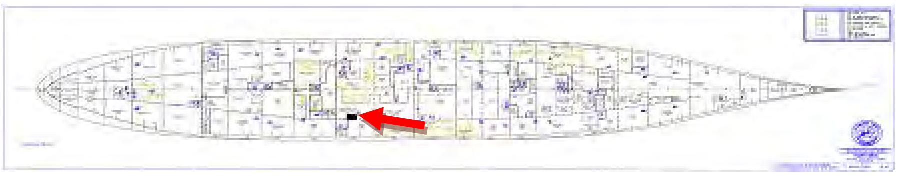


Figure 4.170 Location of compartment B 435 T

Figure 4.171 Overall view of compartment B 435 T

4.64. B 432 T, WT Trunk, Frames 128-131

Structural Observations

- No major structural issues were observed.
- A previously torch-cut hole which has been patched with a welded steel plate, and which measured approximately 17-in W x 18-in H, was observed in the steel bulkhead at Frame 128.

Additional Observations

- Peeling paint, suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

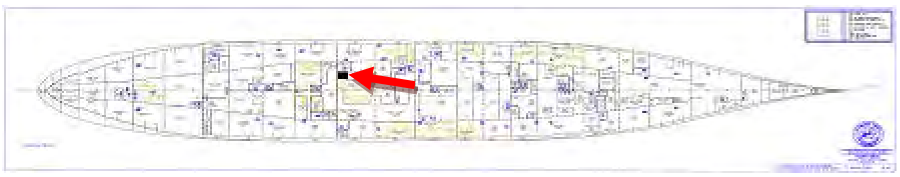


Figure 4.172 Location of compartment B 432 T

Figure 4.173 Overall view of compartment B 432 T

4.65. B 439 A, Aviation Stores, Frames 131-142

Structural Observations

- **A torch-cut hole, which measured approximately 30-in W x 61-in H, was observed in the ½-in thick steel bulkhead at Frame 131. Sections of 2 horizontal members, each of which measured approximately 31-in in length, were removed at the location of the hole. The dimensions of the members were as follows: Depth = 3-in, Flange width = 2-in, Flange & Web thickness = ¼-in. The members appear to be MT3x1.85 sections.**
- **A torch-cut hole, which measured approximately 20-in W x 69-in H, was observed in the 3/8-in thick steel bulkhead at Frame 142. (Figure 3.172)**
- A torch-cut hole, which measured approximately 15-in W x 12-in H, was observed in the ½-in thick steel port bulkhead.
- Isolated areas of light surface corrosion were observed throughout the compartment.

Additional Observations

- “Red lead” primer was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.174 Location of compartment B 439 A

Figure 4.175 Overall view of compartment B 439 A

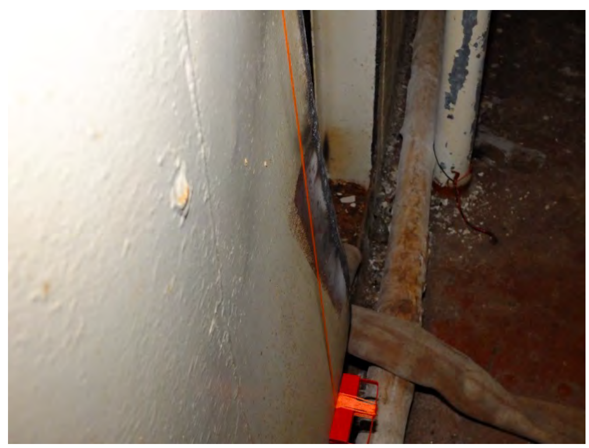


Figure 4.176 Torch-cut hole and deformation in bulkhead at Frame 142

4.66. B 436 A, Dry Provisions Store Room, Frames 131-142

Structural Observations

- **An area of moderate-to-heavy corrosion with 15-20% loss of section was observed on the lower wall and floor in the aft end of the compartment. (Figure 3.175)**
- A torch-cut hole, which measured approximately 8-in W x 12-in H, was observed in the 1-in thick steel inboard bulkhead.
- Isolated areas of light surface corrosion were observed on the floor of the compartment.
- Light-to-moderate surface corrosion was observed at the outboard wall/floor joint.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

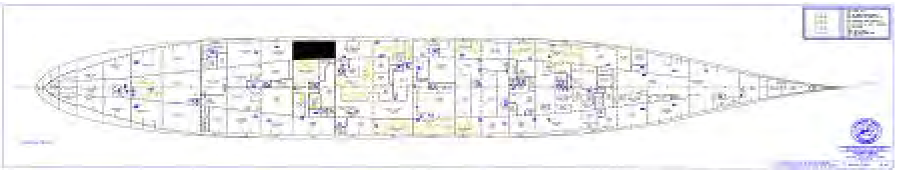


Figure 4.177 Location of compartment B 436 A

Figure 4.178 Overall view of compartment B 436 A

Figure 4.179 Moderate-to-heavy corrosion in aft section of compartment B 436 A

4.67. B 434 E, Valve Shop, Frames 131-135

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 7¼-in W x 5-in H, was observed in the 3/8-in thick steel bulkhead at Frame 131.

Additional Observations

- Peeling paint, suspected asbestos tile and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.180 Location of compartment B 434 E

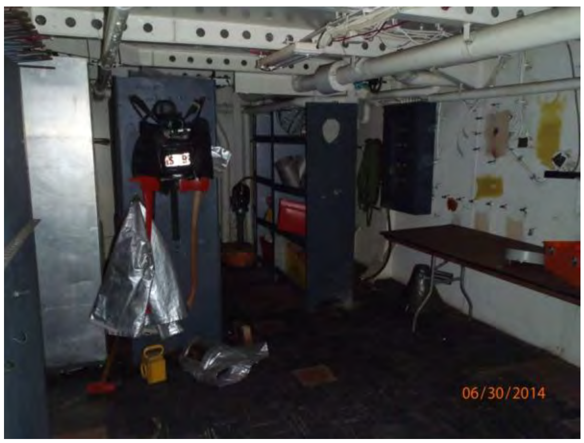


Figure 4.181 Overall view of compartment B 434 E

4.68. B 434 ½ M, Sidewinder Practice Warhead & Flare Stowage, Frames 131-133

Structural Observations

- No major structural issues were observed.
- An area of light surface corrosion was observed on the steel floor in the forward starboard corner of the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.182 Location of compartment B 434 ½ M

Figure 4.183 Overall view of compartment B 434 ½ M

4.69. B 434 ½ A, Sidewinder Inert Stowage, Frames 133-135

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.184 Location of compartment B 434 ½ A

Figure 4.185 Overall view of compartment B 434 ½ A

4.70. B 441 AL, Frames 135-142

<u>MMGSK & S-2 Division Office:</u>

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint, suspected asbestos tile and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.186 Location of compartment B 441 AL “MMGSK & S2 Division Office”

Figure 4.187 Overall view of compartment B 441 AL “MMGSK & S-2 Division Office”

B 441 AL Main GSK Room:

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint, suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.188 Location of compartment B 441 AL "Main GSK Room"

Figure 4.189 Overall view of compartment B 441 AL "Main GSK Room"

B 441 AL Crew's Barber Shop:

Structural Observations

- No major structural issues were observed.
- An area of moderate corrosion and evidence of a previous oil leak were observed on the steel floor in the forward port corner of the compartment. (Figure 3.188)
- An area of light surface corrosion was observed on the steel floor in the forward starboard corner of the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.190 Location of compartment B 441 AL "Crew's Barber Shop"

Figure 4.191 Overall view of compartment B 441 AL "Crew's Barber Shop"

Figure 4.192 Moderate corrosion and oil on floor in compartment B 441 AL "Crew's Barber Shop"

4.71. B 436 T, Water Tight Trunk, Frames 135-138

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 11-in W x 11-in H, was observed in the 1-in thick steel bulkhead at Frame 131. (Figure 3.190)

Additional Observations

- Peeling paint, suspected asbestos tile and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.193 Location of compartment B 436 T

Figure 4.194 Torched cut in bulkhead at Frame 131, compartment B 436 T

4.72. B 440 T, Water Tight Trunk, Frames 141-142

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.195 Location of compartment B 440 T

Figure 4.196 Overall view of compartment B 440 T

4.73. B 442 A, Dry Provisions Store Room, Frames 142-150

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.197 Location of compartment B 442 A

Figure 4.198 Overall view of compartment B 442 A

4.74. B 444 A, Torpedo Battery Stow Room, Frames 142-150

Structural Observations

- No major structural issues were observed.
- Areas of light surface corrosion were observed over approximately 50% of the steel floor of the compartment.
- Light-to-moderate surface corrosion was observed on the steel floor along the forward and starboard walls.
- An approximately 40 square foot (SF) area of light-to-moderate corrosion with up to 20% loss of section was observed in the aft port corner along the wall/floor joint and scantlings. (Figure 3.197)

Additional Observations

- An approximately 50 SF area of spilled oil was observed around an ammunition hoist in the forward portion of the compartment.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.199 Location of compartment B 444 A

Figure 4.200 Overall view of compartment B 444 A

Figure 4.201 Light-to-moderate corrosion in compartment B 444 A

4.75. B 445 A, SD Store Room, Frames 142-150

Structural Observations

- No major structural issues were observed.
- Areas of light surface corrosion were observed throughout the compartment.
- Light corrosion was observed on approximately 6-in of the lower forward/starboard scantlings.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.202 Location of compartment B 445 A

Figure 4.203 Overall view of compartment B 445 A

4.76. B 448 T, WT Trunk, Frames 148-150

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.204 Location of compartment B 448 T

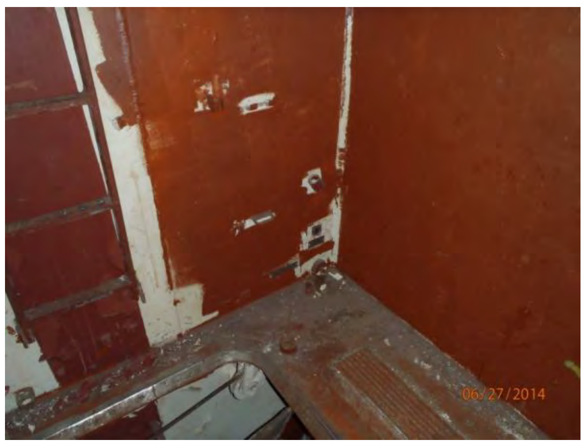


Figure 4.205 Overall view of compartment B 448 T

4.77. B 443 A, Dry Provisions Store Room, Frames 142-150

Structural Observations

- **A torch-cut hole, which measured approximately 32-in W x 70-in H, was observed in the 3/8-in thick steel bulkhead at Frame 159. Sections of 2 horizontal members, each of which measured approximately 34-in in length, were removed at the location of the hole. The dimensions of the members were as follows: Depth = 4-in, Flange width = 2½-in, Flange & Web thickness = ¼-in. The members appear to be MT4x3.1 sections. (Figure 3.204)**
- Areas of light surface corrosion were observed throughout the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.206 Location of compartment B 443 A

Figure 4.207 Overall view of compartment B 443 A

Figure 4.208 Torch-cut hole in bulkhead at Frame 159.

4.78. C 406 A, Dry Provisions, Frames 150-159

Structural Observations

- No major structural issues were observed.
- An approximately 10 square foot (SF) area of moderate-to-heavy corrosion was observed on the steel floor in the forward starboard corner of the compartment. (Figure 3.207)
- An approximately 15 SF area of moderate-to-heavy corrosion was observed on the floor under utility pipe connections on the port side of the compartment.
- Isolated areas of light surface corrosion were observed on the floor and walls of the compartment.

Additional Observations

- 1 tank access hatch was open and uncovered.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 4.209 Location of compartment C 406 A

Figure 4.210 Overall view of compartment C 406 A

Figure 4.211 Moderate-to-heavy corrosion on floor in compartment C 406 A

4.79. C 404 T, WT Trunk, Frames 150-151

Structural Observations

- No major structural issues were observed.
- Areas of spotty, light corrosion were observed on all wall surfaces.
- Light-to-moderate corrosion was observed over 100% of the steel floor of the compartment.

Additional Observations

- Peeling paint was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.212 Location of compartment C 404 T

Figure 4.213 Overall view of compartment C 404 T

4.80. C 402 A, Aviation Stores, Frames 150-159

Structural Observations

- **Moderate-to-heavy corrosion with 20-25% loss of section was observed to a height of approximately 3-in along the lower scantlings in the forward starboard corner of the compartment. (Figure 3.212)**
- Isolated areas of light surface corrosion were observed throughout the compartment.
- An area of light-to-moderate corrosion was observed on the steel floor in the forward port corner of the compartment.

Additional Observations

- Peeling paint, suspected asbestos tile and “red lead” primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 4.214 Location of compartment C 402 A

Figure 4.215 Overall view of compartment C 402 A

Figure 4.216 Moderate-to-heavy corrosion of lower scantlings in compartment C 402 A

4.81. C 401 E, Gyro Room, Frames 150-153

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.217 Location of compartment C 401 E

Figure 4.218 Overall view of compartment C 401 E

4.82. C 405 A, Dry Provision Store Room, Frames 150-159

Structural Observations

- No major structural issues were observed.
- A torch-cut hole, which measured approximately 5½-in W x 5½-in H, was observed in the 1-in thick steel port bulkhead.
- Evidence of previous flooding to a depth of approximately 3-in to 6-in. was observed.
- Light-to-moderate corrosion was observed along approximately 6-in of the lower walls and scantlings. (Figure 3.217)
- Isolated areas of light surface corrosion were observed on the steel floor of the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.219 Location of compartment C 405 A

Figure 4.220 Overall view of compartment C 405 A

Figure 4.221 Light-to-moderate corrosion of lower scantlings in compartment C 405 A

4.83. C 403 T, WT Trunk, Frames 150-151

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.222 Location of compartment C 403 T

Figure 4.223 Overall view of compartment C 403 T

4.84. C 411 A, Aviation Stores, Frames 159-166

Structural Observations

- No major structural issues were observed.
- Light-to-moderate corrosion was observed over approximately 50% of the floor of the compartment, with up to 10-15% loss of section.

Additional Observations

- 3 tank access hatches were open and uncovered.
- "Red lead" primer was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.224 Location of compartment C 411 A

Figure 4.225 Overall view of compartment C 411 A

4.85. C 409 E, Oxygen Nitrogen Producer Room, Frames 159-166

Structural Observations

- **Heavy corrosion was observed under equipment mounts in the compartment. (Figure 3.224)**

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 4.226 Location of compartment C 409 E

Figure 4.227 Overall view of compartment C 409 E

Figure 4.228 Heavy corrosion under equipment in compartment C 409 E

4.86. C 407 ½ M, Torpedo Storage, Frames 159-166

Structural Observations

- No major structural issues were observed.
- Inward bulging was observed on approximately 16-in of the lower section of the starboard bulkhead.
- Isolated areas of surface corrosion were observed on the floors and walls of the compartment.
- An approximately 50 square foot (SF) area of light-to-moderate corrosion, with up to 15-20% loss of section, was observed on the steel floor along the port bulkhead.
- Light-to-moderate corrosion, with up to 10-15% loss of section, was observed on the steel floor in the aft starboard corner of the compartment.

Additional Observations

- An oil spill was observed in the forward port corner of the compartment.
- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.229 Location of compartment C 407 ½ M

Figure 4.230 Overall view of compartment C 407 ½ M

4.87. C 407 G, Gas Trunk & Control Rm, Frames 159-160

Structural Observations

- No major structural issues were observed.
- An approximately 10 square foot (SF) area of light corrosion was observed on the steel floor in the starboard end of the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.231 Location of compartment C 407 G

Figure 4.232 Overall view of compartment C 407 G

4.88. C 408 A, Chemical Warfare Defence, Frames 159-166

Structural Observations

- **Heavy corrosion with 30-45% loss of section was observed on the aft end of the port side horizontal frame member. (Figure 3.231)**
- Evidence of a previous or slow active leak was observed at a fire main connection on the starboard bulkhead.
- Moderate-to-heavy corrosion with 20-25% loss of section was observed over the entire starboard wall-floor joint area.
- An area of moderate-to-heavy corrosion was observed on the steel floor in the aft starboard corner of the compartment.
- A band of light-to-moderate corrosion, which measured approximately 3-ft in width, was observed along all wall/floor connections.
- Light corrosion was observed at the port bulkhead/ceiling joint.

Additional Observations

- The access hatch to tank C22 was open and uncovered.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 4.233 Location of compartment C 408 A

Figure 4.234 Overall view of compartment C 408 A

Figure 4.235 Heavy corrosion in compartment C 408 A

4.89. C 413 T, WT Trunk, Frames 165-166

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.236 Location of compartment C 413 T

Figure 4.237 Overall view of compartment C 413 T

4.90. C 415 T, WT Trunk, Frames 166-169

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.238 Location of compartment C 415 T

Figure 4.239 Overall view of compartment C 415 T

4.91. C 410 AT, Aviation Stores, Frames 166-169

Structural Observations

- No major structural issues were observed.
- Impact damage was observed around the edges of the elevator shaft at the 3rd Deck level.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.240 Location of compartment C 410 AT

Figure 4.241 Overall view of compartment C 410 AT

4.92. C 410 A, Aviation Stores, Frames 166-176

Structural Observations

- **A torch-cut hole, which measured approximately 6-ft 11-in W x 5-ft 9-in H, was observed in the port side of the 3/8-in thick steel bulkhead at Frame 176. (Figure 3.240, 3.241)**
- **A torch-cut hole, which measured approximately 7-ft W x 5-ft 11-in H, was observed in the starboard side of the 3/8-in thick steel bulkhead at Frame 176. (Figure 3.242, 3.243)**
- **Vertical framing members have been removed at both torch cut locations in the steel bulkhead at Frame 176. The dimensions of the members were as follows: Depth = 4-in, Flange width = 5 1/8-in, Flange & Web thickness = 1/8-in.**

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.242 Location of compartment C 410 A

Figure 4.243 Overall view of compartment C 410 A

Figure 4.244 Torch-cut hole in port section of the bulkhead at Frame 176, compartment C 410 A

Figure 4.246 Torch-cut hole in starboard section of the bulkhead at Frame 176, compartment C 410 A

Figure 4.245 Arrow shows vertical member removed from the bulkhead at Frame 176, compartment C 410 A

Figure 4.247 Arrow shows vertical member removed from the bulkhead at Frame 176, compartment C 410 A

4.93. C 417 A, Aviation Stores, Frames 176-184

Structural Observations

- **A torch-cut hole, which measured approximately 7-ft W x 7-ft 4-in H, was observed in the starboard side of the 3/8-in thick steel bulkhead at Frame 184. (Figure 3.246)**
- **1 vertical and 2 horizontal framing members were removed at the torched cut in the bulkhead at Frame 184. The dimensions of the members were as follows:**
    - **(Vertical) Depth = 6-in, Flange width = 4-in, Flange & Web Thickness = ¼-in. The vertical members appear to be W6x12 sections. (Figure 3.247)**
    - **(Horizontal) Depth = 3-in, Flange width = 1¾-in, Flange & Web Thickness = 1/8-in. The horizontal members appear to be MT3x2.2 sections.**
- A torch-cut hole, which measured approximately 10-in W x 14-in H, was observed in the starboard bulkhead.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.248 Location of compartment C 417 A

Figure 4.249 Overall view of compartment C 417 A

Figure 4.250 Torch-cut hole in bulkhead at Frame 184, compartment C 417 A

Figure 4.251 Arrow indicates member removed from bulkhead at Frame 184, compartment C 417 A

4.94. C 418 A, Aviation Stores, Frames 176-184

Structural Observations

- No major structural issues were observed.
- Isolated areas of light surface corrosion were observed throughout the compartment.
- Light corrosion with 5-10% loss of section was observed along approximately 3-in of the lower portions of the aft wall and scantlings.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.252 Location of compartment C 418 A

Figure 4.253 Overall view of compartment C 418 A

4.95. C 416 E, Aft Generator Room, Frames 176-184

Structural Observations

- No major structural issues were observed.
- Light surface corrosion was observed along approximately 4-in of the lower portion of the aft wall.
- Oil was observed on the floor along the forward and port walls.

Additional Observations

- Peeling paint, suspected asbestos tile and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.254 Location of compartment C 416 E

Figure 4.255 Overall view of compartment C 416 E

4.96. C 419 A, Aviation Engine Storage, Frames 184-198

Structural Observations

- No major structural issues were observed.
- Light-to-moderate corrosion with 15% loss of section was observed over approximately 6-in of the lower portion of all walls.
- Isolated areas of light, spotty corrosion were observed on all walls throughout the compartment.
- The floor of the compartment was observed to be warped in some areas.
- Impact damage to a horizontal frame member was observed on the bulkhead at Frame 184.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.256 Location of compartment C 419 A

Figure 4.257 Overall view of compartment C 419 A

4.97. C 420 T, WT Trunk, Frames 186-188

Structural Observations

- No major structural issues were observed.
- Evidence of possible surface corrosion under wall paint was observed to a height of approximately 6-ft on the lower portion of the aft wall.
- Moderate-to-heavy corrosion was observed under equipment mounts in the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 4.258 Location of compartment C 420 T

Figure 4.259 Overall view of compartment C 420 T

4.98. C 421 A, Engineer's Stores, Frames 198-202

Structural Observations

- No major structural issues were observed.
- Multiple holes were observed in the steel floor in the port and starboard sections of the compartment; 4 holes measured approximately 2.5-in in diameter, 1 measured approximately 1-in in diameter.
- Light-to-moderate corrosion was observed over large areas of the floor of the compartment.
- **Heavy corrosion was observed in the forward area of the center section of the compartment.**
- Impact damage was observed to 1 horizontal scantling around the hatch to the 3rd deck. The dimensions of the member were as follows: Length = 40-in, Depth = 3-in, Flange width = 1¾-in, Flange thickness = ¼-in. The member appears to be an MT3x2.2 section.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 4.260 Location of compartment C 421 A

Figure 4.261 Overall view of compartment C 4121 A

4.99. C 422 A, Engineer's Stores, Frames 202-206

Structural Observations

- No major structural issues were observed.
- Light-to-moderate corrosion was observed on the floor and to a height of approximately 6-in on the lower scantlings throughout the compartment.

Additional Observations

- "Red lead" primer was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 4.262 Location of compartment C 422 A

Figure 4.263 Overall view of compartment C 422 A

4.100. Transverse Bulkheads

- Deformation of transverse bulkheads was observed at several locations on the 4th Deck. The following bulkheads were found to have significant deformation in excess of ¼-in:
  - Port side bulkheads at frames: 50, 58, 67, 79, 86, 93, 100, 111, 121, 131, 142, 150, 159, 166, 176, 184, 191.
  - Starboard side bulkheads at frames: 50, 58, 79, 86, 142, 150, 159, 166, 176, 184, 191.

Figure 4.264 Deformation of transverse bulkhead at Frame 50, port side

Figure 4.266 Deformation of transverse bulkhead at Frame 121, port side

Figure 4.265 Deformation of transverse bulkhead at Frame 58, port side

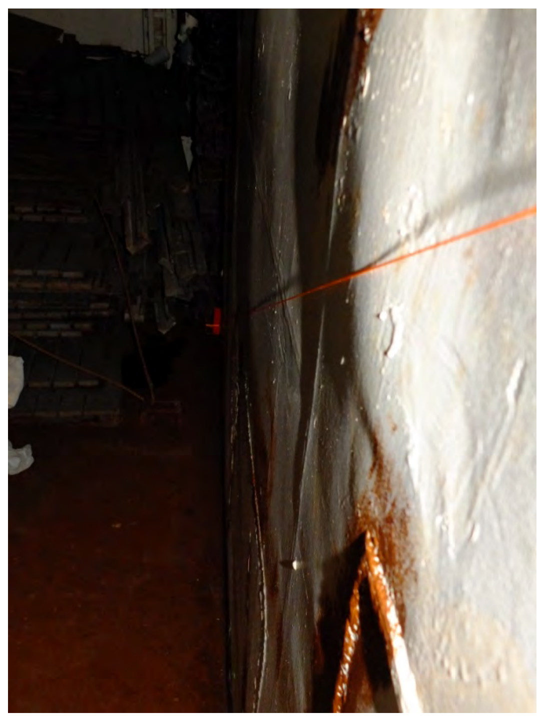


Figure 4.267 Deformation of transverse bulkhead at Frame 150, port side

Figure 4.268 Deformation of transverse bulkhead at Frame 159, port side

Figure 4.270 Deformation of transverse bulkhead at Frame 142, starboard side

Figure 4.269 Deformation of transverse bulkhead at Frame 184, port side

Figure 4.271 Deformation of transverse bulkhead at Frame 191, starboard side

5. 1st Platform

Typical conditions: The majority of the compartments on the 1st Platform (5th Deck) were generally found to be in structurally sound condition with varying degrees of deterioration that typically included peeling paint and light surface corrosion. However, several compartments were observed to be severely deteriorated. A graphic representation of the severity of the deterioration observed at each compartment is provided on the following page. Potential environmental and/or health hazards were observed at a number of compartments, including asbestos, "red lead" primer, and oil/fluid spills or leaks. An environmental assessment of the vessel was performed by The Shaw Group (Shaw) in 2013 and was not included in the scope of this structural assessment. A summary of Shaw's findings and recommendations was provided in Shaw's report dated April 12th, 2013.

5.1. Overview of 1st Platform

1st Platform

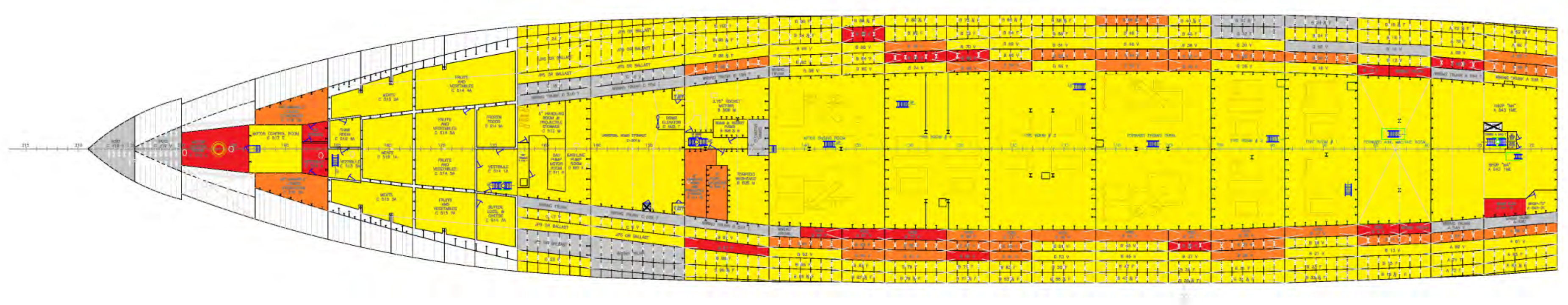


Figure 5.1 Overview of 1st Platform

- Minor deterioration - long-term concern
- Moderate deterioration - monitoring recommended
- Significant deterioration - near-term repair recommended
- Inaccessible / not inspected

5.2. A 522 M, Universal Bomb Storage, Frames 50-58

Structural Observations

- **Moderate-to-heavy corrosion was observed on the floor in both forward corners of the compartment, and to a height of approximately 6-in on the lower portions of the scantlings and forward bulkhead at Frame 50. (Figure 4.8)**
- **Moderate corrosion was observed over 75% of the floor of the compartment, with isolated areas of heavy corrosion.**

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

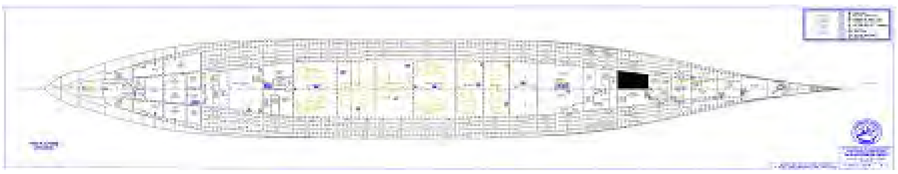


Figure 5.2 Location of compartment A 522 M

Figure 5.3 Overall view of compartment A 522 M

Figure 5.4 Corrosion on lower scantlings in compartment A 522 M

5.3. A 525 T, Wiring Trunk, Frames 50-58

Structural Observations

- **Moderate corrosion was observed to a height of approximately 6-in on the lower walls, and over the entire floor of the compartment.**
- **Evidence of previous flooding to a depth of approximately 6-in was observed.**

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

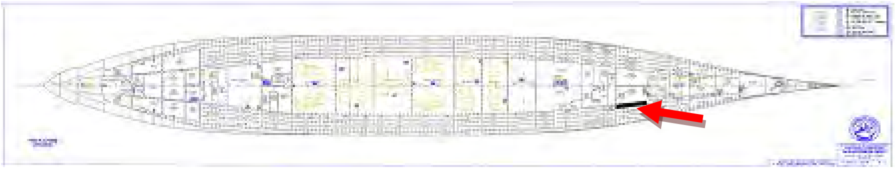


Figure 5.5 Location of compartment A 525 T

Figure 5.6 Overall view of compartment A 525 T

5.4. A 523 M, Universal Bomb Storage, Frames 50-58

Structural Observations

- **Standing water at a depth of approximately 1-in to 2-in was observed over approximately 50% of the floor of the compartment. (Figure 4.12)**
- **Moderate-to-heavy corrosion was observed to a height of approximately 6-in on the lower walls and scantlings, with 25-35% loss of section (LOS) on the lower scantlings. (Figure 4.13, 4.15)**
- **A torch-cut hole, which measured approximately 20-in W x 52.5-in H, was observed in the 3/8-in thick steel bulkhead at Frame 58.**
- **The entire floor of the compartment was observed to be heavily corroded, with up to 50% LOS.**
- **This compartment is severely deteriorated and near term repairs are recommended.**
- Two torch-cut holes, which measured approximately 17-in W x 28.5-in H and 4-in W x 4-in H respectively, were observed in the ½-in thick steel starboard bulkhead.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 5.7 Location of compartment A 523 M

Figure 5.8 Overall view of compartment A 523 M

Figure 5.9 Corrosion of lower scantlings in compartment A 523 M

Figure 5.10 Overall view #2 of compartment A 523 M

Figure 5.11 Corrosion along lower walls in compartment A 523 M

5.5. A 521 T, WT Trunk, Frames 50-51

Structural Observations

- No major structural issues were observed.
- Light surface corrosion was observed on isolated portions of the floor and walls throughout the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

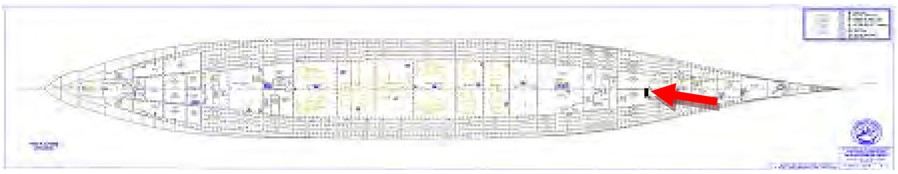


Figure 5.12 Location of compartment A 521 T

Figure 5.13 Overall view of compartment A 521 T

5.6. A 525 ½ T, Bomb Elevator, Frames 55-58

Structural Observations

- **Severe corrosion, with up to 60-70% loss of section, was observed over 100% of the floor and approximately 18-in of the lower walls in the compartment. (Figure 4.20)**
- **This compartment is severely deteriorated and near term repairs are recommended.**
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

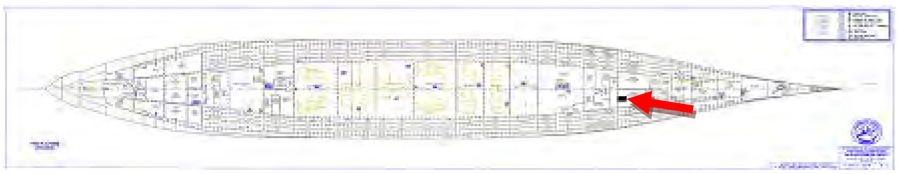


Figure 5.14 Location of compartment A 525 ½ T

Figure 5.15 Overall view of compartment A 525 ½ T

Figure 5.16 Severe corrosion in compartment A 525 ½ T

5.7. A 526 G, Gasoline Pump Room, Frames 58-63

Structural Observations

- **Initial inspection on 6/25/2014 found evidence of previous flooding to a depth of approximately 6-in; subsequent inspection on 7/23/2014 found the compartment to be flooded to this depth. (Figure 4.22)**
- **Moderate corrosion, with 5-10% loss of section, was observed to a height of approximately 6-in along the lower walls and scantlings of the compartment.**
- A torch-cut hole, which measured approximately 39-in W x 20-in H, was observed in the ½-in thick steel forward bulkhead at Frame 58.
- Heavy corrosion was observed in the piping system and its supports. (Figure 4.23)

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 5.17 Location of compartment A 526 G

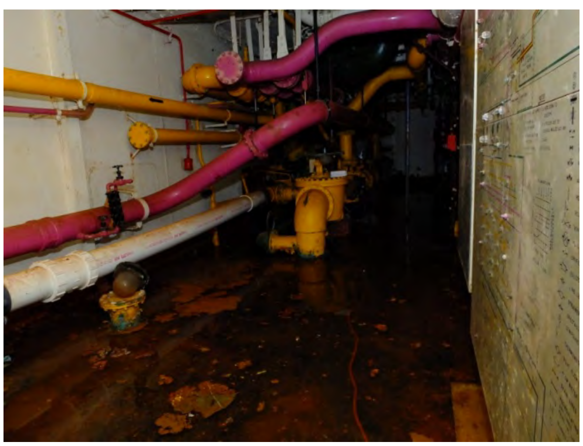


Figure 5.18 Overall view of compartment A 526 G

Figure 5.19 Heavy corrosion under piping system in compartment A 526 G

5.8. A 526 ½ G, Gaspump Motor Room, Frames 60-62

Structural Observations

- No major structural issues were observed.
- Isolated areas of surface corrosion were observed on the floor of the compartment.

Additional Observations

- Approximately 75% of the floor paint was found to be peeling.
- Unidentified liquid spills were observed under pump motors.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

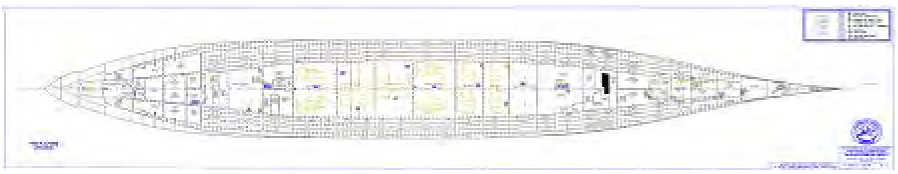


Figure 5.20 Location of compartment A 526 ½ G

Figure 5.21 Overall view of compartment A 526 ½ G

5.9. A 527 M, Universal Bomb Stowage, Frames 60-67

Structural Observations

- No major structural issues were observed.
- Isolated areas of light surface corrosion were observed throughout the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

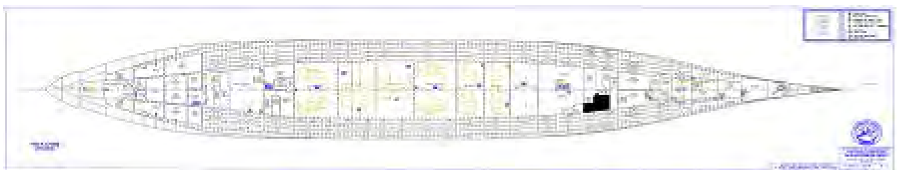


Figure 5.22 Location of compartment A 527 M

Figure 5.23 Overall view of compartment A 527 M

5.10. A 531 T, WT Trunk, Frames 61-64

Structural Observations

- No major structural issues were observed.

Additional Observations

- A previous oil spill was observed over approximately 50% of the floor of the compartment.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.24 Location of compartment A 531 T

Figure 5.25 Overall view of compartment A 531 T

5.11. A 535 T, Bomb Elevator, Frames 64-67

Structural Observations

- No major structural issues were observed.
- An area of light-to-moderate corrosion was observed over approximately 50% of the steel floor in the forward half of the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

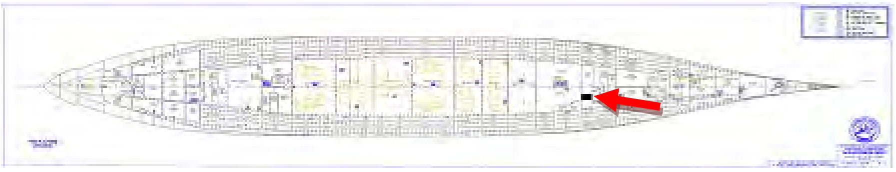


Figure 5.26 Location of compartment A 535 T

Figure 5.27 Overall view of compartment A 535 T

5.12. A 528 M, "M" Shop (Fwd), Frames 64-67

Structural Observations

- No major structural issues were observed.
- An area of light corrosion, with up to 5% loss of section, was observed on the steel floor in the forward starboard corner of the compartment.

Additional Observations

- Evidence of a previous oil leak was observed from a "Fire Main" valve in the aft section of the compartment.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.28 Location of compartment A 528 M

Figure 5.29 Overall view of compartment A 528 M

5.13. A 543 2E, Shop "0", Frames 67-70

Structural Observations

- No major structural issues were observed.
- An area of moderate-to-heavy corrosion was observed on the steel floor of the compartment near the bulkhead at Frame 67.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

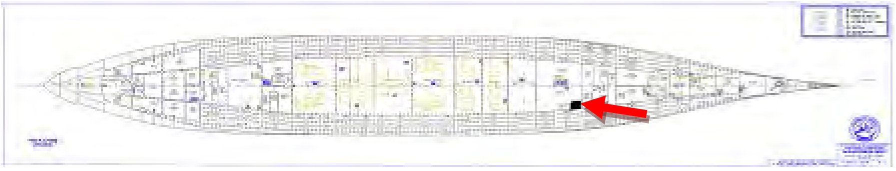


Figure 5.30 Location of compartment A 543 2E

Figure 5.31 Corrosion near Bulkhead 67 in compartment A 543 2E

5.14. A 543 1ME, Shop "MA", Frames 67-79

Structural Observations

- No major structural issues were observed.
- Light-to-moderate corrosion was observed on the steel floor along the forward bulkhead at Frame 67.
- An area of moderate corrosion, which measured approximately 1-ft x 3-ft, was observed on the steel floor along the port bulkhead. (Figure 4.38)

Additional Observations

- Peeling paint was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

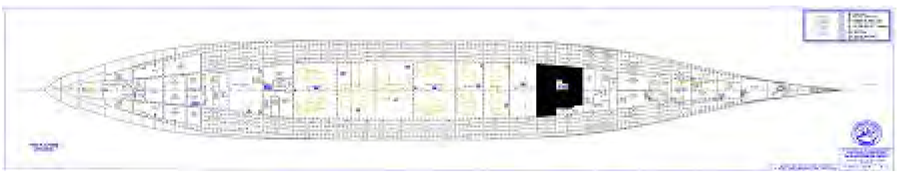


Figure 5.32 Location of compartment A 543 1ME

Figure 5.33 Overall view of compartment A 543 1ME

Figure 5.34 Moderate corrosion along port bulkhead in compartment A 543 1ME

5.15. A 541 ET, Bomb Elev., Frames 70-74

Structural Observations

- **Severe corrosion with up to 100% loss of section (LOS) was observed along all of the lower walls and scantlings. (Figure 4.41)**
- **Severe corrosion, with 20-50% LOS, was observed over the entire floor of the compartment.**
- **This compartment is severely deteriorated and near term repairs are recommended.**

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

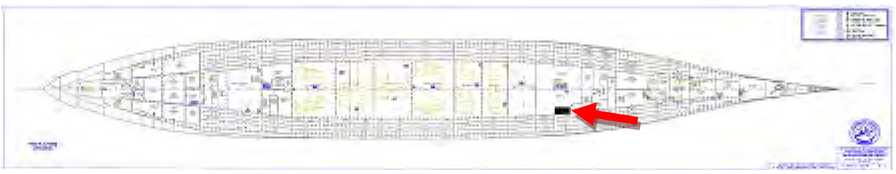


Figure 5.35 Location of compartment A 541 ET

Figure 5.36 Overall view of compartment A 541 ET

Figure 5.37 100% loss of section on scantlings in compartment A 541 ET

5.16. A 542 T, Escape Trunk, Frames 71-72

Structural Observations

- No major structural issues were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

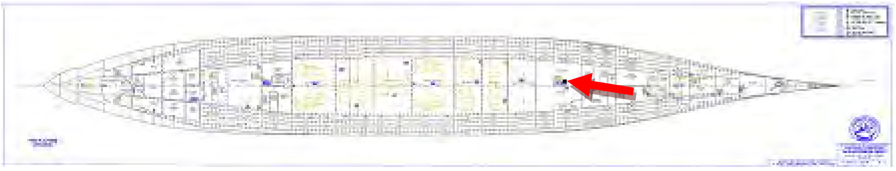


Figure 5.38 Location of compartment A 542 T

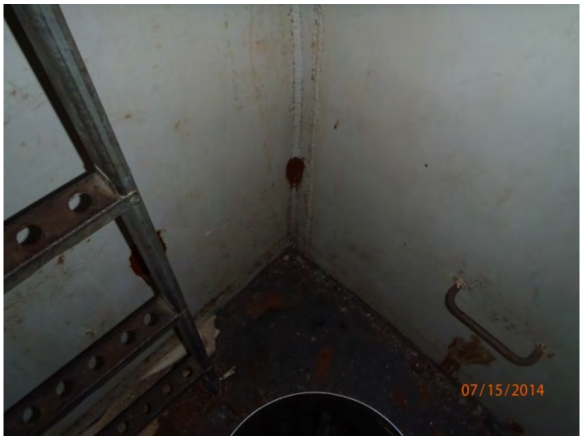


Figure 5.39 Overall view of compartment A 542 T

5.17. A 546 T, Dumbwaiter, Frames 71-72

Structural Observations

- No major structural issues were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

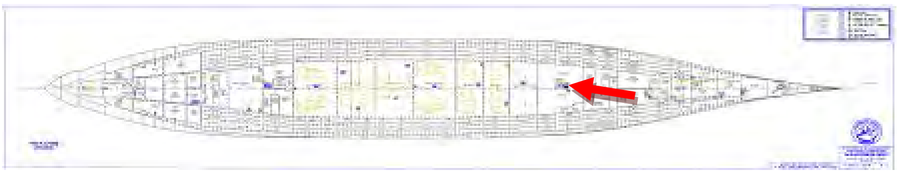


Figure 5.40 Location of compartment A 546 T

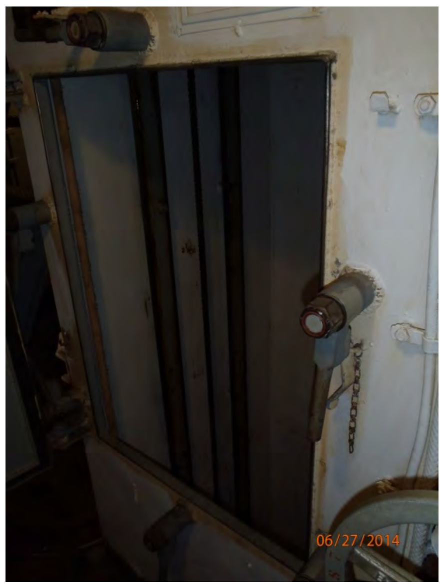


Figure 5.41 Overall view of compartment A 546 T

5.18. A 540 T, Trunk, Frames 72-74

Structural Observations

- No major structural issues were observed.

Additional Observations

- “Red lead” primer was observed.

Due to the observed deficiencies, this space classifies as a long term concern.

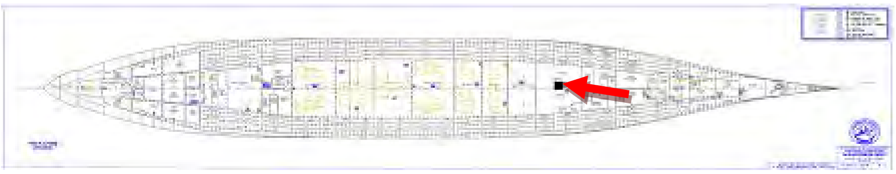


Figure 5.42 Location of compartment A 540 T

Figure 5.43 Overall view of compartment A 540 T

5.19. B 505 M, Torpedo Warheads, Frames 142-150

Structural Observations

- No major structural issues were observed.
- An area of moderate corrosion, with 5-10% loss of section, was observed on the steel floor in the forward end of the compartment. (Figure 4.50)
- Isolated areas of light surface corrosion were observed on the steel floor of the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

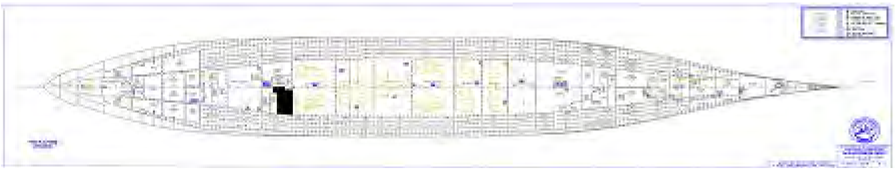


Figure 5.44 Location of compartment B 505 M

Figure 5.45 Overall view of compartment B 505 M

Figure 5.46 Moderate corrosion on floor in compartment B 505 M

5.20. B 506 M, 2.75” Rocket Motors, Frames 142-150

Structural Observations

- No major structural issues were observed.
- Isolated areas of light-to-moderate corrosion were observed on the floor of the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.47 Location of compartment B 506 M

Figure 5.48 Overall view of compartment B 506 M

5.21. B 506 ½ M, Bomb & Rocket Fuses, Frames 144-147

Structural Observations

- No major structural issues were observed.
- An approximately 12-in wide band of moderate corrosion was observed around the perimeter of the steel floor of the compartment. (Figure 4.54)

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

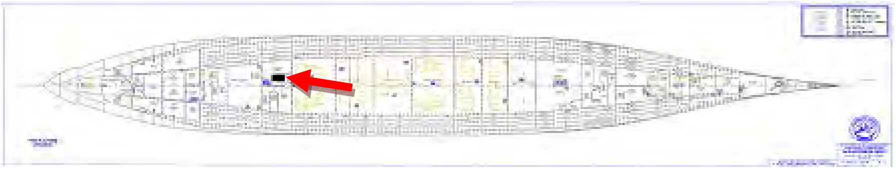


Figure 5.49 Location of compartment B 506 ½ M

Figure 5.50 Moderate corrosion in compartment B 506 ½ M

5.22. B 510 T, WT Trunk, Frames 144-150

Structural Observations

- No major structural issues were observed.

Additional Observations

- Evidence of previous oil leakage was observed on the floor in the forward end of the compartment.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.51 Location of compartment B 510 T

Figure 5.52 Overall view of compartment B 510 T

5.23. B 509 M, 5" Powder Magazine, Frames 146-148

Structural Observations

- **Moderate corrosion was observed over 100% of the steel floor of the compartment.**
- **An active fresh water leak was observed from a fire main connection; a 5-gallon plastic bucket was being used to contain water from the leak. (Figure 4.59)**

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

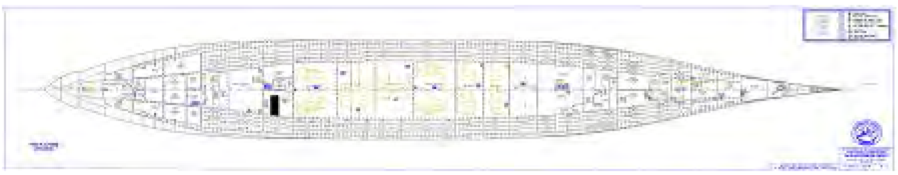


Figure 5.53 Location of compartment B 509 M

Figure 5.54 Overall view of compartment B 509 M

Figure 5.55 Corrosion and leaking fire main in compartment B 509 M

5.24. B 511 M, 5" Handling Room, Frames 147-150

Structural Observations

- **Moderate-to-heavy corrosion was observed on the steel floor along the starboard and aft walls of the compartment. (Figure 4.62)**
- **Moderate corrosion with 15-20% loss of section was observed over all exposed areas of the steel floor of the compartment.**

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 5.56 Location of compartment B 511 M

Figure 5.57 Overall view of compartment B 511 M

Figure 5.58 Moderate-to-heavy corrosion in compartment B 511 M

5.25. C 501 M, Universal Bomb Stowage, Frames 150-159

Structural Observations

- No major structural issues were observed.
- Isolated areas of light surface corrosion were observed on the steel floor of the compartment.
- Light-to-moderate corrosion was observed to a height of approximately 8-in along the lower portion of the starboard bulkhead.

Additional Observations

- Evidence of a previous oil spill was observed on the floor of the compartment.
- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

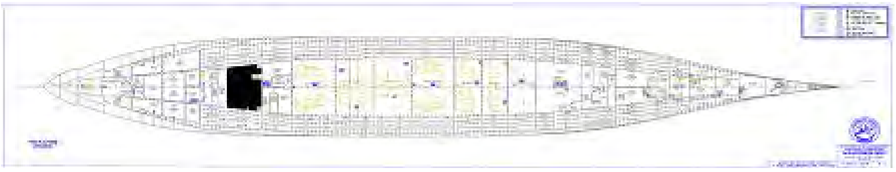


Figure 5.59 Location of compartment C 501 M

Figure 5.60 Overall view of compartment C 501 M

5.26. C 504 T, WT Trunk, Frames 150-151

Structural Observations

- No major structural issues were observed.
- Isolated areas of surface corrosion were observed on the steel walls and floor of the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

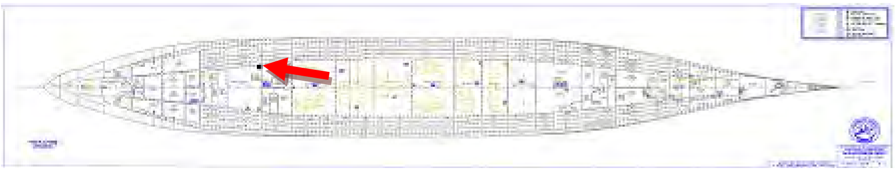


Figure 5.61 Location of compartment C 504 T

Figure 5.62 Overall view of compartment C 504 T

5.27. C 502 T, Bomb Elevator, Frames 150-153

Structural Observations

- No major structural issues were observed.
- The area below the elevator was inaccessible because the elevator is lowered to the bottom of the shaft.
- Light surface corrosion was observed on the steel floor in the corners of the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.63 Location of compartment C 502 T

Figure 5.64 Overall view of compartment C 502 T

5.28. C 503 T, WT Trunk, Frames 150-151

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

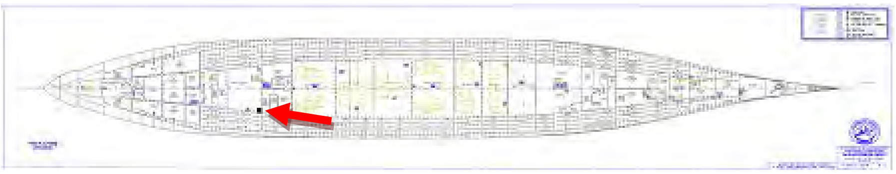


Figure 5.65 Location of compartment C 503 T

Figure 5.66 Overall view of compartment C 503 T

5.29. C 507 G, Gasoline Pump Room, Frames 159-165

Structural Observations

- No major structural issues were observed.
- Light-to-moderate corrosion was observed to a height of approximately 6-in on the lower walls, and over 70% of the floor of the compartment.
- Moderate corrosion was observed to a height of approximately 8-in on the lower scantlings.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.67 Location of compartment C 507 G

Figure 5.68 Overall view of compartment C 507 G

5.30. C 511 G, Gas Pump Motor Room, Frames 161-162

Structural Observations

- No major structural issues were observed.
- Light surface corrosion, with 5-10% loss of section, was observed on horizontal scantlings along the forward bulkhead at Frame 161.
- Surface corrosion was observed on the floor under motor mounts on the starboard side of the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

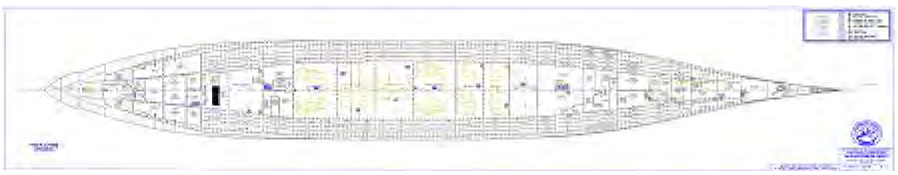


Figure 5.69 Location of compartment C 511 G

Figure 5.70 Overall view of compartment C 511 G

5.31. C 512 M, 5" Handling Room & Projectile Stowage, Frames 161 ½-166

Structural Observations

- No major structural issues were observed.
- Isolated areas of light surface corrosion were observed on the steel floor of the compartment.

Additional Observations

- Large areas of spilled oil were observed on the floor of the compartment.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.71 Location of compartment C 512 M

Figure 5.72 Overall view of compartment C 512 M

5.32. C 513 T, WT Trunk, Frames 165-166

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

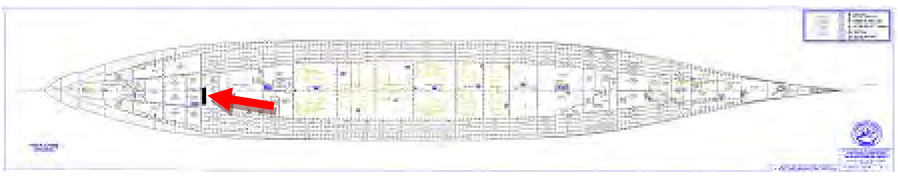


Figure 5.73 Location of compartment C 513 T

Figure 5.74 Overall view of compartment C 513 T

5.33. C 514 1A, Vestibule, Frames 166-170

Structural Observations

- No major structural issues were observed.
- Isolated areas of light-to-moderate corrosion were observed throughout the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.
- Cracking was observed in the Masonite-like material which covers the structural steel floor of the compartment.

Due to the observed deficiencies, this space classifies as a long term concern.

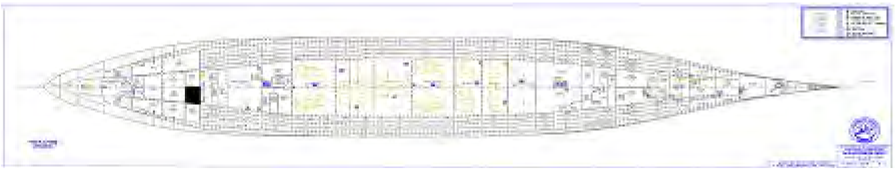


Figure 5.75 Location of compartment C 514 1A

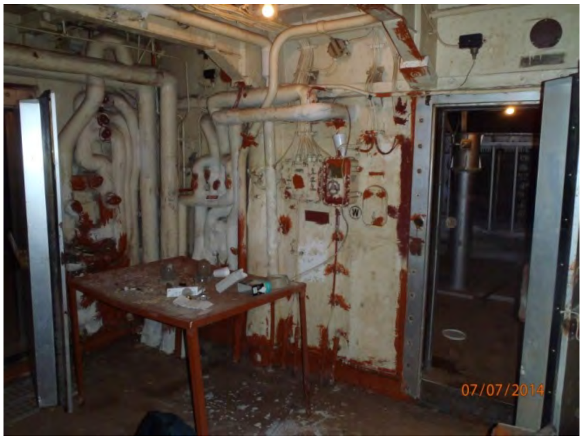


Figure 5.76 Overall view of compartment C 514 1A

5.34. C 514 2A, Frozen Foods, Frames 166-170

Structural Observations

- All surfaces in this compartment are covered with insulation and sheet metal cladding; the underlying structure is obscured and could not be inspected.

Due to the observed deficiencies, this space classifies as a long term concern.

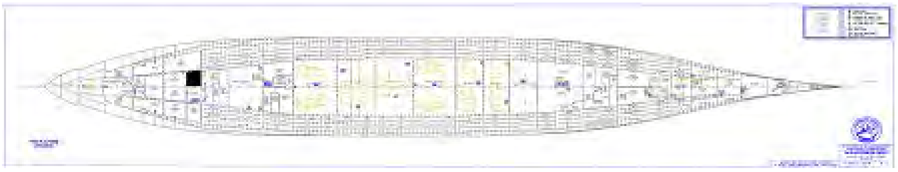


Figure 5.77 Location of compartment C 514 2A

Figure 5.78 Overall view of compartment C 514 2A

5.35. C 514 4A, Fruits and Vegetables, Frames 166-176

Structural Observations

- All surfaces in this compartment are covered with insulation and sheet metal cladding; the underlying structure is obscured and could not be inspected.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.79 Location of compartment C 514 4A

Figure 5.80 Overall view of compartment C 514 4A

5.36. C 514 3A, Butter, Eggs & Cheese, Frames 166-170

Structural Observations

- All surfaces in this compartment are covered with insulation and sheet metal cladding; the underlying structure is obscured and could not be inspected.

Due to the observed deficiencies, this space classifies as a long term concern.

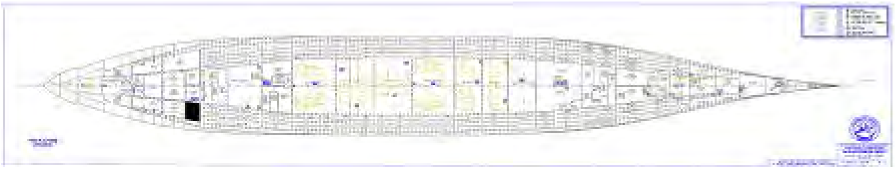


Figure 5.81 Location of compartment C 514 3A

Figure 5.82 Overall view of compartment C 514 3A

5.37. C 514 5A, Fruits and Vegetables, Frames 170-176

Structural Observations

- All surfaces in this compartment are covered with insulation and sheet metal cladding; the underlying structure is obscured and could not be inspected.

Due to the observed deficiencies, this space classifies as a long term concern.

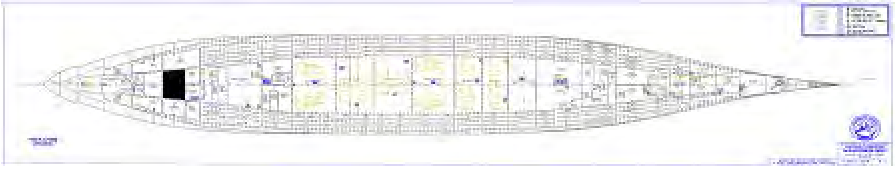


Figure 5.83 Location of compartment C 514 5A

Figure 5.84 Overall view of compartment C 514 5A

5.38. C 515 7A, Fruits and Vegetables, Frames 170-176

Structural Observations

- All surfaces in this compartment are covered with insulation and sheet metal cladding; the underlying structure is obscured and could not be inspected.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.85 Location of compartment C 515 7A

Figure 5.86 Overall view of compartment C 515 7A

5.39. C 515 2A, Meats, Frames 176-184

Structural Observations

- All surfaces in this compartment are covered with insulation and sheet metal cladding; the underlying structure is obscured and could not be inspected.

Due to the observed deficiencies, this space classifies as a long term concern.

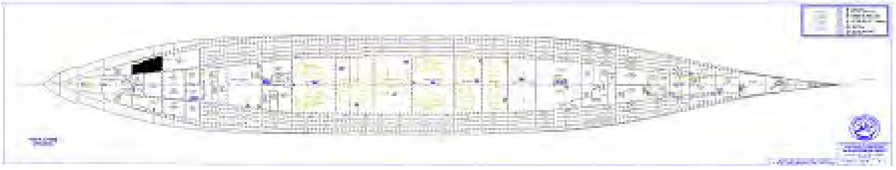


Figure 5.87 Location of compartment C 515 2A

Figure 5.88 Overall view of compartment C 515 2A

5.40. C 515 1A, Meats, Frames 176-181

Structural Observations

- All surfaces in this compartment are covered with insulation and sheet metal cladding; the underlying structure is obscured and could not be inspected.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.89 Location of compartment C 515 1A

Figure 5.90 Overall view of compartment C 515 1A

5.41. C 515 3A, Meats, Frames 176-181

Structural Observations

- All surfaces in this compartment are covered with insulation and sheet metal cladding; the underlying structure is obscured and could not be inspected.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.91 Location of compartment C 515 3A

Figure 5.92 Overall view of compartment C 515 3A

5.42. C 515 4A, Thaw Room, Frames 181-184

Structural Observations

- All surfaces in this compartment are covered with insulation and sheet metal cladding; the underlying structure is obscured and could not be inspected.

Due to the observed deficiencies, this space classifies as a long term concern.

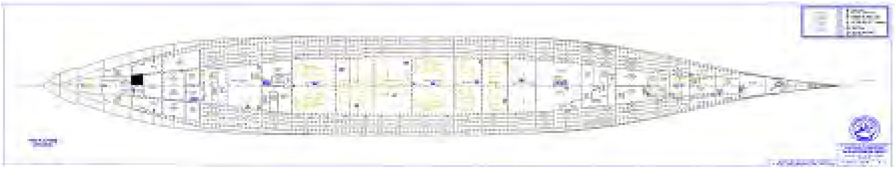


Figure 5.93 Location of compartment C 515 4A

Figure 5.94 Overall view of compartment C 515 4A

5.43. C 515 5A, Vestibule, Frames 181-184

Structural Observations

- No major structural issues were observed.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 5.95 Location of compartment C 515 5A

Figure 5.96 Overall view of compartment C 515 5A

5.44. C 516 A, Vestibule, Frames 184-186

Structural Observations

- **Moderate-to-heavy corrosion was observed on the steel beams surrounding the access hatch from above. Following are the beam dimensions: (Figure 4.103)**
  - **Main longitudinal beam: Depth = 20 $^{7}/_{8}$-in, Flange width = 8 ½in W, Flange thickness = 5/8in. The member appears to be a W21X55 section.**
    - **Up to 50% loss of section (LOS) was observed on this member.**
  - **Secondary longitudinal beam: Depth = 10 3/8in, Flange width = 4in, Flange thickness = ¼in. The member appears to be a W10X19 section.**
    - **Up to 50% LOS was observed on this member.**
  - **Transverse beams: Depth = 6in, Flange width = 3 1/8-in, Flange thickness = 1/8in. The members appear to be MT6x5.9 sections.**
    - **Up to 60% LOS on flange and up to 20% LOS on web were observed on this member.**
- **Heavy-to-severe corrosion was observed over the entire steel floor of the compartment.**
- **Heavy corrosion, with up to 100% loss of section, was observed to a height of approximately 6-in along the lower scantlings. (Figure 4.104)**
- Light surface corrosion was observed on the walls and ceiling of the compartment
- **This compartment is severely deteriorated and near term repairs are recommended.**

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 5.97 Location of compartment C 516 A

Figure 5.98 Overall view of compartment C 516 A

Figure 5.99 Severe corrosion of structural beams in compartment C 516 A

Figure 5.100 Severe corrosion of floor in compartment C 516 A

5.45. C 516 2A, (Port) Inflammable Liquids Storeroom, Frames 184-191

Structural Observations

- **Heavy corrosion was observed on the lower steel floor at the inboard edges of the compartment. (Figure 4.107)**
- **Heavy corrosion was observed in the corners of structural beams throughout the compartment.**
- Light-to-moderate corrosion was observed on the floor, walls, and structural beams in the compartment.
- The lower floor of the compartment slopes downward toward the centerline of the ship; any water collected in the compartment forms puddles at the inboard edge, which may accelerate corrosion in this area.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 5.101 Location of compartment C 516 2A Port

Figure 5.102 Overall view of compartment C 516 2A Port

Figure 5.103 Heavy corrosion on lower floor in compartment C 516 2A Port

5.46. C 516 2A, (Starboard) Inflammable Liquids Storeroom, Frames 184-191

Structural Observations

- **Heavy corrosion was observed on the lower steel floor at the inboard edges of the compartment. (Figure 4.110)**
- **Heavy corrosion was observed in the corners of structural beams throughout the compartment.**
- Light-to-moderate corrosion was observed on the floor, walls, and beams in the compartment.
- The lower floor of the compartment slopes downward toward the centerline of the ship; any water collected in the compartment forms puddles at the inboard edge, which may accelerate corrosion in this area.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 5.104 Location of compartment C 516 2A Starboard

Figure 5.105 Overall view of compartment C 516 2A Starboard

Figure 5.106 Heavy corrosion on lower floor in compartment C 516 2A Starboard

6. 2nd Platform

Typical conditions: The compartments on the 2nd Platform (6th Deck) were generally found to have varying degrees of deterioration that typically included light to moderate corrosion and peeling paint; several compartments were observed to be in a state of severe deterioration. A graphic representation of the severity of the deterioration observed at each compartment is provided on the following page. Potential environmental and/or health hazards were observed at a number of compartments, including asbestos, “red lead” primer, and oil/fluid spills or leaks. An environmental assessment of the vessel was performed by The Shaw Group (Shaw) in 2013 and was not included in the scope of this structural assessment. A summary of Shaw’s findings and recommendations was provided in Shaw’s report dated April 12th, 2013.

6.1. Overview of 2nd Platform

2nd Platform

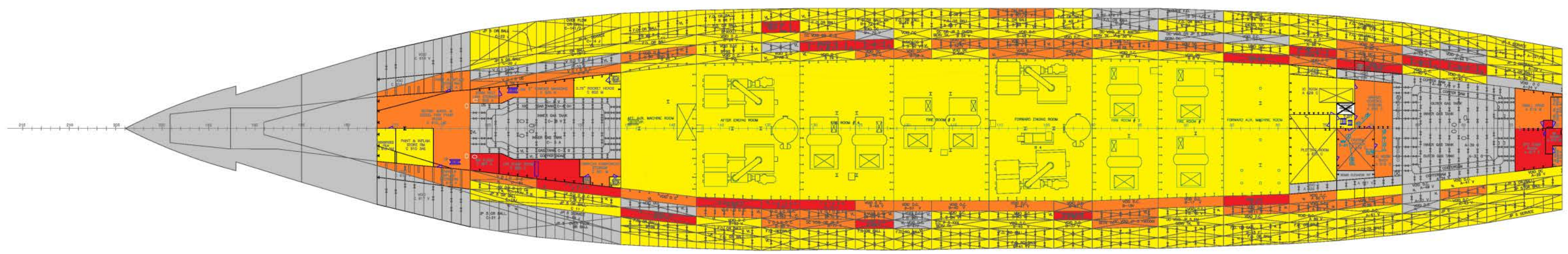


Figure 6.1 Overview of 2nd Platform

Minor deterioration - long-term concern

Moderate deterioration - monitoring recommended

Significant deterioration - near-term repair recommended

Inaccessible / not inspected

6.2. A 610 M, Aircraft Amm. Mag, Frames 44-50

Structural Observations

- The walls, floor, and ceiling of this compartment are covered by insulation. Based on other areas where similar corrosion was observed but portions of the structure behind the lining were exposed, it is likely that corrosion is present behind the lining of this compartment.
- Moderate corrosion was observed in a small area of exposed ceiling.
- Corrosion was observed around fittings on the forward bulkhead at Frame 44.
- Areas of light surface corrosion were observed on the floor of the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 6.2 Location of compartment A 610 M

Figure 6.3 Overall view of compartment A 610 M

6.3. A 611 M, Bomb & Rocket Fuses, Frames 44-50

Structural Observations

- **This compartment is flooded to a depth of approximately 12-in. (Figure 5.6)**
- The walls, floor, and ceiling of this compartment are covered by insulation. Based on other areas where similar corrosion was observed but portions of the structure behind the lining were exposed, it is likely that corrosion is present behind the lining of this compartment.
- Light corrosion was observed to a height of approximately 3-in on the lower walls, and around the edges of the floor pan.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

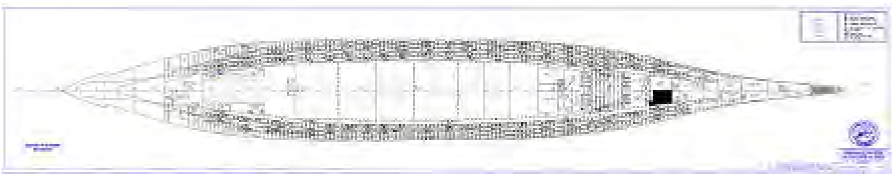


Figure 6.4 Location of compartment A 611 M

Figure 6.5 Overall view of compartment A 611 M

Figure 6.6 Flooding in compartment A 611 M

6.4. A 613 ET, Frames 49-52

A 613 ET, Fuel Oil Control Room:

Structural Observations

- Moderate corrosion was observed to a height of approximately 6-in along the lower walls of the compartment. (Figure 5.9)

Additional Observations

- Peeling paint was observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

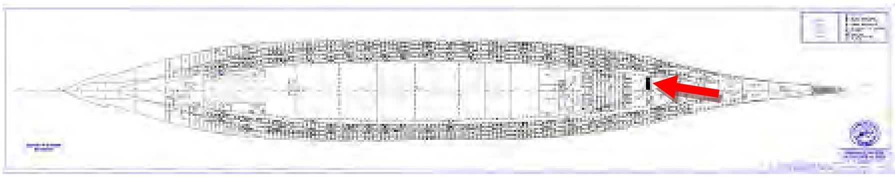


Figure 6.7 Location of compartment A 613 ET Fuel Oil Control Room

Figure 6.8 Overall view of compartment A 613 ET Fuel Oil Control Room

Figure 6.9 Moderate corrosion in compartment A 613 ET Fuel Oil Control Room

A 613 ET, WT Trunk:

Structural Observations

- **This compartment shows evidence of previous flooding; the forward section, which is separated by a bulkhead from the aft section, is flooded to a depth of approximately 12-in. (Figure 5.14)**
- **Severe corrosion was observed at the base of the door which separates the forward and aft sections of the compartment.**
- Moderate corrosion was observed to a height of approximately 12-in along the lower walls and scantlings in the compartment. (Figure 5.12)
- Heavy corrosion was observed on pipes and fittings passing through the floor of the compartment. (Figure 5.13)
- Surface corrosion was observed at the waterline in the flooded forward section of the compartment.
- **This compartment is severely deteriorated and near term repairs are recommended.**

Additional Observations

- Peeling paint and "red lead" primer were observed.
- A film of oil was observed on the lower walls of the compartment.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

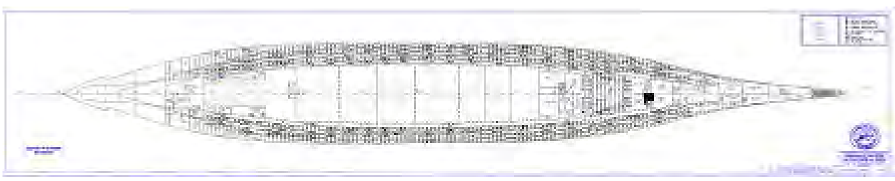


Figure 6.10 Location of compartment A 613 ET WT Trunk

Figure 6.11 Overall view of compartment A 613 ET WT Trunk

Figure 6.12 Moderate corrosion on lower walls in compartment A 613 ET WT Trunk

Figure 6.13 Heavy corrosion of fittings at floor of compartment A 613 ET WT Trunk

Figure 6.14 Flooding in forward section of compartment A 613 ET WT Trunk

6.5. A 615 M, 5" 36 Saluting Ammunition, Frames 50-51

Structural Observations

- **This compartment is flooded to a depth of approximately 3-in.**
- The walls, floor, and ceiling of this compartment are covered by insulation. Based on other areas where similar corrosion was observed but portions of the structure behind the lining were exposed, it is likely that corrosion is present behind the lining of this compartment.

Additional Observations

- Mold-like growth was observed on the floor of the compartment.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 6.15 Location of compartment A 615 M

Figure 6.16 Overall view of compartment A 615 M

6.6. A 612 M, Small Arms, Frames 51-55

Structural Observations

- **This compartment is flooded to a depth of approximately 3-in.**
- Moderate corrosion was observed around the edges of the floor pan. (Figure 5.20)
- The walls, floor, and ceiling of this compartment are covered by insulation. Based on other areas where similar corrosion was observed but portions of the structure behind the lining were exposed, it is likely that corrosion is present behind the lining of this compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.
- Mold-like growth was observed on the floor of the compartment.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

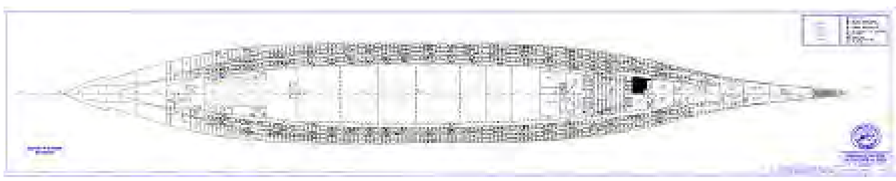


Figure 6.17 Location of compartment A 612 M

Figure 6.18 Overall view of compartment A 612 M

Figure 6.19 Moderate corrosion of floor pan in compartment A 612 M

6.7. A 617 E, JP5 Pump Room, Frames 52-55

Structural Observations

- **This compartment is flooded to a depth of approximately 6-in. (Figure 5.23, 5.25)**
- **Severe corrosion was observed to a height of approximately 6-in on the lower walls and scantlings. (Figure 5.24)**
- The floor of the compartment is obscured by debris and was not observable.

Additional Observations

- 2 Carbon Dioxide fire extinguisher tanks with intact valves are present in the compartment.
- Mold-like growth and oil were observed on the surface of the water.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 6.20 Location of compartment A 617 E

Figure 6.21 Overall view of compartment A 617 E

Figure 6.22 Flooding and corrosion in compartment A 617 E

Figure 6.23 Severe corrosion of lower scantlings in compartment A 617 E

Figure 6.24 Flooding and corrosion in compartment A 617 E

6.8. A 622 V, VOID, Frames 66-72

Structural Observations

- **Heavy corrosion was observed around the bolts securing the hatch. (Figure 5.28)**
- This compartment was not inspected internally; moisture is visible around the hatch bolts, which may be an indication of flooding in the compartment.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 6.25 Location of compartment A 622 V

Figure 6.26 Overall view of hatch to compartment A 622 V

Figure 6.27 Heavy corrosion of bolts on hatch to compartment A 622 V

6.9. A 620 C, Damage Control Station, Frames 67-72

Structural Observations

- **Moderate corrosion with 20-30% loss of section (LOS) was observed on all exposed floor areas and to a height of approximately 6-in along the lower walls of the compartment. (Figure 5.33)**
- **Light-to-moderate corrosion with 10-20% LOS was observed to a height of approximately 6-in on the lower walls and scantlings. (Figure 5.31)**
- **Isolated areas of severe corrosion with up to 80% LOS were observed to a height of approximately 6-in on the lower scantlings. (Figure 5.32)**
- This compartment shows evidence of previous flooding to a depth of approximately 4-in to 6-in.

Additional Observations

- Peeling paint, “red lead” primer and suspected asbestos tile were observed.
- Evidence of moisture was observed on the lower section of the forward bulkhead at Frame 67; this may indicate flooding in the adjacent “Cofferdam” compartment.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

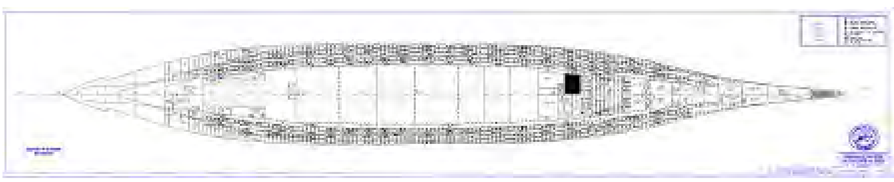


Figure 6.28 Location of compartment A 620 C

Figure 6.29 Overall view of compartment A 620 C

Figure 6.30 Heavy corrosion on lower walls in compartment A 620 C

Figure 6.31 Heavy-to-severe corrosion of lower walls and scantlings in compartment A 620 C

Figure 6.32 Heavy corrosion of floor in compartment A 620 C

6.10. A 619 C, Frames 67-74

<u>A 619 C IC Workshop:</u>

Structural Observations

- **Moderate corrosion, with up to 50% loss of section (LOS), was observed over isolated areas of the floor of the compartment. (Figure 5.36)**
- **Light corrosion with up to 20% LOS was observed to a height of approximately 6-in along the lower walls of the compartment.**

Additional Observations

- Evidence of moisture was observed along the lower edges of the forward bulkhead at Frame 67; this may indicate flooding in the adjacent "Cofferdam" compartment

Due to the observed deficiencies, this space requires monitoring for further deterioration.

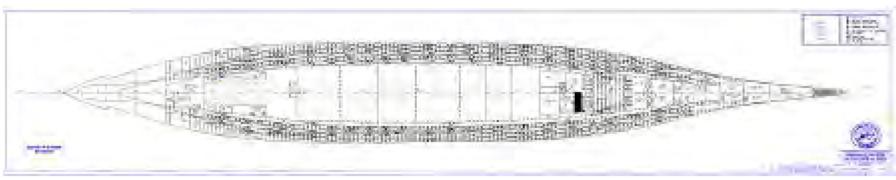


Figure 6.33 Location of compartment A 619 C IC Workshop

Figure 6.34 Overall view of compartment A 619 C IC Workshop

Figure 6.35 Severe corrosion in compartment A 619 C IC Workshop

A 619 C Central Station:

Structural Observations

- **This compartment has a non-structural "false floor" and is flooded to a depth of approximately 3-in under this floor. (Figure 5.39)**
- **Moderate corrosion, with 30-50% loss of section, was observed over the entire floor of the compartment. (Figure 5.40, 5.41)**

Additional Observations

- Peeling paint and "red lead" primer were observed.
- Mold-like growth was observed on the surface of the water under the false floor.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 6.36 Location of compartment A 619 C Central Station

Figure 6.37 Overall view of compartment A 619 C Central Station

Figure 6.38 Flooding under false floor in compartment A 619 C Central Station

Figure 6.39 Severe corrosion of floor in compartment A 619 C Central Station

Figure 6.40 Severe corrosion of compartment A 619 C Central Station

6.11. A 628 V, VOID, Frames 72-79

Structural Observations

- **Light corrosion was observed on the steel floor in the forward section of the compartment. (Figure 5.44)**
- **Light-to-moderate corrosion with up to 30% loss of section was observed on the floor, and to a height of approximately 4-in along the lower walls of the compartment. (Figure 5.44)**

Additional Observations

- An active drip sound was heard from the forward section of the compartment; its source was not determined.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 6.41 Location of compartment A 628 V

Figure 6.42 Overall view of compartment A 628 V

Figure 6.43 Heavy corrosion on floor and lower walls in compartment A 628 V

6.12. A 626 C, IC Room, Frames 72-79

Structural Observations

- Moderate corrosion, with up to 20% loss of section, was observed on the steel floor in the forward corners of the compartment.
- An area of light-to-moderate corrosion was observed on the steel floor along the port bulkhead.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

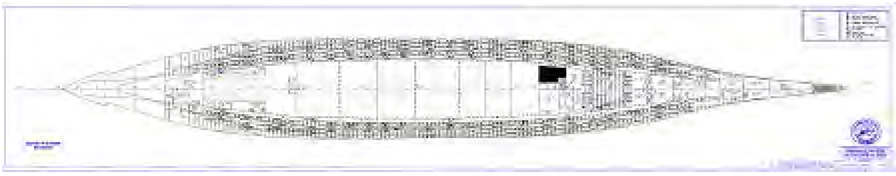


Figure 6.44 Location of compartment A 626 C

Figure 6.45 Overall view of compartment A 626 C

Figure 6.46 Moderate corrosion on floor in compartment A 626 C

6.13. A 625 C, Plotting Room, Frames 74-79

Structural Observations

- Isolated areas of light-to-moderate corrosion, with up to 10% loss of section, were observed on the steel floor throughout the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

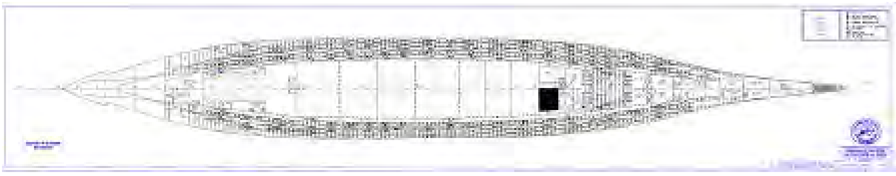


Figure 6.47 Location of compartment A 625 C

Figure 6.48 Overall view of compartment A 625 C

6.14. C 602 M, 2.75" Rocket Heads, Frames 150-155

Structural Observations

- **Light corrosion with up to 10% loss of section was observed on the floor, and to a height of approximately 18-in along the lower walls of the compartment.**
- Light-to-moderate corrosion was observed on the upper walls and ceiling.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 6.49 Location of compartment C 602 M

Figure 6.50 Overall view of compartment C 602 M

Figure 6.51 Moderate-to-heavy corrosion in compartment C 602 M

6.15. C 601 M, Torpedo Component Stowage, Frames 150-154

Structural Observations

- **Moderate-to-heavy corrosion was observed around the floor pan along the perimeter of the room.**
- Light-to-moderate corrosion was observed in exposed areas behind the floor pan.
- The walls, floor, and ceiling of this compartment are covered by insulation. Based on other areas where similar corrosion was observed but portions of the structure behind the lining were exposed, it is likely that corrosion is present behind the lining of this compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 6.52 Location of compartment C 601 M

Figure 6.53 Overall view of compartment C 601 M

Figure 6.54 Moderate-to-heavy corrosion of floor pan in compartment C 601 M

6.16. C 604 T, WT Trunk, Frames 150-151

Structural Observations

- Light corrosion was observed around the perimeter of the steel floor along the wall/floor joint.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 6.55 Location of compartment C 604 T

Figure 6.56 Overall view of compartment C 604 T

6.17. C 603 T, WT Trunk, Frames 150-151

Structural Observations

- Light corrosion was observed on the steel floor in the starboard end of the compartment.
- Isolated areas of light surface corrosion were observed throughout the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

Figure 6.57 Location of compartment C 603 T

Figure 6.58 Overall view of compartment C 603 T

6.18. C 603 ½ T, Dumbwaiter, Frames 153-154

Structural Observations

- **Moderate-to-heavy corrosion was observed on the steel floor at the bottom of the elevator shaft.**

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 6.59 Location of compartment C 603 ½ T

Figure 6.60 Overall view of compartment C 603 ½ T

6.19. C 605 E, JP5 Pump Room, Frames 154-163

Structural Observations

- **Light-to-moderate corrosion with up to 50% loss of section was observed on the floor, and to a height of approximately 6-in along the lower walls of the compartment.**
- **Heavy corrosion with up to 100% loss of section was observed to a height of approximately 6-in along the lower scantlings at the aft end of the compartment.**
- Heavy corrosion was observed on a fire main connection flange at the port side of the compartment.
- **This compartment is severely deteriorated and near term repairs are recommended.**

Additional Observations

- Peeling paint and "red lead" primer were observed.
- Heavy condensation was observed on the floor and lower walls.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

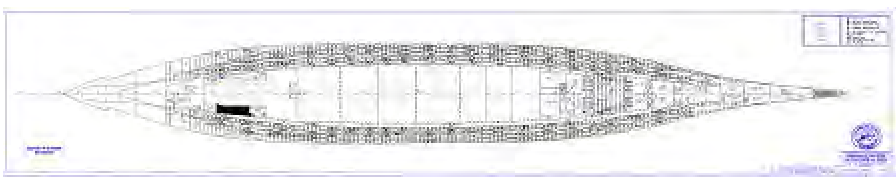


Figure 6.61 Location of compartment C 605 E

Figure 6.62 Overall view of compartment C 605 E

Figure 6.63 Corrosion in aft end of compartment C 605 E

Figure 6.64 Severe corrosion of lower scantlings in compartment C 605 E

Figure 6.65 Heavy corrosion of lower walls in compartment C 605 E

6.20. C 606 M, 5" Powder Magazine, Frames 155-163

Structural Observations

- **Moderate corrosion with up to 50% loss of section was observed to a height of approximately 6-in along the lower scantlings in the aft section of the compartment.**
- Light-to-moderate corrosion was observed on the floor at the forward end of the compartment.
- Evidence of a previous or slow active utility leak was observed in the forward port corner of the compartment.
- The walls, floor, and ceiling of this compartment are covered by insulation. Based on other areas where similar corrosion was observed but portions of the structure behind the lining were exposed, it is likely that corrosion is present behind the lining of this compartment.
- Severe corrosion was observed on the floor pan throughout the compartment.

Additional Observations

- Condensation was observed to a height of approximately 3-ft to 4-ft on the inboard wall of the compartment. This may indicate that the adjacent "Cofferdam" area is flooded to this depth.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 6.66 Location of compartment C 606 M

Figure 6.67 Overall view of compartment C 606 M

Figure 6.68 Evidence of corrosion behind wall insulation in compartment C 606 M

Figure 6.69 Severe corrosion in compartment C 606 M

Figure 6.70 Heavy corrosion of lower scantlings in compartment C 606 M

6.21. C 608 A, 20mm Belt Link Stowage, Frames 163-166

Structural Observations

- **Moderate corrosion with up to 30% loss of section (LOS) was observed to a height of approximately 6-in along the lower walls and scantlings throughout the compartment.**
- **Moderate corrosion with up to 30% loss of section (LOS) was observed to cover the entire floor of the compartment.**
- Moderate corrosion was observed to a height of approximately 4-ft along the lower walls of the compartment.

Additional Observations

- One tank access hatch is open and uncovered; the tank below this compartment is flooded.
- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 6.71 Location of compartment C 608 A

Figure 6.72 Overall view of compartment C 608 A

Figure 6.73 Heavy corrosion of lower walls in compartment C 608 A

Figure 6.74 Heavy-to-severe corrosion of lower scantlings in compartment C 608 A

Figure 6.75 Heavy-to-severe corrosion of lower scantlings in compartment C 608 A

6.22. C 607 A, Air Flask, Frames 163-166

Structural Observations

- **Severe corrosion with up to 75% loss of section was observed over the entire floor of the compartment**.
- **Moderate-to-heavy corrosion was observed to a height of approximately 6-in along the lower scantlings in the compartment.**
- **Light-to-moderate corrosion, with isolated areas of heavy corrosion, was observed on the walls throughout the compartment.**
- **This compartment is severely deteriorated and near term repairs are recommended.**

Additional Observations

- One rung is missing from the access ladder.
- Oil residue was observed on the floor and walls of the compartment.
- Moisture and condensation were observed to a height of approximately 4-ft on the lower portion of the inboard wall; this may indicate flooding in the adjacent "Cofferdam" compartment.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 6.76 Location of compartment C 607 E

Figure 6.77 Overall view of compartment C 607 A

Figure 6.78 Moderate-to-heavy corrosion of lower scantlings in compartment C 607 A

Figure 6.79 Heavy corrosion on walls in compartment C 607 A

6.23. C 610 1AE, Refrig. Mach. & Diesel Fire Pump Room, Frames 166-176

Structural Observations

- **Moderate-to-heavy corrosion was observed along the edges of the floor, and to a height of approximately 6-in along the lower walls of the compartment.**

Additional Observations

- 2 Carbon Dioxide fire extinguisher tanks with intact valves were observed.
- Three of ten treads on the access ladder show evidence of deterioration.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 6.80 Location of compartment C 610 1AE

Figure 6.81 Overall view of compartment C 610 1AE

Figure 6.83 Moderate-to-heavy corrosion of lower scantlings in compartment C 610 1AE

6.82 Overall view #2 of compartment C 610 1AE

Figure 6.84 Moderate-to-heavy corrosion on floor in compartment C 610 1AE

6.24. C 612 A, Paint & Inflam. Store Rm, Frames 166-172

Structural Observations

- **A band of moderate-to-heavy corrosion, extending outboard approximately 24-in, was observed along the inboard edge of the lower floor of the compartment.**
- Areas of light-to-moderate corrosion were observed on the floor and lower structural beams throughout the compartment.

Additional Observations

- 2 Carbon Dioxide fire extinguisher tanks with intact valves were observed.
- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

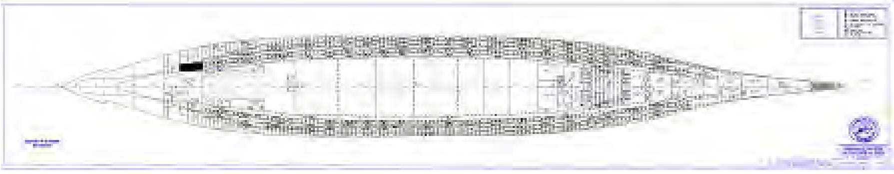


Figure 6.85 Location of compartment C 612 A

Figure 6.86 Overall view of compartment C 612 A

Figure 6.87 Moderate-to-heavy corrosion on floor in compartment C 612 A

Figure 6.88 Light-to-moderate corrosion in compartment C 612 A

6.25. C 613 A, Paint & Inflam. Store Rm, Frames 166-172

Structural Observations

- **A band of moderate-to-heavy corrosion, extending outboard approximately 24-in, was observed along the inboard edge of the lower floor of the compartment.**
- Areas of light-to-moderate corrosion were observed on the floor and lower structural beams throughout the compartment.

Additional Observations

- 2 Carbon Dioxide fire extinguisher tanks with intact valves were observed.
- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 6.89 Location of compartment C 613 A

Figure 6.90 Overall view of compartment C 613 A

Figure 6.91 Moderate-to-heavy corrosion on floor in compartment C 613 A

6.26. C 610 3AE, Paint & Inflam. Store Rm, Frames 170-174

Structural Observations

- No significant structural issues were observed.
- Isolated areas of light-to-moderate corrosion were observed on the floor of the compartment.

Additional Observations

- 2 Carbon Dioxide fire extinguisher tanks with intact valves were observed.
- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

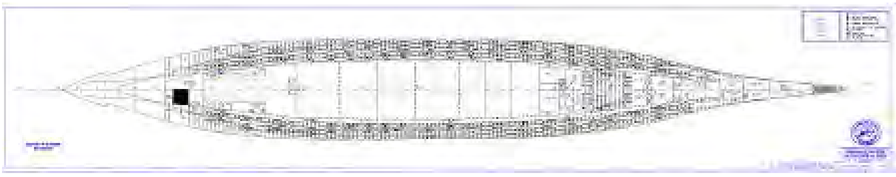


Figure 6.92 Location of compartment C 610 3AE

Figure 6.93 Overall view of compartment C 610 3AE

6.27. C 610 5AE, Sensitized Film, Frames 174-176

Structural Observations

- No significant structural issues were observed.
- Isolated areas of light corrosion were observed under the floor finish throughout the compartment.

Additional Observations

- Peeling paint and “red lead” primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

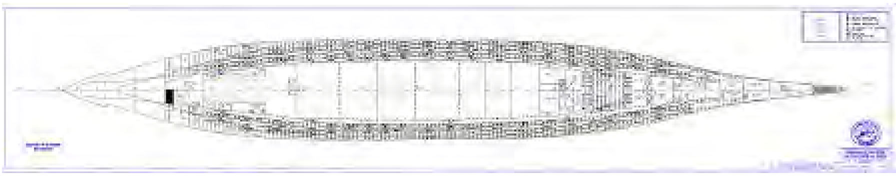


Figure 6.94 Location of compartment C 610 5AE

Figure 6.95 Overall view of compartment C 610 5AE

7. Hold

Typical conditions: The compartments on the Hold level (7th Deck) were generally found to have varying degrees of deterioration that typically included light-to-moderate corrosion and peeling paint. Several compartments were observed to be in a state of severe deterioration. A number of compartments were found to be flooded to unknown depths and were inaccessible for inspection. A graphic representation of the severity of the deterioration observed at each compartment is provided on the following page. Potential environmental and/or health hazards were observed at a number of compartments, including asbestos, "red lead" primer, and oil/fluid spills or leaks. An environmental assessment of the vessel was performed by The Shaw Group (Shaw) in 2013 and was not included in the scope of this structural assessment. A summary of Shaw's findings and recommendations was provided in Shaw's report dated April 12th, 2013.

7.1. Overview of Hold

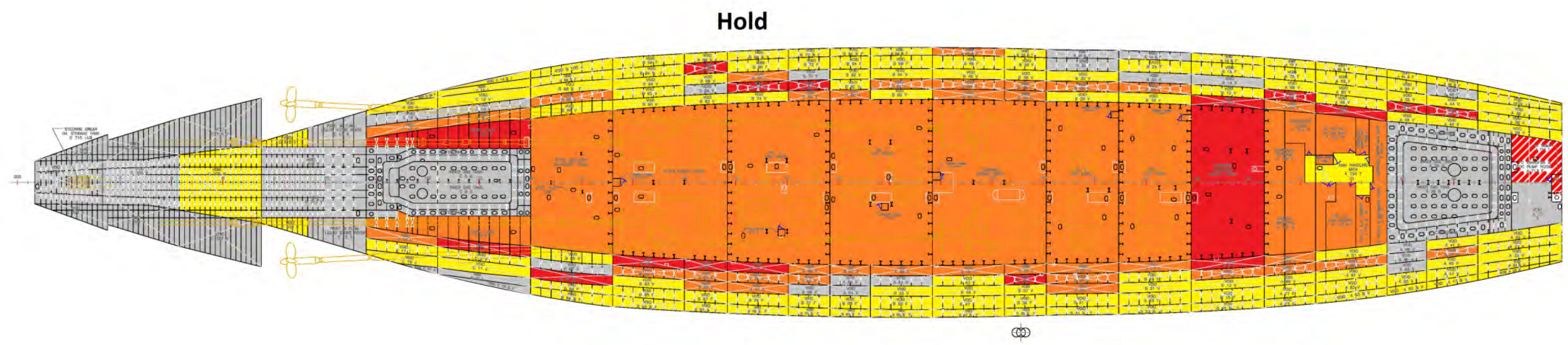


Figure 7.1 Overview of Hold

- Minor deterioration - long-term concern
- Moderate deterioration - monitoring recommended
- Significant deterioration - near-term repair recommended
- Inaccessible / not inspected

7.2. A 712 T, WT Trunk, Frames 50-51

- **This compartment is flooded to an unknown depth and could not be fully inspected.**
- **Corrosion is visible throughout the compartment.**
- **Based on conditions observed in areas of the ship which were previously flooded for extended periods, it is likely that structural components in this compartment are severely deteriorated. Near term repairs are likely warranted.**

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 7.2 Location of compartment A 712 T

Figure 7.3 Overall view of flooding in entry to compartment A 712 T

7.3. A 713 E, FO Transfer & Pump Room, Frames 50-55

- **This compartment is flooded to an unknown depth and could not be fully inspected.**
- **Corrosion is visible throughout the compartment.**
- **Based on conditions observed in areas of the ship which were previously flooded for extended periods, it is likely that structural components in this compartment are severely deteriorated. Near term repairs are likely warranted.**

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 7.4 Location of compartment A 713 E

Figure 7.5 Overall view of flooding in compartment A 713 E

7.4. A 720 M, Sidewinder Motor Mag Comp, Frames 67-68 ½

Structural Observations

- **Severe corrosion was observed to a height of approximately 8-in along the lower scantlings at the starboard end of the compartment.**
- **Moderate corrosion was observed on the floor at the starboard end of the compartment.**
- **Moderate corrosion was observed on the remainder of the floor and on all walls.**

Additional Observations

- Moisture was observed on the lower section of the forward wall; this may indicate flooding in the adjacent “Cofferdam” compartment

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 7.6 Location of compartment A 720 M

Figure 7.7 Overall view of compartment A 720 M

Figure 7.9 Heavy-to-severe corrosion in starboard end of compartment A 720 M

Figure 7.8 Heavy-to-severe corrosion in starboard end of compartment A 720 M

Figure 7.10 Severe corrosion of lower walls in compartment A 720 M

7.5. A 721 M, 5" Rocket & Sidewinder Heads, Frames 67-68 ½

Structural Observations

- **Light corrosion with 20-25% loss of section (LOS) was observed over the entire floor of the compartment. This corrosion was most severe at the starboard end of the compartment.**
- **Moderate corrosion was observed along the full height of all walls.**
- **Varying degrees of corrosion, from light-to-moderate to heavy, were observed along the lower flanges of ceiling beams. The second beam from the ship's centerline has up to 50% LOS on its lower flange.**

Additional Observations

- Moisture was observed on the lower section of the forward wall; this may indicate flooding in the adjacent "Cofferdam" compartment

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 7.11 Location of compartment A 721 M

Figure 7.12 Overall view of compartment A 721 M

Figure 7.13 Moderate-to-heavy corrosion on floor in compartment A 721 M

Figure 7.14 Moderate-to-heavy corrosion on walls in compartment A 721 M

Figure 7.15 Heavy corrosion on lower flange of ceiling beam in compartment A 721 M

7.6. A 724 T, Amm Handling Area, Frames 68-75

Structural Observations

- **Light-to-moderate corrosion, with up to 15% loss of section, was observed along the bottom flanges of the ceiling beams.**
- Light-to-moderate corrosion was observed on all surfaces in the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space classifies as a long term concern.

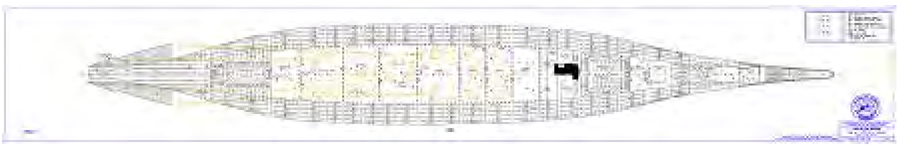


Figure 7.16 Location of compartment A 724 T

Figure 7.17 Overall view of compartment A 724 T

Figure 7.19 Light-to-moderate corrosion on walls in compartment A 724 T

Figure 7.18 Light-to-moderate corrosion on ceiling beams in compartment A 724 T

Figure 7.20 Light-to-moderate corrosion on floor in compartment A 724 T

7.7. A 721 ½ M, 100lb GP Bombs, Frames 68 ½ -70

Structural Observations

- **An approximately 6-ft wide area of light-to-moderate corrosion was observed on the floor in the port end of the compartment.**
- **Moderate corrosion was observed on the ceiling, ceiling beams and walls with up to 50% loss of section on ceiling beams.**
- **This compartment is severely deteriorated and near term repairs are recommended.**

Additional Observations

- Evidence of moisture was observed throughout the compartment.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 7.21 Location of compartment A 721 ½ M

Figure 7.22 Heavy corrosion on floor in compartment A 721 ½ M

Figure 7.23 Heavy-to-severe corrosion on floor in starboard end of compartment A 721 ½ M

Figure 7.24 Moderate-to-heavy corrosion on ceiling beams in compartment A 721 ½ M

Figure 7.25 Heavy corrosion on floor in starboard end of compartment A 721 ½ M

7.8. A 720 ½ A, Sidewinder Target Kits, Frames 68 ½ -70

Structural Observations

- **Moderate-to-heavy corrosion was observed on the floor at the starboard end of the compartment.**
- Isolated areas of light-to-moderate corrosion were observed throughout the compartment.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 7.26 Location of compartment A 720 ½ A

Figure 7.27 Overall view of compartment A 720 ½ A

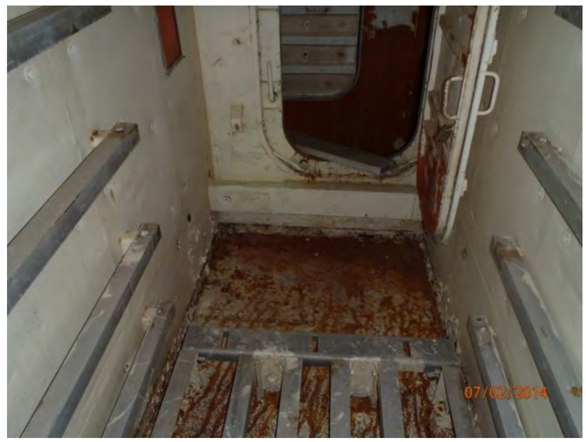


Figure 7.28 Moderate-to-heavy corrosion on floor in starboard end of compartment A 720 ½ A

7.9. A 722 M, 5" Rocket Motor Mag, Frames 70-74

Structural Observations

- **Moderate-to-heavy corrosion was observed along the starboard and aft walls and adjoining areas of the floor of the compartment.**
- Isolated areas of light-to-moderate corrosion were observed throughout the compartment.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 7.29 Location of compartment A 722 M

Figure 7.30 Overall view of compartment A 722 M

Figure 7.31 Moderate-to-heavy corrosion on floor in compartment A 722 M

7.10. A 723 M, 100lb Frag Bombs, Frames 70-73

Structural Observations

- **Light corrosion was observed on the floor and to a height of approximately 12-in along the lower walls and scantlings throughout the compartment.**
- Light-to-moderate corrosion was observed along the full height of all walls.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 7.32 Location of compartment A 723 M

Figure 7.33 Overall view of compartment A 723 M

Figure 7.35 Moderate corrosion and peeling paint on wall in compartment A 723 M

Figure 7.34 Corrosion on floor and walls in compartment A 723 M

Figure 7.36 Moderate-to-heavy corrosion on lower scantlings in compartment A 723 M

7.11. A 725 M, Rocket Magazine, Frames 72-79

Structural Observations

- **Moderate corrosion was observed along the interface of the wall and the floor along the port end of the compartment.**
- **Moderate-to-severe corrosion with 40-50% loss of section was observed on the floor, and to a height of approximately 4-in of the lower scantlings in the forward port corner of the compartment.**
- **Moderate corrosion was observed to a height of approximately 6-in along the lower walls along the perimeter of the compartment.**

Additional Observations

- Severe corrosion, with 100% loss of section, was observed on the lower portion of one overhead utility pipe.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

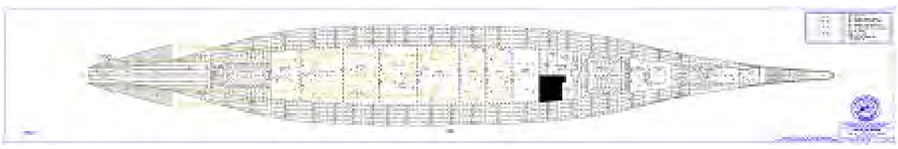


Figure 7.37 Location of compartment A 725 M

Figure 7.38 Overall view of compartment A 725 M

Figure 7.39 Heavy-to-severe corrosion on lower scantlings in compartment A 725 M

Figure 7.40 Corrosion behind insulation on ceiling beam in compartment A 725 M

Figure 7.41 Corroded utility pipe in compartment A 725 M

7.12. A 724 ½ T, Ammo Hoist, Frames 72 ½ -74

Structural Observations

- Light-to-moderate corrosion was observed over the entire floor, and to a height of approximately 3-in along the lower walls in the compartment.

Additional Observations

- Peeling paint and "red lead" primer were observed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 7.42 Location of compartment A 724 ½ T

Figure 7.43 Overall view of compartment A 724 ½ T

Figure 7.44 Light-to-moderate corrosion on floor and lower walls in compartment A 724 ½ T

7.13. A 726 M, Sidewinder Fuzes, Frames 74-77

Structural Observations

- **Moderate-to-heavy corrosion was observed on the floor at the starboard end of the compartment.**
- **Moderate-to-heavy corrosion was observed at the base of scantlings along the forward bulkhead at Frame 74.**
- Light surface corrosion was observed over 100% of the floor of the compartment.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

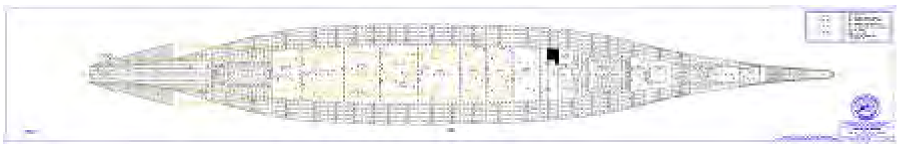


Figure 7.45 Location of compartment A 726 M

Figure 7.46 Overall view of compartment A 726 M

Figure 7.47 Moderate-to-heavy corrosion at base of scantlings in compartment A 726 M

7.14. A 728 A, Sonobuoy Stowage, Frames 75-79

Structural Observations

- **Light-to-moderate corrosion was observed along the interface of the wall and the floor, and along the lower scantlings, at the starboard end of the compartment.**
- **Proceeding outward from centerline, the 2nd, 3rd and 4th longitudinal ceiling beams have light corrosion with 10-15% loss of section.**
- Light-to-moderate corrosion was observed under the floor finish throughout compartment.

Additional Observations

- 5 of 7 scantlings on the starboard bulkhead of the compartment do not have stiffener plates at the base of the scantling; this is inconsistent with construction practices observed throughout the rest of the ship.
- Severe corrosion, with 100% loss of section, was observed on the lower portion of one overhead utility pipe.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 7.48 Location of compartment A 728 A

Figure 7.49 Overall view of compartment A 728 A

Figure 7.50 Corrosion on lower portions of ceiling beams in compartment A 728 A

Figure 7.51 Light-to-moderate corrosion on lower scantlings in compartment A 728 A

Figure 7.52 Severe corrosion of utility pipe in compartment A 728 A

7.15. C 702 E, Shaft Alley (Port), Frames 150-161

Structural Observations

- **Moderate-to-heavy corrosion with up to approximately 60% loss of section (LOS) was observed on the floor plate, lower bulkheads, and scantlings throughout the compartment.**
- **The outboard bulkhead of the compartment was observed to be bulging inward in an area of moderate corrosion with up to 30% LOS.**
- **Areas of severe corrosion with up to 100% LOS were observed on the floor gratings and handrail of the walkway used to access the aft portion of the compartment.**
- **Standing water approximately 8-in deep was observed on the lower floor at the inboard edge of the compartment.**

Additional Observations

- The ladder used to access the compartment is loosely attached to the forward bulkhead; moderate corrosion was observed on several portions of the ladder and its supports.
- Peeling paint was observed.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 7.53 Location of compartment C 702 E Shaft Alley (Port)

Figure 7.54 Overall view of compartment C 702 E

Figure 7.55 Corrosion of floor and fittings in compartment C 702 E

Figure 7.56 Standing water at inboard edge of compartment C 702 E

Figure 7.57 Corrosion of walkway grating and handrail in compartment C 702 E

7.16. C 701 E, Shaft Alley (Stbd), Frames 150-161

Structural Observations

- **Moderate corrosion with up to approximately 30% loss of section (LOS) was observed on the floor plate and lower scantlings throughout the compartment.**
- **Areas of severe corrosion with up to 100% LOS were observed on the floor gratings and handrail of the walkway used to access the aft portion of the compartment.**

Additional Observations

- Peeling paint and “red lead” primer were observed.
- The compartment shows evidence of possible previous flooding to a depth of approximately 5-ft to 6-ft.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

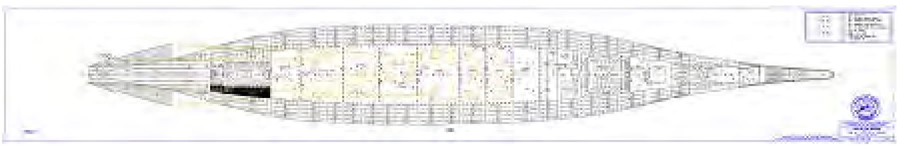


Figure 7.58 Location of compartment C 701 E Shaft Alley (Stbd)

Figure 7.59 Overall view of compartment C 701 E

Figure 7.61 Corrosion of lower scantlings in compartment C 701 E

Figure 7.60 Moderate corrosion of floor and lower scantlings in compartment C 701 E

Figure 7.62 Oil band showing depth of possible previous flooding in compartment C 701 E

8. AUXILIARY MACHINERY ROOMS (AMR)

- *See "Ship's History and Equipment" for a detailed report of the equipment contained within the Auxiliary Machinery Rooms.*

8.1. Forward Auxiliary Machinery Room, B-1-1, Frames 79 – 86

Upper Flat

- In excellent structural condition with flaking paint and minor asbestos dust in corners and on top of some components.
- Rear of 480V, 3 Phase power panels not secured from casual entry.

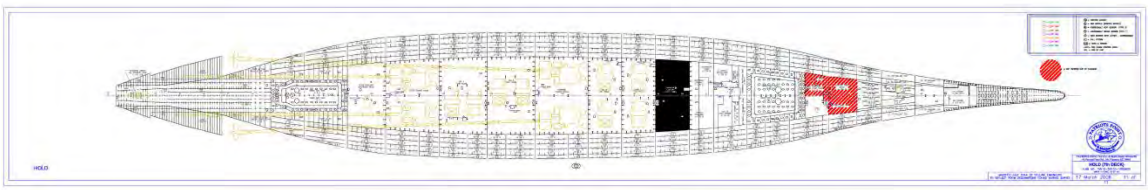


Figure 8.1 Location of Forward AMR B-1-1

Figure 8.2 Steam turbo generator on upper flat of AMR.

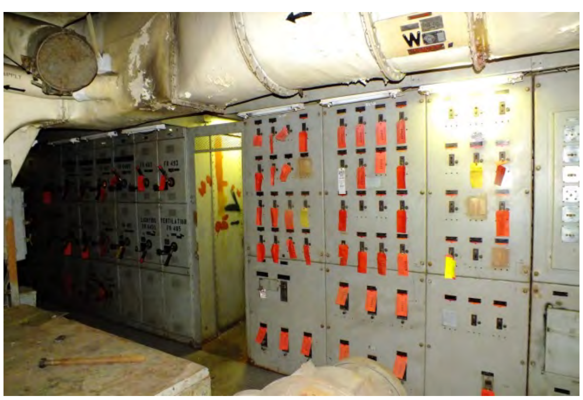


Figure 8.3 Ship's 480V AC power/breaker panels on upper flat of AMR.

Figure 8.4 Compressor and side shell redundant wiring trunks.

Lower Flat

- **An active leak was observed from a utility connection at the starboard bulkhead of the compartment.**
- Minor amounts of oil on floor under all fuel oil manifolds outboard (port & starboard) and where piping has been disturbed. Piping to both port & starboard where dissimilar metals are utilized show moderate to heavy corrosion; this is a condition warranting attention as piping extends into outboard tankage.
- Foundations of all major components in lower flat have minor to moderate rust/scale; but are in good condition.
- Heavy amounts of flaking paint throughout space and minor amounts of asbestos dust on components and in corners.
- Lighting needs repair as there are many burned out fixtures.
- Floor panels require refastening.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 8.5 Active leak from utility connection at starboard bulkhead.

Figure 8.6 Outboard fuel piping manifold, showing leakage from valves and oil on deck.

Figure 8.7 General condition of floor and intersection of vertical stanchion.

Figure 8.8 General condition of aft transverse bulkhead where it intersects the floor.

8.2. Aft Auxiliary Machinery Room, B-8-1, Frames 142 – 150

This space contains one flat for machinery components.

- **This space contains 8"+ of standing oil/water throughout space.**
- This space has much peeling/flaking paint throughout.
- Minor amounts of friable asbestos dust on components or in corners of space.
- Structural condition of the space, foundations and bulkheads is excellent.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

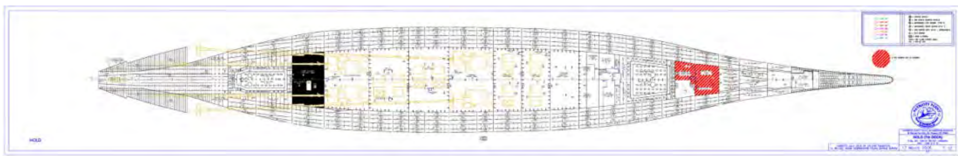


Figure 8.9 Location of Aft Machinery Room B-8-1

Figure 8.10 Standing oil in lower portions of compartment

Figure 8.11 Standing oil in lower portions of compartment

Figure 8.12 Shaft flax packing gland for starboard outboard shaft.

Figure 8.13 Debris around and on top of components in Aft Machinery Room.

Figure 8.14 Pillow block or bearing for inboard shaft in Aft Machinery Room

9. Engineering Plant

- *See "Ship's History and Equipment" for a detailed report of the equipment contained within the Auxiliary Machinery Rooms.*

9.1. No. 1 FIREROOM, B-2-1, Frames 86 – 93

The nomenclature of these Fireroom spaces has already been discussed and is not recounted here.
Upper Flat

- Missing stanchions and handrails on centerline ladders to lower flat.
- Deck plating and support foundations corroded between boilers at aft bulkhead at Frame 93.
- Fuel manifolds leaking minor amounts of fuel oil.
- Heavy flaking of paint throughout space.
- Generally in good structural condition on the upper flat.

Classify this space as an area to monitor for long term concerns.

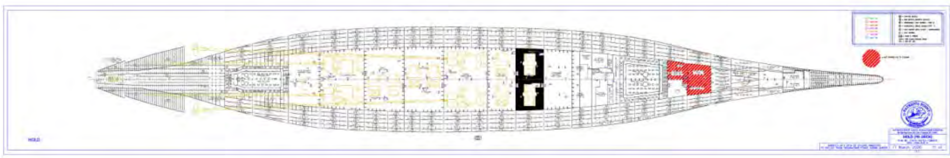


Figure 9.1 Location of No. 1 Fireroom B-2-1

Figure 9.2 Missing flooring at aft bulkhead

Figure 9.3 Missing handrails from centerline ladder well.

Lower Flat

- Lower bilge scantlings exhibit 20 – 30% plate loss throughout space; although major foundations and vertical stanchions are in good condition.
- Friable asbestos is present throughout space due to loose piping covers.
- Heavy flaking of paint systems throughout lower flat.
- Aft bulkhead showing 30 – 40% plate loss at base. Forward bulkhead showing 20% plate loss.
- There are two vintage CO-2 bottles that should be removed.
- Intercostals on lower aft bulkhead are corroded away on centerline.
- Forward vertical bulkhead frames corroded 20 – 30% away at bases.
- Piping on boilers and in lower bilges at aft bulkhead badly corroded; some leaking bunker oil into bilges.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 9.4 Moderate corrosion of vertical aft bulkhead scantling.

Figure 9.5 Heavy corrosion of bulkhead surrounding dissimilar metal piping.

Figure 9.6 Athwartships view of lower fireroom flat, looking to port.

9.2. No. 2 FIREROOM, B-3-1, Frames 93 – 100

Upper Flat

- Upper Flat is open to the public. Space is well lighted and properly marked.
- Minor amount of friable asbestos dust on components and in corners.
- Paint in relatively good condition; flaking behind wire trunk runs outboard.
- Space is in excellent structural condition.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

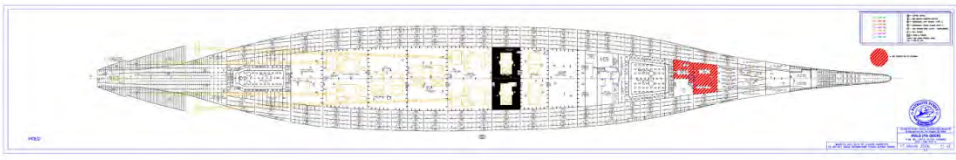


Figure 9.7 Location of No. 2 Fireroom B-#-1

Figure 9.8 Upper flat of Fireroom #2.

Figure 9.9 Upper flat, looking aft to bulkhead cut-out to Forward Engineroom.

Figure 9.10 Upper flat, showing detail of port Bulkhead

Figure 9.11 Large steam powered blower in upper flat of fireroom.

Lower Flat

- Lower bilge scantlings exhibit 20 – 30% plate loss throughout space; major foundations and vertical stanchions are in good condition.
- Friable asbestos dust is present throughout space to starboard.
- Heavy flaking of paint systems throughout lower flat.
- Aft bulkhead exhibits 30 – 40% plate loss at base. Forward bulkhead exhibits 30- 40% plate loss.
- Lower outboard bulkhead vertical frames exhibit 20 – 30% corrosion port & starboard.
- Forward vertical bulkhead frames corroded 20 – 30% away at bases.
- Corroded piping in lower bilges.
- Space exhibits evidence of approximately 6-in of standing water in the past.
- CO-2 bottles to port on the forward bulkhead should be removed.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 9.12 Dissimilar metal manifolds at aft bulkhead. Notice degradation of floor and bulkhead interface.

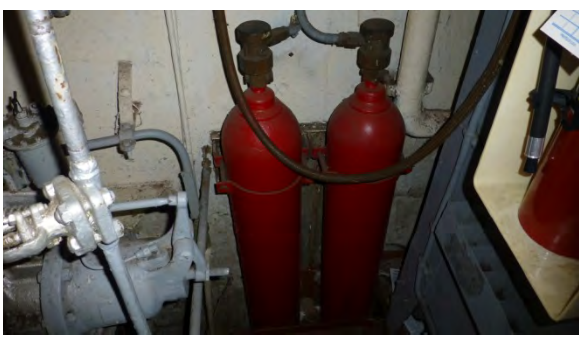


Figure 9.13 CO-2 bottles port side forward.

Figure 9.14 Fireroom floor, notice evidence of past standing water. Rust/scale abound.

Figure 9.15 Lower flat of Fireroom #2, well painted components.

9.3. FORWARD ENGINEROOM, B-4-1, Frames 100 – 111

This space contains two turbine/reduction gear units mounted to the outboard sides of the space with a pair of output shafts for the outboard propellers.

Upper Flat

- Upper Flat is open to the public. Space is well lighted and properly marked.
- In excellent structural and cosmetic condition.
- Minor paint flaking throughout space.

Classify this space as a long term concern only.

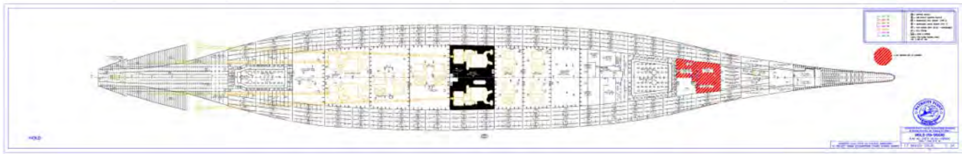


Figure 9.16 Location of Forward Engine Room B-4-1

Figure 9.17 Throttle board to starboard for starboard turbine & reduction gear.

Figure 9.19 L.P. steam turbine, looking aft to starboard.

Figure 9.18 Port forward bulkhead, upper forward engine room.

Figure 9.20 Reduction gear to starboard.

Lower Flat

- Friable asbestos throughout space.
- Moderate peeling and flaking of paint systems throughout space.
- Heavily scaled piping through forward and aft bulkheads low in bilges.
- 7” O.D. vertical stanchions corroded 30% at bases.
- **Forward and aft bulkheads corroded with up to 25% loss of section where they intersect floor.**
- Minor oil and standing water in bilges; evidence of greater than 1’ standing oil/water in past.
- Caps to sounding tubes not installed.
- Lube oil and bunker oil in piping and filters on lower flat.
- Heavy rust/scale of bulkhead and vertical frames on port side.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 9.21 Heavily corroded piping through transverse bulkhead.

Figure 9.23 Uncapped sounding tubes.

Figure 9.22 Standing 2”+ oil/water at aft bulkhead

Figure 9.24 Typical foundation base in lower flat of engineroom.

Figure 9.25 Output shaft at rear of reduction gear.

Figure 9.26 Rear catwalk, aft bulkhead, lower engineroom flat.

9.4. #3 FIREROOM, B-5-1, Frames 111 – 121

Upper Flat

- Deck plating and support foundations corroded between boilers in various places.
- Fuel manifolds leaking minor amounts of fuel oil.
- Heavy flaking of paint throughout space.
- Generally in good structural condition on the upper flat with intact foundations and vertical stanchions..
- Many lighting fixtures need new bulbs/starters.

Classify this space as an area to monitor for long term concerns.

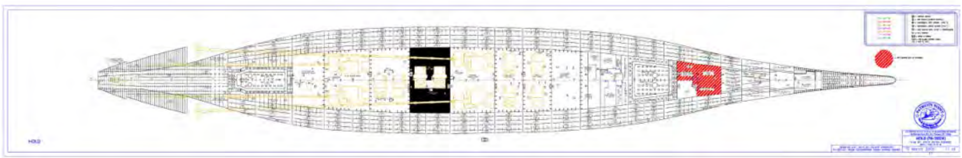


Figure 9.27 Location of Fireroom B-5-1

Figure 9.28 Missing floor plates in Upper Flat.

Figure 9.30 Electrical panels in Upper Flat of Fireroom #3.

Figure 9.29 Athwartships passage between fore and aft boiler, looking to port.

Figure 9.31 Ship's steam turbo generator on Upper Flat.

Lower Flat

- Friable asbestos dust throughout space.
- Moderate/heavy peeling and flaking of paint systems throughout space.
- Heavily scaled piping through forward and aft bulkheads low in bilges.
- **Forward and aft bulkheads corroded 25% where bulkheads intersect floor.**
- Minor oil and standing water in bilges; evidence of greater than 1’ standing oil/water in past.
- Caps to sounding tubes not installed.
- Lube oil and bunker oil in sumps, piping & filters on lower flat.
- Light to moderate rust/scale of bulkhead and vertical frames on port and starboard sides
- Many lighting fixtures require new bulbs and/or starters..

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 9.32 Dried & caked bunker oil on bilge floors throughout space.

Figure 9.34 Face of forward boiler in lower flat of #3 Fireroom, looking to starboard.

Figure 9.33 Foundations and caked oil on bilge floors.

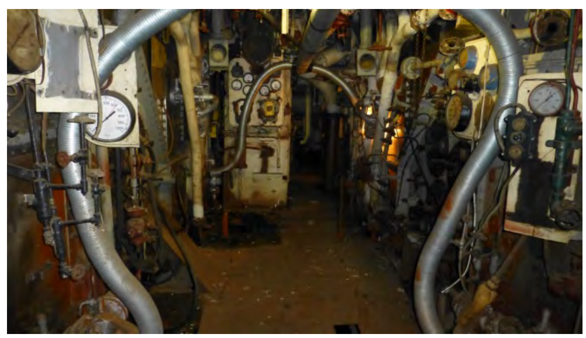


Figure 9.35 Path between both fore and aft boilers, lower flat, #3 Fireroom.

9.5. No. #4 FIREROOM, B-6-1, Frames 121 – 131

Upper Flat

- Deck plating and support foundations corroded between boilers in various places.
- Fuel manifolds leaking minor amounts of fuel oil.
- Heavy flaking of paint throughout space.
- Generally in good structural condition on the upper flat with intact foundations and vertical stanchions..
- Many lighting fixtures need new bulbs/starters.

Classify this space as an area to monitor for long term concerns.

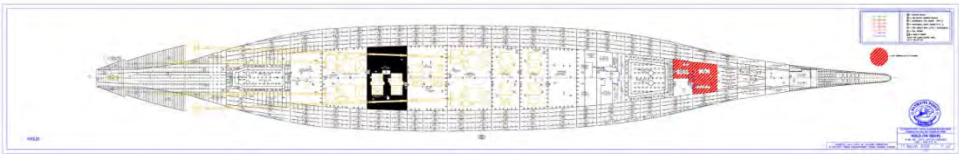


Figure 9.36 Location of No. 4 Fireroom B-6-1

Figure 9.37 Path between both boilers. set end-to-end on upper flat of #4 Fireroom.

Figure 9.39 Heavy wiring connections behind electrical panels.

Figure 9.38 480V, 3 Phase, electrical panel in upper flat of Fireroom #4.

Lower Flat

- Friable asbestos dust throughout space.
- Moderate/heavy peeling and flaking of paint systems throughout space.
- Heavily scaled piping through forward and aft bulkheads low in bilges.
- **Forward bulkhead corroded 20 – 25% at floor and aft bulkheads corroded 25 - 40% where it intersects floor.**
- Minor oil & standing water in bilges; evidence of greater than 1’ standing oil/water in past.
- Caps to sounding tubes not installed.
- Lube oil & bunker oil in sumps, piping, and filters on lower flat.
- Light to moderate rust/scale of bulkheads and vertical frames on port and starboard sides
- Many lighting fixtures require new bulbs and/or starters.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 9.40 Face of forward boiler, looking to starboard, lower flat of #4 Fireroom.

Figure 9.42 Typical bilge condition found in Fireroom #4.

Figure 9.41 Starboard shaft exiting to Aft Engineroom.

Figure 9.43 Typical foundation in Fireroom #4.

Figure 9.44 Oil stained piping and floor in Fireroom #4.

Figure 9.45 Heavily corroded piping through aft bulkhead in Fireroom #4.

9.6. AFT ENGINEROOM, B-7-1, Frames 131 – 142

This space contains two turbine/reduction gear units mounted to the inboard sides of the space with a pair of output shafts for the inboard propellers. Outboard shafts pass through this space.
Upper Flat

- In excellent structural and fair/good cosmetic condition. Space is not well lighted and marked.
- Heavy paint flaking throughout space.
- Friable asbestos dust on deck and components.
- Lighting fixtures require new bulbs and/or starters.

Classify this space as a long term concern only.

Figure 9.46 Location of Aft Engine Room B-7-1

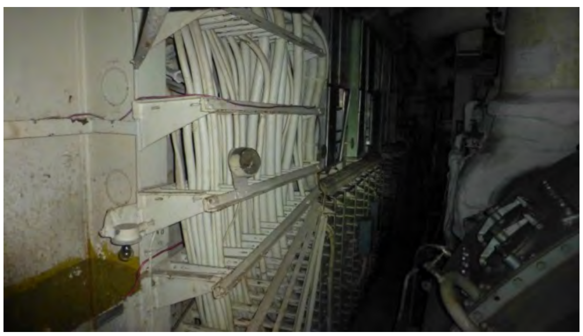


Figure 9.47 Wiring trunks outboard of reduction gear to port on upper flat.

Figure 9.49 High & low pressure steam turbines in upper flat of Aft Engineroom.

Figure 9.48 Light to moderate corrosion on port outboard bulkhead in upper flat of Aft Engineroom.

Figure 9.50 Corroded paint system on side shell and vertical scantling, port side, upper flat.

Lower Flat

- Friable asbestos throughout space.
- Moderate peeling and flaking of paint systems throughout space.
- Heavily scaled piping through forward and aft bulkheads low in bilges.
- 7" O.D. vertical stanchions corroded 30% at bases.
- **Forward and aft bulkheads corroded 25% where bulkheads intersect floor.**
- Evidence of oil and standing water in bilges; evidence of greater than 1-ft standing oil/water in past.
- Caps to sounding tubes not installed.
- Lube oil and bunker oil in sumps, piping and filters on lower flat.
- Heavy rust/scale of bulkhead and vertical frames on port side and starboard sides.

Due to the observed deficiencies, this space requires monitoring for further deterioration.

Figure 9.51 Typical bilge conditions with debris and old standing oil detritus; notice corroded piping at aft transverse bulkhead.

Figure 9.52 Dis-similar metal component (bronze) lying in waste oil tank below engineroom floor.

Figure 9.53 Output shaft to starboard reduction gear in lower flat of Aft Engineroom.


Figure 9.54 Typical condition of major component foundations.


Figure 9.55 Typical condition of major component foundations.

10. Steering Gear and Motor Control Rooms

10.1. MOTOR CONTROL ROOM, C-517E, Frames 186 1/2 – 191 1/2

- This space (C-517E) contains the motor controllers for the pair of steering gear motors. A large hole was cut into the armored overhead for removal of components in the past. Main controllers and associated equipment has been removed.
- Corrosion was observed around the edges of the cut in the overhead of the compartment.
- Much standing hydraulic oil on components.
- The space has red lead, PCB and standing oil.
- Peeling paint throughout space.

Classify this space as a long term maintenance concern, unless work is contemplated in Steering Gear Ram Room just aft.

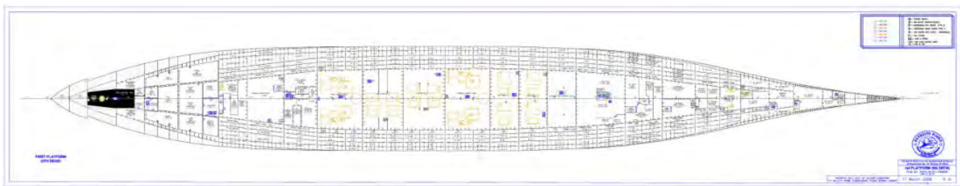


Figure 10.1 Location of Motor Control Room C 517 E

Figure 10.2 Corrosion at edges of torched hole in overhead of compartment C 517 E

Figure 10.3 Looking aft on centerline in Motor Controller Room, showing where controllers were removed.

Figure 10.4 Looking aft on centerline in Motor Controller Roo

10.2. STEERING GEAR RAM ROOM, C-518E, Frames 191 ½ - 198

- This space is aft of the Motor Controller Ram room. Mostly original as these are major components consisting of the rudder post, crosshead and pair of hydraulic rams
- The space has red lead, PCB and standing oil/water issues to a depth of 6-in.
- Peeling paint throughout space.
- Exposed & operational wiring unsafe for personnel due to standing water.
- Rudder pushed up 2-in+ due to Hurricane Hugo allowing water to enter when outside conditions raise water level above Steering Flat. Consider digging out around rudder, lowering rudder and repacking flax packing gland. A watertight dogging door is fitted to the forward bulkhead to insulate the forward space and vertical trunk from further flooding.

Due to the observed deficiencies, this space requires near term repair. Refer to Task 7 for recommended repairs.

Figure 10.5 Starboard hydraulic rams, looking aft to crosshead.

Figure 10.6 Rudder post between hydraulic rams showing packing ring underwater at base of rudder post.

11. Tanks

11.1. Condition Assessment of Structural Tanks by Shaw

On behalf of Collins Engineers, Inc., a corrosion survey for the structural tanks and compartments of the USS Yorktown, located at Patriots Point in Mount Pleasant, South Carolina was conducted by Shaw Environmental & Infrastructure (SHAW) a CB&I company during the months of November and December 2012. A visual corrosion inspection rating scale was used for the accessible compartments in the interior of the vessel. This visual corrosion was ranked as (Type 1) only minor spot rusting, paint intact or little to no deterioration, (Type 2) surface corrosion, flaking and light pitting or minor deterioration, (Type 3) moderate metal loss, severe pitting and peeling or moderate deterioration, and (Type 4) significant metal loss or significant deterioration. Only types 1, 2, and 3 were observed with no type 4 detected. Pictures were taken in each structural tank including top of deck head, sides, and bottom of tank to document the condition of the metal in the compartment. Only accessible representative spaces were inspected with notation made as to general structural condition. Shaw has found and documented 428 tanks, structures, or compartments that contain environmental contaminants or hazards. This photo documented corrosion survey includes 346 of these structural tanks and compartments that have been inspected and included in Table 1. There was no access to 119 of these tanks which included 78 that could only be accessed by sounding tubes, 31 that were water filled, and 10 compartments could not be accessed. There was 227 type 1, 2, and 3 tanks, tank structures, or compartments accessible for inspection for this survey. Tanks, tank structures, and compartments were inspected from Bow to Stern and included the fourth, fifth, sixth, and seventh decks, and the hull of the ship.

There were 311 tanks located within the scope of Task 5 of this assessment, beginning at Frame 50 and continuing aft to the stern of the ship. Of the 311 tanks located within the scope of Task 5, 106 were inaccessible; 139 were found to have minor deterioration; 50 were found to have moderate deterioration; and 16 were found to have significant deterioration.

11.2. Table of Tank Inspection Findings

Tank ID	Name	Frame	Condition
A28V	Inner Void A-28V	52	No Access
A612V	Interior Void Comp	52	No Access
A-805V	Central Lower Skin	52	No Access
A-909F	Bottom Skin	52	No Access
A-911W	Bottom Skin	52	No Access
A34.5V	Inner Void A-34.5V	60	No Access
A35.5V	Inner Void A-35.5V	60	No Access
A-44V	Inner Ballast A-44V	60	No Access
A-46F	Outer Ballast A-46F	60	No Access
A-52V	Inner Ballast A-52V	64	No Access
A622V	Upper Inner Skin	72	No Access
A-807V	Central Lower Skin	72	No Access
A-808 V	Central Lower Skin	72	No Access
A-913V	Bottom Skin	72	No Access
A-915V	Bottom Skin	72	No Access
A627V	Upper Inner Skin	76	No Access
A-917W	Bottom Skin	76	No Access
A-918W	Bottom Skin	76	No Access
B-14V	Inner Ballast B-14V	83	No Access
B-801V	FWD AMR Floor	83	No Access
B-802V	FWD AMR Floor	83	No Access
B-902W	FWD AMR Hull Skin	83	No Access
B-903W	FWD AMR Hull Skin	83	No Access
B-904W	FWD AMR Hull Skin	83	No Access
B-905V	FWD AMR Hull Skin	83	No Access
B-22V	Inner Ballast B-22V	92	No Access
B-24.5F	Outer Skin A-24.5F	92	No Access
B-803V	Fireroom #1 Floor	92	No Access
B-804V	Fireroom #1 Floor	92	No Access
B-907V	Fireroom #1 Hull Skin	92	No Access
B-909V	Fireroom #1 Hull Skin	92	No Access
B-910V	Fireroom #1 Hull Skin	92	No Access
B-912V	Fireroom #1 Hull Skin	92	No Access
B-913V	Fireroom #1 Hull Skin	92	No Access
B-914V	Fireroom #1 Hull Skin	92	No Access
B-806V	Fireroom #2 Floor	96	No Access
B-915W	Fireroom #2 hull Skin	96	No Access
B-916W	Fireroom #2 hull Skin	96	No Access
B-917W	Fireroom #2 hull Skin	96	No Access

Tank ID	Name	Frame	Condition
B-918W	Fireroom #2 hull Skin	96	No Access
B-920V	Fireroom #2 hull Skin	96	No Access
B-922V	Fireroom #2 hull Skin	96	No Access
B-923V	Fireroom #2 hull Skin	96	No Access
B-808V	FWD Eng Rm Floor	103	No Access
B-810V	FWD Eng Rm Floor	103	No Access
B-812V	FWD Eng Rm Floor	103	No Access
B-924W	FWD Eng Rm Hull Skin	103	No Access
B-925W	FWD Eng Rm Hull Skin	103	No Access
B-928W	FWD Eng Rm Hull Skin	106	No Access
B-929W	FWD Eng Rm Hull Skin	106	No Access
B-930W	FWD Eng Rm Hull Skin	106	No Access
B-932W	FWD Eng Rm Hull Skin	106	No Access
B-934V	FWD Eng Rm Hull Skin	106	No Access
B-51V	Inner Ballast B-51V	113	No Access
B-935W	Fireroom #3 hull Skin	113	No Access
B-936W	Fireroom #3 hull Skin	113	No Access
B-938V	Fireroom #3 hull Skin	113	No Access
B-939V	Fireroom #3 hull Skin	113	No Access
B-940W	Fireroom #3 hull Skin	113	No Access
B-59 V	Inner Ballast B-59V	119	No Access
B-61 V	Inner Ballast B-61V	119	No Access
B-942W	Fireroom #3 hull Skin	119	No Access
B-70V	Inner Ballast B-70V	123	No Access
B-814V	Fireroom #4 Floor	123	No Access
B-819V	Fireroom #4 Floor	123	No Access
B-947W	Fireroom #4 hull Skin	123	No Access
B-948W	Fireroom #4 hull Skin	123	No Access
B-949W	Fireroom #4 hull Skin	128	No Access
B-950V	Fireroom #4 hull Skin	128	No Access
B-951V	Fireroom #4 hull Skin	128	No Access
B-953V	Fireroom #4 hull Skin	128	No Access
B-954V	Fireroom #4 hull Skin	128	No Access
MH1	Aft Engine Room	133	No Access
B-84V	Inner Ballast B-84V	133	No Access
B-955V	AFT ENG Rm Hull Skin	133	No Access
B-957V	AFT ENG Rm Hull Skin	133	No Access
B-960F	AFT ENG Rm Hull Skin	133	No Access
B-961F	AFT ENG Rm Hull Skin	137	No Access
B-964F	AFT ENG Rm Hull Skin	137	No Access

Tank ID	Name	Frame	Condition
B-825V	AFT AMR Floor	145	No Access
B-965F	AFT AMR Hull Skin	145	No Access
B-966F	AFT AMR Hull Skin	145	No Access
B-967F	AFT AMR Hull Skin	145	No Access
B-968F	AFT AMR Hull Skin	145	No Access
B-97V	Inner Ballast B-97V	149	No Access
C-1.5V	Inner Void C-1.5V	153	No Access
C-2.5V	Inner Void C-1.5V	153	No Access
C-4HG	Central Void C-4HG	153	No Access
C-10V	Inner Ballast C-10V	153	No Access
C-403.5V	Upper Outer Skin	153	No Access
C-904F	Inner Hull Skin Void	153	No Access
C-6HG	Hull Skin C-6HG	160	No Access
C-6.5G	Central Ballast C-6.5G	160	No Access
C-18V	Inner Ballast C-18V	160	No Access
C-905F	Inner Hull Skin Void	164	No Access
C-614V	Outer Hull Skin Void	168	No Access
C-617V	Outer Hull Skin Void	168	No Access
C-703V	Sounding Tube	168	No Access
C-704V	Sounding Tube	168	No Access
C-614V	Outer Void	172	No Access
C-707V	Sounding Tube	180	No Access
C-708V	Sounding Tube	180	No Access
C-710V	Sounding Tube	195	No Access
C-711V	Sounding Tube	195	No Access
C-519V	Sounding Tube	200	No Access
C-520V	Sounding Plate	205	No Access
A29V	Inner Void A-29V	52	1
A30F	Inner Ballast A-30F	52	1
A31F	Inner Ballast A-31F	52	1
A32F	Outer Ballast A-32F	52	1
A32.5F	Outer Skin A-32.5F	52	1
A33F	Outer Ballast A-33F	52	1
A33.5F	Outer Skin A-33.5F	52	1
A-40V	Inner Void A-40V	60	1
A-41V	Inner Void A-41V	60	1
A-45V	Outer Ballast A-45V	60	1
A-46.5 H	Outer Skin A-46.5H	60	1
A-47F	Outer Ballast A-47F	60	1
A-47.5H	Outer Skin A-47.5	60	1

Tank ID	Name	Frame	Condition
A-423.5V	Upper Outer Skin	60	1
A-48V	Inner Void A-48V	64	1
A-54F	Outer Ballast A-54H	64	1
A-54.5F	Outer Skin A-54.5H	64	1
A-55F	Outer Ballast A-54H	64	1
A-55.5F	Outer Skin A-54.5H	64	1
A-57V	Inner Void A-57V	72	1
A-428.5V	Upper Outer Skin	72	1
A-429.5V	Upper Outer Skin	72	1
A538T	Upper Inner Skin	72	1
A618V	Inside Tank	72	1
A628V	Upper Inner Skin	76	1
B-404.5V	Upper Outer Skin	83	1
B-409.5V	Upper Outer Skin	92	1
B-413.5V	Upper Outer Skin	96	1
B-4XX	FWD Eng Room	103	1
B-419.5V	Upper Outer Skin	103	1
B-43V	Inner Ballast B-43V	106	1
B-45V	Inner Ballast B-45V	106	1
B-50V	Inner Void B-50V	113	1
B-425.5V	Upper Outer Skin	113	1
B-428.5V	Upper Outer Skin	113	1
B-60V	Inner Ballast B-60V	119	1
B-437.5V	Upper Outer Skin	123	1
B-82V	Inner Void B-82V	133	1
B-436.5V	Upper Outer Skin	133	1
B-439.5V	Upper Outer Skin	133	1
B-821V	AFT Eng Rm Floor	133	1
B-90V	Inner Void B-90V	137	1
B-442.5V	Upper Outer Skin	145	1
B-443.5V	Upper Outer Skin	145	1
B-970F	AFT AMR Hull Skin	145	1
B-96.5V	Inner Void B-96.5V	149	1
C-11V	Inner Ballast C-11V	153	1
C-12V	Inner Ballast C-12V	153	1
C-14.5F	Outer Ballast C-14.5F	153	1
C-14F	Outer Skin C-14F	153	1
C-17V	Inner Ballast C-17V	160	1
C-19H	Inner Ballast C-19H	160	1
C-22F	Outer Ballast C-22F	160	1

Tank ID	Name	Frame	Condition
C-408.5V	Upper Outer Skin	160	1
C-411.5V	Upper Outer Skin	160	1
C-616V	Inner Hull Skin Void	168	1
C-615V	Inner Hull Skin Void	172	1
C-705V	Inner Hull Skin Void	180	1
C-423V	Void Outer Skin	208	1
A-61V	Inner Ballast A-61V	72	Oil Coated (1)
A-62F	Outer Ballast A-62F	72	Oil Coated (1)
A-62.5F	Outer Skin A-62.5F	72	Oil Coated (1)
A-63F	Outer Ballast A-63F	72	Oil Coated (1)
A-63.5F	Outer Skin A-63.5F	72	Oil Coated (1)
A-68V	Inner Ballast A-68V	76	Oil Coated (1)
A-69V	Inner Ballast A-69V	76	Oil Coated (1)
A-70F	Outer Ballast A-70F	76	Oil Coated (1)
A-71F	Outer Ballast A-71F	76	Oil Coated (1)
A-72F	Outer Skin A-72F	76	Oil Coated (1)
A-73F	Outer Skin A-73F	76	Oil Coated (1)
B-12V	Inner Ballast B-12V	83	Oil Coated (1)
B-13V	Inner Ballast B-13V	83	Oil Coated (1)
B-15F	Outer Ballast B-15F	83	Oil Coated (1)
B-15.5F	Outer Skin B-15.5F	83	Oil Coated (1)
B-16F	Outer Ballast A-16F	83	Oil Coated (1)
B-16.5F	Outer Skin A-16.5F	83	Oil Coated (1)
B-18V	Inner Void B-18V	92	Oil Coated (1)
B-19V	Inner Ballast B-19V	92	Oil Coated (1)
B-21V	Inner Ballast B-21V	92	Oil Coated (1)
B-23F	Outer Ballast B-23F	92	Oil Coated (1)
B-23.5F	Outer Skin A-23.5F	92	Oil Coated (1)
B-24F	Outer Ballast B-24F	92	Oil Coated (1)
B-26V	Inner Void B-26V	96	Oil Coated (1)
B-30V	Inner Ballast B-30V	96	Oil Coated (1)
B-31F	Outer Ballast A-31F	96	Oil Coated (1)
B-31.5F	Outer Skin A-31.5F	96	Oil Coated (1)
B-418.5V	Upper Outer Skin	96	Oil Coated (1)
B-37V	Inner Ballast B-37V	103	Oil Coated (1)
B-38V	Inner Ballast B-38V	103	Oil Coated (1)
B-39F	Outer Ballast A-39F	103	Oil Coated (1)
B-39.5F	Outer Skin A-39.5F	103	Oil Coated (1)
B-40F	Outer Ballast A-40F	103	Oil Coated (1)
B-40.5F	Outer Skin A-40.5F	103	Oil Coated (1)

Tank ID	Name	Frame	Condition
B-420.5V	Upper Outer Skin	103	Oil Coated (1)
B-46V	Inner Ballast B-46V	106	Oil Coated (1)
B-47F	Outer Ballast A-47F	106	Oil Coated (1)
B-47.5F	Outer Skin A-47.5F	106	Oil Coated (1)
B-48F	Outer Ballast A-48F	106	Oil Coated (1)
B-53V	Inner Ballast B-53V	113	Oil Coated (1)
B-54V	Inner Ballast B-54V	113	Oil Coated (1)
B-55F	Outer Ballast A-55F	113	Oil Coated (1)
B-55.5F	Outer Skin A-55.5F	113	Oil Coated (1)
B-56F	Outer Ballast A-56F	113	Oil Coated (1)
B-56.5F	Outer Skin A-56.5F	113	Oil Coated (1)
B-62V	Inner Ballast B-62V	119	Oil Coated (1)
B-63F	Outer Ballast A-63F	119	Oil Coated (1)
B-63.5F	Outer Skin A-63.5F	119	Oil Coated (1)
B-64F	Outer Ballast A-64F	119	Oil Coated (1)
B-64.5F	Outer Skin A-64.5F	119	Oil Coated (1)
B-71F	Outer Ballast A-71F	123	Oil Coated (1)
B-71.5F	Outer Skin A-71.5F	123	Oil Coated (1)
B-72F	Outer Ballast A-72F	123	Oil Coated (1)
B-72.5F	Outer Skin A-72.5F	123	Oil Coated (1)
B-430.5V	Upper Outer Skin	123	Oil Coated (1)
B-74V	Inner Void B-74V	128	Oil Coated (1)
B-79F	Outer Ballast A-79F	128	Oil Coated (1)
B-79.5F	Outer Skin A-79.5F	128	Oil Coated (1)
B-80F	Outer Ballast A-80F	128	Oil Coated (1)
B-80.5F	Outer Skin A-80.5F	128	Oil Coated (1)
B-86V	Inner Ballast B-86V	133	Oil Coated (1)
B-87F	Outer Ballast B-87F	133	Oil Coated (1)
B-87.5F	Outer Skin B87.5F	133	Oil Coated (1)
B-88.5F	Outer Skin B-88.5F	133	Oil Coated (1)
B-92V	Inner Ballast B-92V	137	Oil Coated (1)
B-93V	Inner Ballast B-92V	137	Oil Coated (1)
B-93.5F	Outer Ballast B-93.5F	137	Oil Coated (1)
B-94V	Inner Ballast B-94V	137	Oil Coated (1)
B-94.5F	Outer Ballast B-94.5F	137	Oil Coated (1)
B-95F	Outer Skin B-95F	137	Oil Coated (1)
B-96F	Outer Skin B-96F	137	Oil Coated (1)
B-98.5F	Inner Ballast B-98.5	149	Oil Coated (1)
B-98.75F	Outer Ballast B98.75	149	Oil Coated (1)
B-99F	Outer Ballast B-99F	149	Oil Coated (1)

Tank ID	Name	Frame	Condition
B-99.5F	Outer Skin B-99.5F	149	Oil Coated (1)
B-100F	Outer Skin B-100F	149	Oil Coated (1)
C-9V	Inner Ballast C-9V	153	Oil Coated (1)
C-20F	Inner Ballast C-20F	160	Oil Coated (1)
C-23F	Outer Skin C-23F	160	Oil Coated (1)
C-24F	Outer Skin C-24F	160	Oil Coated (1)
A-43V	Inner Ballast A-43V	60	2
A-424.5V	Upper Outer Skin	60	2
A-58V	Inner Ballast A-58V	72	2
A-59V	Inner Ballast A-59V	72	2
A-60V	Inner Ballast A-60V	72	2
A-64V	Inner Void A-64V	76	2
A-65V	Inner Void A-65V	76	2
A-67V	Inner Ballast A-67V	76	2
A-728A	Central Storage	76	2
B-901W	FWD AMR Hull Skin	83	2
B-807V	Fireroom #2 Floor	96	2
B-41V	Inner Void B-41V	106	2
B-42V	Inner Void B-42V	106	2
B-44V	Inner Ballast B-44V	106	2
B-811V	FWD Eng Rm Floor	106	2
B-49V	Inner Void B-49V	113	2
B-52V	Inner Ballast B-52V	113	2
B-813W	Fireroom #3 Floor	113	2
B-57V	Inner Void B-57V	119	2
B-815V	Fireroom #3 Floor	119	2
B-65V	Inner Void B-65V	123	2
B-66V	Inner Void B-66V	123	2
B-67V	Inner Ballast B-67V	123	2
B-75V	Inner Ballast B-75V	128	2
B-83V	Inner Ballast B-83V	133	2
B-85V	Inner Ballast B-85V	133	2
B-818V	Aft Eng Rm Floor	133	2
B-91V	Inner Ballast B-91V	137	2
B-822V	AFT AMR Floor	145	2
B-95.5V	Inner Void B-95.5V	149	2
B-98V	Inner Ballast B-98V	149	2
C-8V	Inner Void C-8V	153	2
C-406.5V	Upper Outer Skin	153	2
C-15V	Inner Void C-15V	160	2

Tank ID	Name	Frame	Condition
C-16V	Inner Void C-16V	160	2
B-11V	Inner Ballast B-11V	83	Oil Coated (2)
B-17V	Inner Void B-17V	92	Oil Coated (2)
B-20V	Inner Ballast B-20V	92	Oil Coated (2)
B-25V	Inner Void B-25V	96	Oil Coated (2)
B-27V	Inner Ballast B-27V	96	Oil Coated (2)
B-28V	Inner Ballast B-28V	96	Oil Coated (2)
B-29V	Inner Ballast B-29V	96	Oil Coated (2)
B-33V	Inner Void B-33V	103	Oil Coated (2)
B-34V	Inner Void B-34V	103	Oil Coated (2)
B-36V	Inner Ballast B-36V	103	Oil Coated (2)
B-48.5F	Outer Skin A-48.5F	106	Oil Coated (2)
B-931W	FWD Eng Rm Hull Skin	106	Oil Coated (2)
B-58V	Inner Void B-58V	119	Oil Coated (2)
B-77V	Inner Ballast B-77V	128	Oil Coated (2)
B-78V	Inner Ballast B-78V	128	Oil Coated (2)
A-42V	Inner Ballast A-42V	60	3
A-50V	Inner Ballast A-50V	64	3
A-56V	Inner Void A-56V	72	3
A-66V	Inner Ballast A-66V	76	3
B-9V	Inner Void B-9V	83	3
B-68V	Inner Ballast B-68V	123	3
B-69V	Inner Ballast B-69V	123	3
B-73V	Inner Void B-73V	128	3
B-76V	Inner Ballast B-76V	128	3
B-81V	Inner Void B-81V	133	3
B-89V	Inner Void B-89V	137	3
B-97.5F	Inner Ballast B-97.5	149	3
C-7V	Inner Void C-7V	153	3
B-10V	Inner Void B-10V	83	Oil Coated (3)
B-35V	Inner Ballast B-35V	103	Oil Coated (3)
B-88F	Outer Ballast B-88F	133	Oil Coated (3)

11.3. Tank Inspection Photos

Figure 11.1 "Side of inner void A-29V with no corrosion on starboard side section FR 52"

Figure 11.2 "Side of inner ballast A-30F with light to no corrosion on port side section FR 52"

Figure 11.3 "Back corner of inner ballast A-31F with minor corrosion on starboard side section FR 52"

Figure 11.4 "Front wall of outer skin A-32.5F with light corrosion on port side section FR 52"

Figure 11.5 "Side wall of outer ballast A-32F with no corrosion on port side section FR 52"

Figure 11.6 "Side wall of outer skin A-32.5F with no corrosion on starboard side section FR 52"

Figure 11.7 "Side wall of outer ballast A-33F with no corrosion on starboard side section FR 52"

Figure 11.10 "Side of outer ballast A-45V with light surface corrosion on starboard side section FR 60"

Figure 11.8 "Side of inner void A-40V with peeling paint and light surface corrosion on port side section FR 60"

Figure 11.11 "Bottom and sides of outer skin A-46.5F with minor corrosion on beams on port side section FR 60"

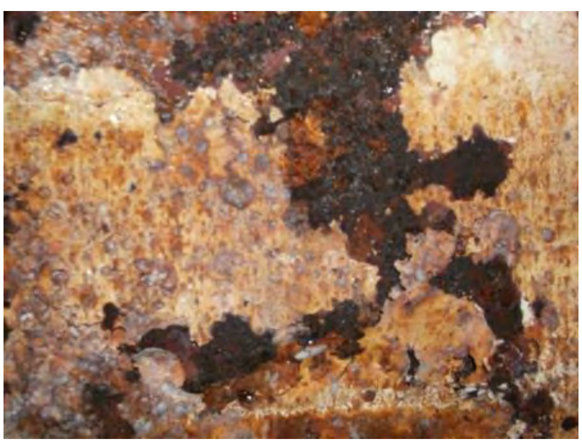


Figure 11.9 "Bottom and front side of inner void A-41V with light surface corrosion on port side section FR 60"

Figure 11.12 "Front corner of outer ballast A-47F with no corrosion on starboard side section FR 60"

Figure 11.13 "Front wall of outer skin A-47.5F with little to no corrosion on starboard side section FR 60"

Figure 11.16 "Back corner of outer ballast A-54F with light surface corrosion on port side section FR 64"

Figure 11.14 "Front side of inner void A-48V with peeling paint and light surface corrosion on port side section FR 64"

Figure 11.17 "Bottom and sides of outer ballast A-55F with minor to no corrosion on starboard side section FR 64"

Figure 11.15 "Side of outer skin A-54.5F with minor to no corrosion on port side section FR 64"

Figure 11.18 "Bottom and sides of outer skin A-55.5F with minor to no corrosion on starboard side section FR 64"

Figure 11.19 "Side of inner void A-57V with light surface corrosion on starboard side section FR 72"

Figure 11.22 "Side of inner ballast A-62F with no corrosion mostly full of water on port side section FR 72"

Figure 11.20 "Side of inner ballast A-61V with oil coated and no corrosion on starboard side section FR 72"

Figure 11.23 "Back side of outer ballast A-63F with no corrosion mostly full of water on starboard side section FR 72"

Figure 11.21 "Bottom and sides of outer skin A-62.5F with little or no corrosion on port side section FR 72"

Figure 11.24 "Side of outer ballast A-63.5F with no corrosion mostly full of water on starboard side section FR 72"

Figure 11.25 "Side of inner ballast A-68V with no corrosion mostly full of water on port side section FR 76"

Figure 11.26 "Side of inner ballast A-69V with light surface corrosion with water on starboard side section FR 76"

Figure 11.27 "Side of outer ballast A-70F with oil coated and light surface corrosion on port side section FR 76"

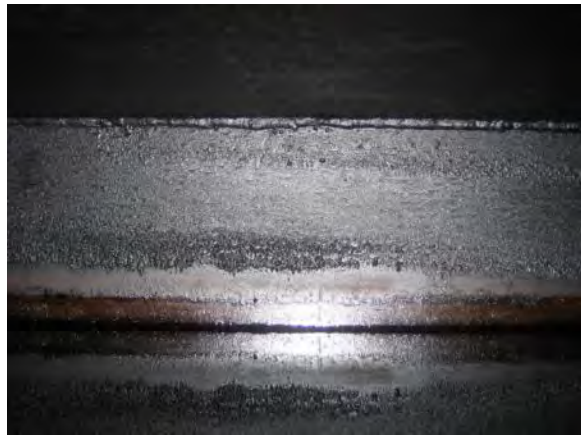


Figure 11.28 "Side of outer ballast A-71F with oil coated and no corrosion on starboard side section FR 76"

Figure 11.29 "Side of outer skin A-72F with oil coated and no corrosion on port side section FR 76"

Figure 11.30 "Side of outer skin A-73F with oil coated and no corrosion with water on starboard side section FR 76"


Figure 11.31 "Floor and sides of upper outer skin A-423.5V with light surface corrosion starboard side section FR 60"


Figure 11.34 "Front side of upper inner skin A-512T with no corrosion on port side section FR 43"


Figure 11.32 "Floor and sides of upper outer skin A-428.5V with no corrosion on port side section FR 72"


Figure 11.35 "Front side of upper inner skin A-538T with no corrosion on port side section FR 72"


Figure 11.33 "Floor and sides of upper outer skin A-429.5V with light corrosion on starboard side section FR 72"


Figure 11.36 "Front side of inside tank A-538T with no corrosion on center section FR 72"


Figure 11.37 "Side wall of upper inner skin A-628V with no corrosion on port side section FR 76"


Figure 11.40 "Floor and walls of FWD Eng Rm B-4XX.5 no corrosion with oil coated floor on center section FR 103"


Figure 11.38 "Front side of lower inner A-705.25LUB with oil coated and no corrosion on center section FR 39"


Figure 11.41 "Side of inner ballast B-12V with light surface corrosion with water on port side section FR 83"

Figure 11.39 "Front side of lower inner A-706.25LUB with oil coated and no corrosion on center section FR 39"

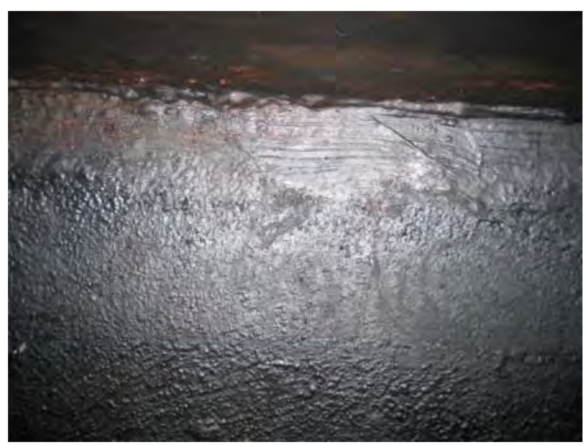


Figure 11.42 "Side of inner ballast B-13V with oil coated and no corrosion on starboard side section FR 83"

Figure 11.43 “Side of outer ballast B-15F with oil coated and no corrosion on starboard side section FR 83”

Figure 11.44 “Side of outer skin B-15.5F with oil coated and no corrosion on starboard side section FR 83”

Figure 11.45 “Floor and walls of outer ballast B-16F with oil/wtr coated and no corrosion on port side section FR 83”

Figure 11.46 “Side of outer skin B-16.5F with oil coated and no corrosion on port side section FR 83”

Figure 11.47 “Side of inner void B-18V with oil coated and no corrosion with water on port side section FR 92”

Figure 11.48 “Side of inner ballast B-19V with oil coated and no corrosion with water on port side section FR 92”

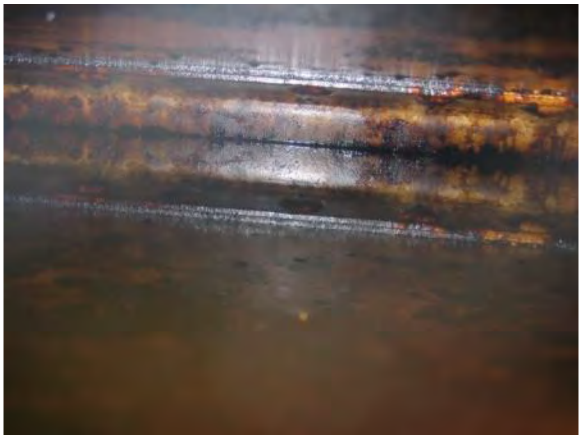


Figure 11.49 “Side of inner ballast B-21V with oil coated and no corrosion with water on starboard side section FR 92”

Figure 11.52 “Front side of outer ballast B-24F with oil coated and no corrosion on port side section FR 92”

Figure 11.50 “Side of outer ballast B-23F with oil coated and no corrosion on starboard side section FR 92”

Figure 11.53 “Bottom and sides of inner void B-26V with oil coated and no corrosion on port side section FR 96”

Figure 11.51 “Side of outer skin B-23.5F with oil coated and no corrosion on starboard side section FR 92”

Figure 11.54 “Front corner of inner ballast B-30V with oil coated light surface corrosion on port side section FR 96”

Figure 11.55 “Front corner of outer ballast B-31F with oil coated and light corrosion on starboard side section FR 96”

Figure 11.58 “Side of inner ballast B-38V with oil coated and light surface corrosion on port side section FR 103”

Figure 11.56 “Side of outer skin B-31.5F with oil coated and no corrosion on starboard side section FR 96”

Figure 11.59 “Side of outer ballast B-39F with oil coated and light corrosion on starboard side section FR 103”

Figure 11.57 “Side of inner ballast B-37V with oil coated and no corrosion on starboard side section FR 103”

Figure 11.60 “Back corner of outer ballast B-40F mostly full of water and no corrosion on port side section FR 103”

Figure 11.61 “Side of outer skin B-40.5F mostly full of water and no corrosion on port side section FR 103”

Figure 11.64 “Side of inner ballast B-46V with oil coated and no corrosion on port side section FR 106”

Figure 11.62 “Side of inner ballast B-43V with oil coated and no corrosion on starboard side section FR 106”

Figure 11.65 “Sides of outer ballast B-47Fwith oil coated and partly full of water on starboard side section FR 106”

Figure 11.63 “Side of inner ballast B-45V with light surface corrosion on starboard side section FR 106”

Figure 11.66 “Side of outer skin B-47.5F with oil coated and no corrosion on starboard side section FR 106”


Figure 11.67 "Side of outer ballast B-48F with oil coated and no corrosion on port side section FR 106"

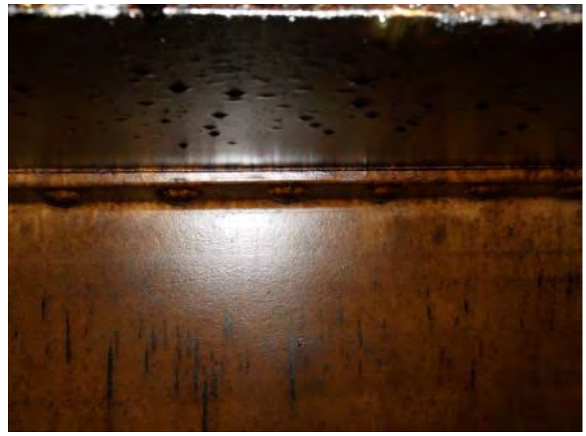


Figure 11.70 "Side of inner ballast B-54V with oil coated and no corrosion on port side section FR 113"


Figure 11.68 "Side of inner void B-50V with oil coated and light surface corrosion on port side section FR 113"

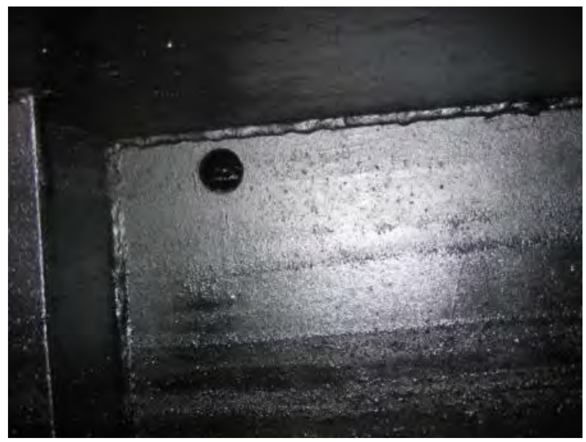


Figure 11.71 "Back corner of outer ballast B-55F with oil coated and no corrosion on starboard side section FR 113"


Figure 11.69 "Side of inner ballast B-53V with oil coated and light surface corrosion on starboard side section FR 113"


Figure 11.72 "Side of outer skin B-55.5F with oil coated and no corrosion on starboard side section FR 113"

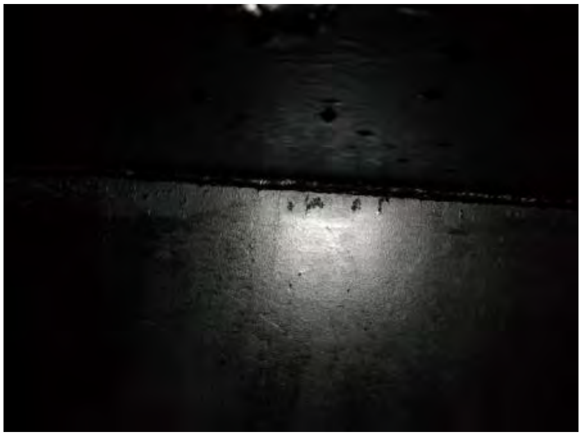


Figure 11.73 "Side of outer skin B-56.5F with oil coated and no corrosion on port side section FR 113"

Figure 11.74 "Side of inner ballast B-56F with oil coated and partly full of water on port side section FR 113"

Figure 11.75 "Side of inner ballast B-60V with oil coated and partly full of water on port side section FR 119"

Figure 11.76 "Side of inner ballast B-62V with oil coated and no corrosion on port side section FR 119"

Figure 11.77 "Side of outer ballast B-63F with oil coated and mostly full of water on starboard side section FR 119"

Figure 11.78 "Sides of outer skin B-63.5F with oil coated and partly full of oil/water on starboard side section FR 119"

Figure 11.79 “Side of outer skin B-64.5F with oil coated and no corrosion on port side section FR 119”

Figure 11.82 “Side of outer skin B-71.5F with oil coated and minor corrosion on starboard side section FR 123”

Figure 11.80 “Side of outer ballast B-64F with oil coated and mostly full of water on port side section FR 119”

Figure 11.83 “Side of outer skin B-72.5F with oil coated and no corrosion on port side section FR 123”

Figure 11.81 “Side of outer ballast B-71F with oil coated and no corrosion on starboard side section FR 123”

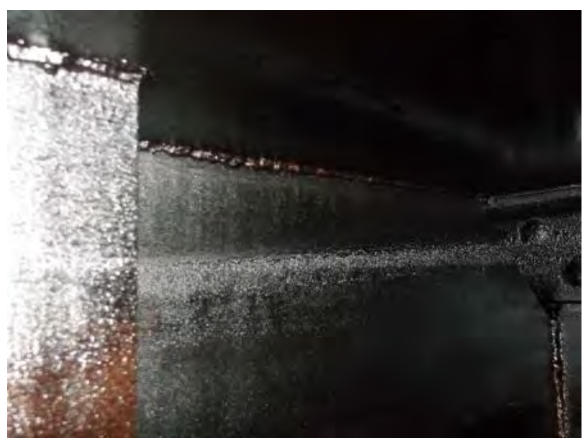


Figure 11.84 “Back corner of outer ballast B-72F with oil coated and no corrosion on port side section FR 123”

Figure 11.85 "Side of inner void B-74V with oil coated and minor corrosion on port side section FR 128"

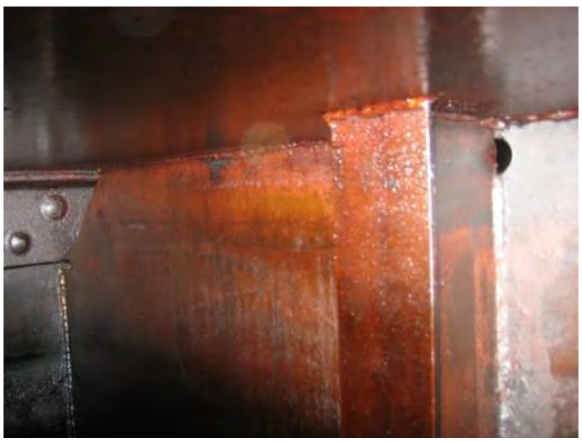


Figure 11.86 "Front corner of outer ballast B-79F with oil coated and no corrosion on starboard side section FR 128"

Figure 11.87 "Sides of outer skin B-79.5F with oil coated and partly full of oil/water on starboard side section FR 128"

Figure 11.88 "Side of outer skin B-80.5F with oil coated and no corrosion on port side section FR 128"

Figure 11.89 "Back corner of outer ballast B-80F with oil coated and no corrosion on port side section FR 128"

Figure 11.90 "Front corner of inner void B-82V with light surface corrosion on port side section FR 133"

Figure 11.91 “Front corner of inner ballast B-86V with peeling paint and light corrosion on port side section FR 133”

Figure 11.94 “Side of outer skin B-88.5F with oil coated and no corrosion on port side section FR 133”

Figure 11.92 “Side of outer ballast B-87F with oil coated and no corrosion on starboard side section FR 133”

Figure 11.95 “Side of inner void B-90V with peeling paint and light corrosion on port side section FR 137”

Figure 11.93 “Side of outer skin B-87.5F with oil coated and no corrosion on starboard side section FR 133”

Figure 11.96 “Back corner of inner ballast B-92V with light corrosion on port side section FR 137”

Figure 11.97 "Front corner of inner ballast B-93V with oil coated and no corrosion on starboard side section FR 137"

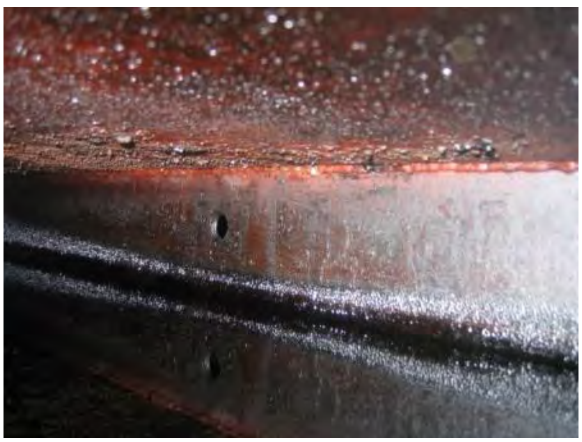


Figure 11.98 "Side of outer ballast B-93.5F with oil coated and no corrosion on starboard side section FR 137"

Figure 11.99 "Back corner of outer ballast B-94.5F with oil coated and no corrosion on port side section FR 137"

Figure 11.100 "Side of inner ballast B-94V with oil coated and no corrosion on port side section FR 137"

Figure 11.101 "Side of outer skin B-95F with oil coated and no corrosion on starboard side section FR 137"

Figure 11.102 "Front corner of inner void B-96.5V with light surface corrosion on port side section FR 149"

Figure 11.103 "Side of outer skin B-96F with oil coated and no corrosion on starboard side section FR 137"

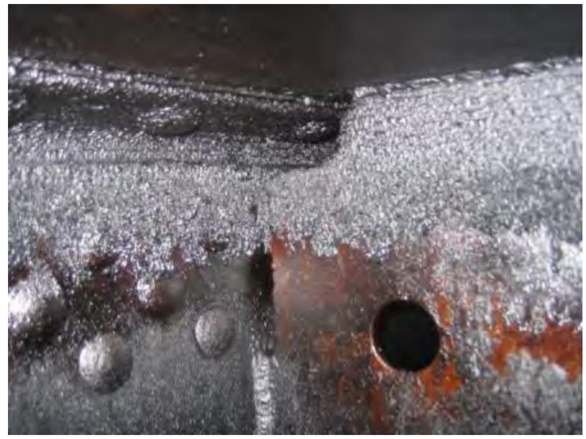


Figure 11.106 "Back corner of outer ballast B-99F with oil coated and no corrosion on starboard side section FR 149"

Figure 11.104 "Side of inner ballast B-98.5F with oil coated and no corrosion on port side section FR 149"

Figure 11.107 "Side of outer skin B-99.5F with oil coated and no corrosion on starboard side section FR 149"

Figure 11.105 "Side of outer ballast B-98.75F with oil coated and no corrosion on port side section FR 149"

Figure 11.108 "Side of outer skin B-100F with oil coated and no corrosion on starboard side section FR 149"

Figure 11.109 "Floor and walls of upper outer skin B-404.5V with no corrosion on port side section FR 83"

Figure 11.110 "Floor of upper outer skin B-409.5V with light surface corrosion on starboard side section FR 92"

Figure 11.111 "Floor and walls of upper outer skin B-413.5V with no corrosion on starboard side section FR 96"

Figure 11.112 "Floor and walls of upper outer skin B-418.5V with oil coated, no corrosion on port side section FR 96"

Figure 11.113 "Floor and walls of upper outer skin B-419.5V with no corrosion on starboard side section FR 103"

Figure 11.114 "Walls of upper outer skin B-420.5V with oil coated, light surface corrosion on port side section FR 103"

Figure 11.115 "Floor and walls of upper outer skin B-425.5V with no corrosion on starboard side section FR 113"

Figure 11.118 "Floor and walls of upper outer skin B-436.5V with no corrosion on port side section FR 133"

Figure 11.116 "Walls and ceiling of upper outer skin B-428.5V with no corrosion on port side section FR 113"

Figure 11.119 "Floor and walls of upper outer skin B-437.5V with no corrosion on starboard side section FR 123"

Figure 11.117 "Floor and walls of upper outer skin B-430.5V with oily floor, no corrosion on port side section FR 123"

Figure 11.120 "Floor and walls of upper outer skin B-439.5V with surface corrosion on starboard side section FR 133"

Figure 11.121 "Floor and walls of upper outer skin B-442.5V with no corrosion on port side section FR 145"

Figure 11.122 "Floor and walls of upper outer skin B-443.5V with no corrosion on starboard side section FR 145"

Figure 11.123 "Side wall of AFT Eng Rm Floor B-821V with light surface corrosion on center section FR 133"

Figure 11.124 "Side wall of AFT AMR Hull Skin B-970F with no corrosion on center section FR 145"

Figure 11.125 "Side wall of inner ballast C-9V with no corrosion on starboard side section FR 153"

Figure 11.126 "Back corner of inner ballast C-11V with no corrosion on starboard side section FR 153"

Figure 11.127 "Front corner of inner ballast C-12V with light surface corrosion on port side section FR 153"

Figure 11.128 "Side wall of outer ballast C-14.5F with light surface corrosion on port side section FR 153"

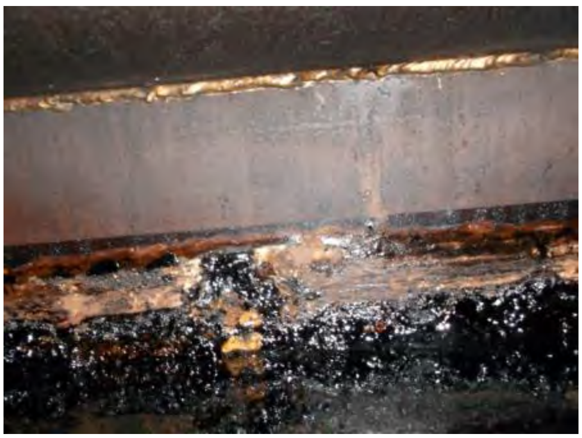
Figure 11.129 "Side walls and floor of outer ballast C-14F partly full of water, no corrosion on port side section FR 153"

Figure 11.130 "Side wall of inner ballast C-9V with light surface corrosion on starboard side section FR 160"

Figure 11.131 "Side wall of inner ballast C-19J with light surface corrosion on starboard side section FR 160"

Figure 11.132 "Side wall of inner ballast C-20J with light surface corrosion on port side section FR 160"

Figure 11.133 “Side walls and floor of outer ballast C-22J partly full of water, no corrosion on port side section FR 160”



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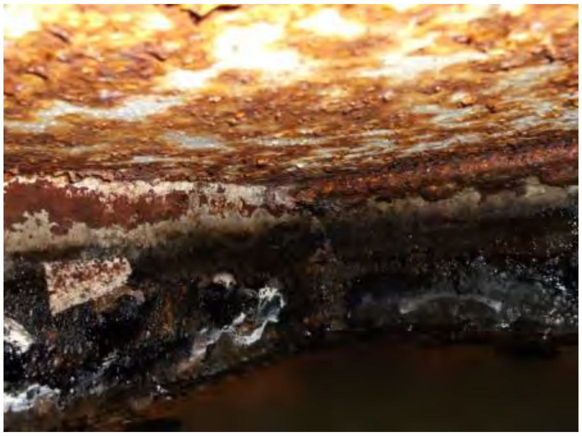

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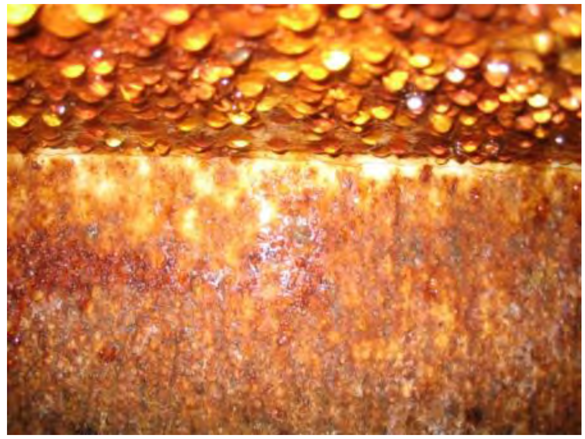

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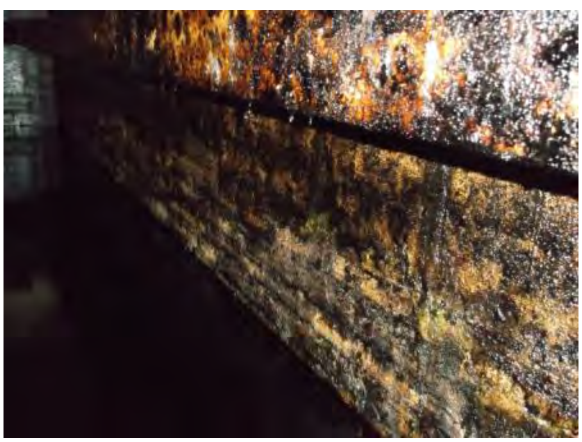

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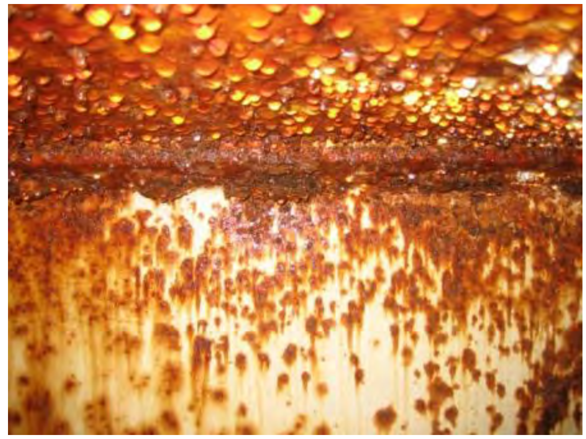

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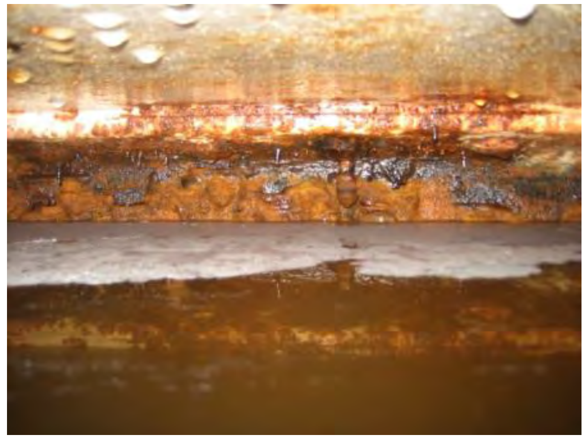

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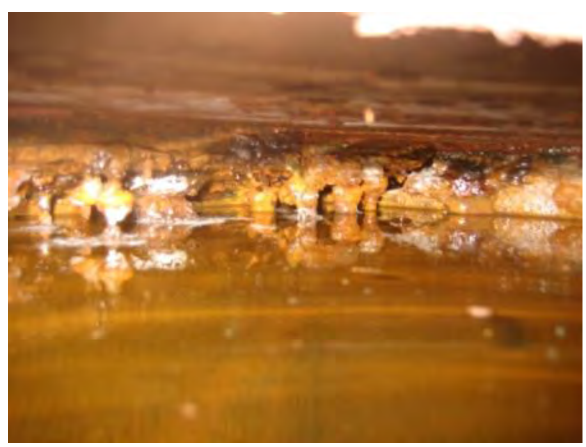

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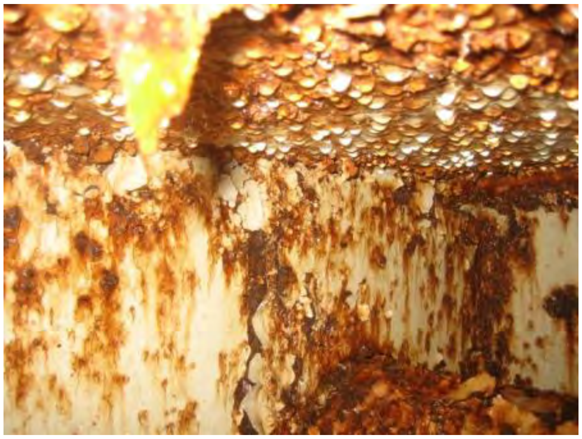

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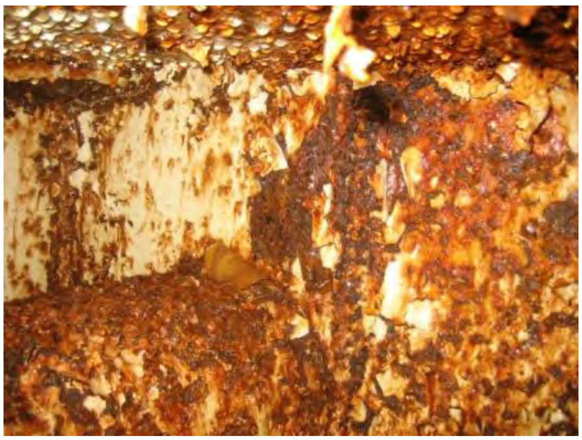

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USS YORKTOWN

Task 6: Estimation of Rates of Corrosion and Development Of Ongoing Maintenance Plan

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1. Executive Summary

The information generated from Tasks 1 through 5 was used to determine the rate of corrosion and percentage of section loss for the critical structural elements of the vessel. The corrosion rates of the hull are greatest in the splash zone. Corrosion rates in this area typically are estimated to be approximately 0.002-in. to 0.007-in. per year. However, in localized areas there is already a metal loss of 70% to 80%, with a handful of isolated areas with up to 100% loss of section. Corrosion in the tidal and submerged zones has been estimated at approximately 0.00062-in. to 0.0015-in. per year. Corrosion in the mud zone could not adequately be estimated as the majority of the compartments with shell plate in contact with the mud zone are the outside tanks and the double bottom tanks which were not included in the scope of the assessment.

The observed internal corrosion is primarily the result of compartments being currently and/or previously flooded. Where evident, corrosion was typically observed on the deck plate, lower walls and lower portions of structural members.

Repairs for areas that exhibit significant deterioration are recommended in Task 7. In conjunction with these repairs, to prevent ongoing internal corrosion and an increase in corrosion rates, watertight integrity must be restored/maintained, resources must be committed to maintaining the coating systems in all compartments, and the cathodic protection system must function with maximum effectiveness. Regular daily, weekly, and long-term maintenance and inspection schedules should also be established to monitor the structural condition of the vessel.

Note that a number of the ongoing maintenance tasks recommended in Task 6 are already performed by PPDA staff. For example, the engineering staff conducts weekly visual inspections of all accessible compartments and a corrosion engineer performs quarterly inspections of the cathodic protection system.

Also note that assessment of the hull forward of Frame 50 was not performed during Tasks 1 and 3 as Collins was informed by PPDA that PPDA was aware of significant structural deterioration of the hull plate at the forward approximately 200-ft of the vessel and that the hull plate in this region was known to require replacement. While assessment of this portion of the hull was not performed, the estimated cost of hull replacement is included in the Task 7 order-of-magnitude cost estimate. Due to the deterioration of hull plate reported by PPDA, Collins recommends that any tanks containing hazardous materials along the hull plate in this region be remediated to prevent the risk of environmental contamination.

2. Introduction

2.1. Purpose and Scope

Task 6 of the Assessment consisted of a determination of the rates of corrosion and percentage loss for critical structural elements identified during the previous Tasks. The project team created a protocol for monitoring the corrosion and degradation of the vessel structure, including guidelines for monitoring and ongoing maintenance after the completion of any required repairs to the Yorktown.

2.2. Exterior Hull Corrosion Rates

According to existing drawings provided by Patriots Point, the original shell plate thickness typically ranges between 3/8"and 3/4". The corrosion rates for the exterior hull have been estimated for each of five different exposure zones: the atmospheric, splash, tidal, submerged and mud zones. These zones are shown in Figure 2.1. The type and extent of corrosion in each of these zones is described below. The estimates of the applicable hull average general corrosion rates have been determined based on the metal loss data reported during previous tasks and an assumed exposure of approximately 34 years at its current location with minimal maintenance.

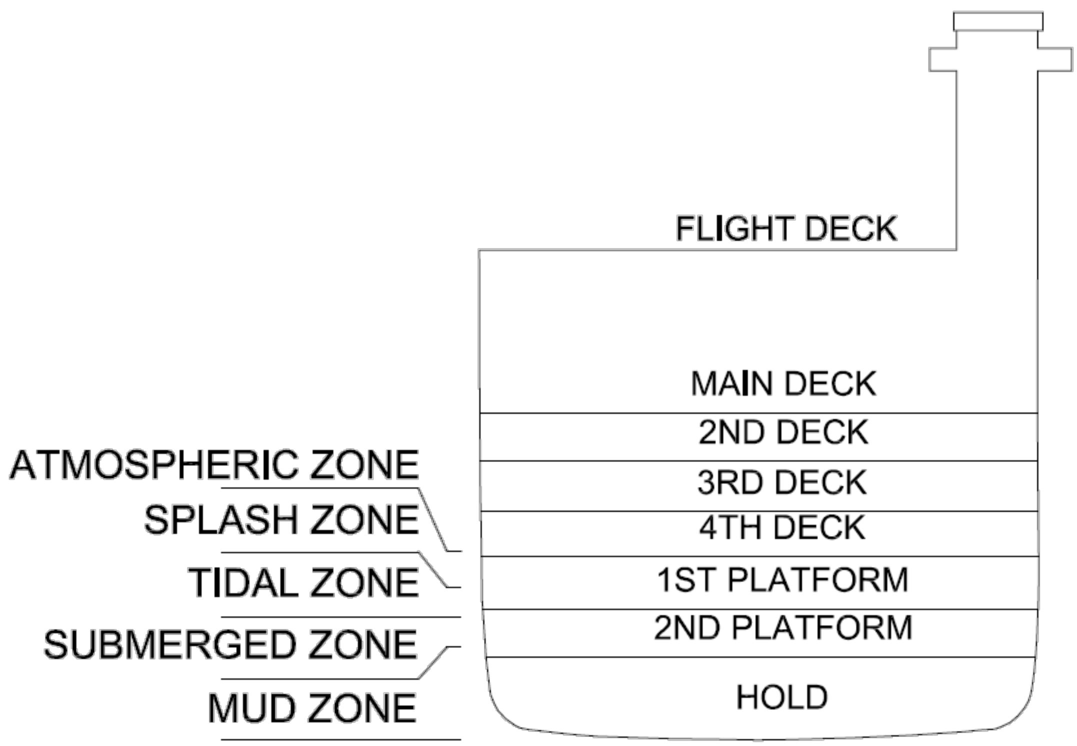

Figure 2.1 USS Yorktown Exposure Zones

2.3. Atmospheric Zone

The atmospheric zone is above the elevation of the 4th deck. Proper coating maintenance could significantly extend the life of the hull in this zone; the atmospheric zone on the starboard side of the ship has been recently painted and appears to be in good condition. At the bow of the vessel, the hull plates in the atmospheric zone can be accessed from the 4th deck compartments, so periodic thickness monitoring can be performed. No evidence of significant corrosion was observed in this zone. Figures 2.2 and 2.3 show the typical condition of the atmospheric zone of the ship.

Figure 2.2 Atmospheric Zone at bow, starboard side

Figure 2.3 Atmospheric Zone, port side of ship

2.4. Splash Zone

The splash zone is located directly above the Mean High Water elevation and encompasses an approximately 6-ft high band that includes the upper portion of the 1st Platform (500 level compartments) and the lower portion of the 4th Deck. Pitting corrosion was the most common type of deterioration observed in this zone. The typical condition of the hull in the vessel's splash zone is shown in Figures 2.4 and 2.5. Representative measurements of the shell plate thickness in this zone were recorded from the exterior of the hull during Task 1. During Tasks 4 and 5, the hull thickness was investigated from the inside of the compartments, where accessible. The shell plate thickness in the bow area was significantly impacted by corrosion, with the thickness loss typically ranging from 20% to 70%. This corresponds to an average general corrosion rate of approximately 2 to 7 mils/year. Isolated locations have already completely corroded through in this zone and additional locations will completely lose their section if unrepaired. The most severe corrosion was observed at the splash zone, with up to 100% loss of section observed at isolated areas. Table 1 presents the results of the splash zone thickness measurements performed during Tasks 1, 4, and 5.

Table 1. Splash Zone Corrosion Assessment

Location	Assessment Task No.	Impacted Structures	Comments
A-401A	4	Hull and deck plates	>70% loss
A-402A	4	Hull and deck plates	>50% loss
A-403A	4	Hull and deck plates	>60% loss, standing water
Port Side	1	3-ft tall band of corrosion	Up to 100% loss of section
Starboard Side, Fr 25 to 36	1	Band of corrosion	Significant loss of section
Starboard Side, Aft 100'	1	Band of corrosion	Significant loss of section
CHAIN LOCKER	4	Unknown	Flooded

Figure 2.4 Typical condition of splash zone, port side.

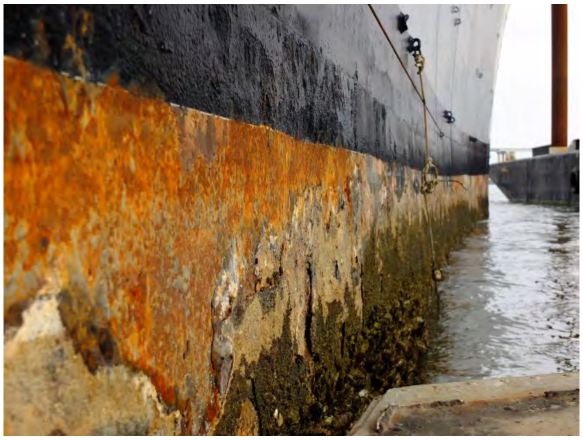

Figure 2.5 Typical condition of splash zone, starboard side.

2.5. Tidal and Submerged Zones

The tidal zone ranges from approximately the top of the 2nd Platform (600 level compartments) to the middle of the 1st Platform (500 level compartments) and the submerged zone ranges approximately from the bottom to the top of the 2nd Platform (600 level compartments). Marine growth is typically present on the hull in the tidal zone, as shown in Figure 2.6.

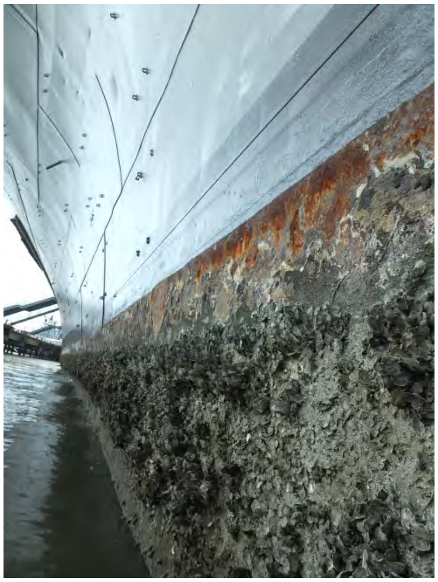

Figure 2.6 Tidal zone with typical marine growth.

During Task 1, the shell plate thickness was measured at isolated locations in the tidal and submerged zones and the observed section loss typically ranged between 2% to 6%, with isolated areas with up to 100% loss of section observed. The most significant results from the thickness measurements performed in this zone are presented in Table 2.

Table 2. Tidal and Submerged Zone Corrosion Assessment			
Location	Assessment Task No.	Impacted Structures	Comments
A-504A	4	Hull and deck plates	>70% loss shell, >80% deck
C-516 1A	5	Floor, lower wall, bottom of scantlings, structural beams	20-30% loss
C-516 2A	5	Edge of floor and wall, corners of structural beams	20-30% loss

The tidal and submerged zones are the areas most protected by the impressed current cathodic protection system installed at Patriots Point. In Appendix C of the Task 1 Structural Condition Assessment, the voltage potentials measured at the hull are presented. The voltage potentials were recorded both when the cathodic protection system was active and when the system had been disabled for over 24 hours. When the system was active, all measured voltages were near or above 0.85 volts. This indicates that the current system delivers an acceptable level of cathodic protection. When the cathodic protection system was disabled, the voltage potentials measured at a number of hull locations were below 0.85 volts. This indicates that these locations may be more susceptible to corrosion in the absence of an effective cathodic protection system. However, this voltage data is insufficient to calculate corrosion rates at these locations.

Corrosion in the tidal and submerged zones varied widely along the ship. At some accessible locations (A-605 1/2M and A-605A) in the bow area, no ultrasonic thickness readings were taken on the shell plating due to the very fragile condition of the plating. The estimate of average general corrosion rates for the tidal and submerged zones are presented in Table 3 below and are based on the data reported in the Task 1 and 3 report.

Table 3. Estimated Hull General Corrosion Rates (mils/year)					
Port			Starboard		
Minimum	Maximum	Average	Minimum	Maximum	Average
0	1.5	0.7	0	1.2	0.62
These estimated general corrosion rates are very low. These rates do not apply to localized corrosion mechanisms such as pitting or microbiologically influenced corrosion. Localized corrosion rates can be much higher but are usually not an overall structural concern.					

2.6. Mud Zone

The mud zone is located below the 2nd Platform and includes the Hold, Third Bottom and Double Bottom levels (700, 800 and 900 level compartments). The majority of the compartments with shell plate in contact with the mud zone are the outside tanks and the double bottom tanks. The corrosion in the accessible tanks was evaluated based on visual observations from photos taken during the environmental assessment performed by the Shaw Group in 2013; the results of this assessment are presented in the reports for Tasks 4 and 5. The corrosion rates in the tanks cannot be estimated based solely on visual data.

3. Deck Plate and Other Internal Structural Elements

The Task 4 assessment included an evaluation of the interior compartments in the bow of the ship, where the highest rates of corrosion were typically observed. The structural members in this area typically had less than 20% metal loss, though isolated components exhibited up to 100% loss of section. Below is a description of the corrosion assessment for the deck plates and other internal structural elements.

3.1. Deck Plate

The observed section loss at the deck plates was typically 20% or less; however, there were a number of locations where the loss was greater than 50%, with some areas exhibiting a complete loss of section. For example, the deck plate in compartment A-504A exhibited an 80% loss of section and the deck plate in compartment A-605A exhibited 80% to 100% loss of section. The high corrosion rates typically were associated with previously or currently flooded compartments. The approximate average general corrosion rates applicable to the deck plates are presented in Table 4 below.

Table 4. Deck Plate Corrosion Assessment

Location	Average Approximate General Corrosion Rate, mils/year
A401A Boatswains Stores, Frames 4-8	9
A402A Storeroom Frames, 8-15	5
A403A Electrical Storeroom, Frames 15-19	5
A504A SD Stores, Frames 19-26	7
These compartments exhibit very high corrosion rates and are recommended for near term repair.	

3.2. Internal Structural Elements

During Tasks 4 and 5, corrosion of the internal structural elements at accessible interior compartments was evaluated. Of the 229 total inspected compartments, 30 compartments were observed to have areas of significant section loss on structural members, as noted in Table 5. Similar to the deck plates, flooded or previously flooded compartments exhibited the highest corrosion rates on structural elements.

Table 5. Internal Structural Elements Corrosion Assessment			
Location	**Assessment Task No.**	**Impacted Structures**	**Comments**
A-425T	5	Vertical support columns	100% loss
C-408A	5	Horizontal frame members	30 - 45% loss
A-502A	4	Unknown	Flooded
A-503A	4	Unknown	Flooded
A-506A	4	Unknown	Flooded
A-523M	5	Deck, scantlings, lower wall	Standing water
A-525.5T	5	Deck, lower wall	60-70% loss
A-526G	5	Lower wall and pipe supports	6" flooded
A-541ET	5	Floor, lower wall and scantlings	100% loss of section on scantlings
A-602A	4	Unknown	Flooded
A-603A	4	Unknown	Flooded
A-605A	4	Bulkheads, vertical stanchions	Heavy corrosion
A-605 ½ M	4	Bulkheads, vertical stanchions	Heavy corrosion
A-607E	4	Heavy rust on deck plate	>60% loss
A-613ET	5	Floor lower walls, scantlings	Flooded
A-617E	5	Bulkheads, lower scantlings	Severe corrosion
C-605E	5	Floor, lower wall, scantlings	100% loss on lower scantlings
C-606M	5	Floor and lower scantlings	50% loss
C-607A	5	Floor and scantlings	>75% loss
A-703 V2A	4	Unknown	Flooded
A-708E	4	Severe corrosion expected	Flooded
A-709M	4	Corrosion visible throughout	Flooded
A-711T	4	Corrosion visible throughout	Flooded
A-712T	5	Severe corrosion	Flooded
A-713E	5	Severe corrosion	Flooded
A-721M	5	Lower walls, floor and beams	Up to 50% loss
A-721.5M	5	Lower wall, floor and ceiling beams	Up to 50% loss
A-725M	5	Lower scantlings	40-50% loss
C-702E	5	Lower bulkheads, scantlings	Up to 60% loss
Fwd AMR B-1-1	5	Lower bulkheads	Heavy corrosion

4. Recommended Maintenance

The following represents recommended maintenance procedures to reduce the corrosion rates and to protect the integrity of the hull and structural members of the Yorktown. The key components of the vessel's maintenance plan include regular inspection, maintenance of the impressed current cathodic protection system, and the regular repair and/or replacement of coatings. The maintenance recommendations are broken down into daily/weekly, annual/intermediate, and long term tasks. The following is a comprehensive maintenance plan for the vessel; a number of these tasks are already being performed by the ship's engineering staff.

4.1. Daily/Weekly Ship Maintenance Schedule

The following items are recommended to be performed on a daily/weekly basis:

- Daily cleaning of spaces exposed to weather by ship's maintenance team.
- Routine inspection to ensure watertight integrity of vessel.
- Prepare routine maintenance and inspection plan
- To ensure that the above tasks can be performed properly, it is also recommended that a monthly review of the budget needed to implement the Maintenance Plan is performed.

4.2. Annual/Periodic Ship Maintenance Schedule

The following items are recommended to be performed on an annual/periodic basis:

- Preparation and painting of exterior areas exposed to weather by ship's maintenance team.
- Preparation and painting of interior spaces by ship's maintenance team.
- Cleaning of interior spaces by ship's maintenance team.
- Repair/maintenance of vessel's impressed cathodic system.
- Engage divers to survey the vessel's underwater shell plating and appendages and review the condition of the hull in the splash zone.
- Prepare ongoing maintenance plan for five year intervals for up to 15 years in the future.

4.3. Long Term Ship Maintenance Schedule

The following items are recommended to be performed on a long term basis:

- Prepare and implement vessel repair plan and budget.
- Prepare ongoing 10 year and 20 year maintenance data into a central planning effort.

5. Detail of Maintenance Tasks

The following are detailed descriptions of some of the maintenance tasks presented in the Daily, Annual, and Long Term maintenance plans presented in Section 4 of this report. The following is a comprehensive maintenance plan for the vessel; a number of these tasks are already being performed by the ship's engineering staff.

5.1. Preparation and painting of exterior areas exposed to weather by Ship's Maintenance Team

The Maintenance crew has historically renewed the vessel's topside paint system with the use of semi-gloss silicon alkyd enamels. The frequency of renewing coatings depends upon damage due to exposure to UV rays and chemical breakdown of the coating depending upon which side of the ship is exposed to the sun. Coatings generally last longer on the port side, as the starboard side of the ship suffers from sun and rain damage while the port side is protected by the overhanging flight deck.

It behooves the Ship's Engineer to closely study new technologies with regard to new paint systems and their application methodology; many incorporate a one part primer/finish coat with one application over prepared steel surfaces.

The maintenance crew needs to be properly trained in the art of surface steel preparation, priming, and final coating applications. Many paint companies send their paint specialists into the field and are eager to educate the team on proper paint application and all of the variables, such as mil thickness, application procedure with respect to humidity and temperature variations, drying times, etc.

5.2. Daily cleaning of spaces exposed to weather by Ship's Maintenance Team

As noted above, it is recommended that proper daily cleaning of the topside spaces be performed to maintain a clean topside environment for the visiting public and for the well keeping of the vessel. Following are more detailed recommendations for daily cleaning of the vessel:

- Ensure all drainage conduits and waterways are clear of dirt and debris
- Ensure all downpipes are free and not blocked with debris
- Ensure all downpipes have proper screens over their drains
- Eliminate all concrete waterways and replace deteriorated steel; prime/paint as needed
- Clean vessel from top to bottom on a monthly basis with fresh water fire hoses and clean drains, superstructure and appendages
- Hose down waterways outboard with fresh water and clean all overboard discharge openings
- Renew deteriorated rubber drain water fairleads as needed

5.3. Ensure watertight integrity of vessel

The following recommendations are provided for the Ship's Engineer to assist in maintaining the watertight integrity of the vessel.

- A tank sounding log with appropriate labels for locations of tank sounding tubes should be prepared for all fuel/ballast tanks and voids and a dedicated person should be tasked to sound these tanks on a weekly basis. These inspections should be logged both on paper and on computer and the computer results should be presented to the Operations Director on a quarterly basis or as needed to verify the current status of the tankage.
- A daily round of bilge inspections throughout the ship should be performed and these inspections should be logged both in a paper book and on computer. Any slight changes observed should be reported immediately to the Operations Director.
- The vessel's high water bilge alarm system should be properly maintained and should be tested weekly. Results of the test should be logged.
- The vessel's high water bilge alarm system should be tested by the manufacturer or competent Contractor on a twice yearly basis (or as required). Results of these tests should be reported in writing to the Operations Director.
- All unnecessary hatches, watertight doors and scuttles below the waterline of the vessel should be closed.
- Any water intrusion detected below the waterline should be reported to the Operations Director. No pump-out of water overboard should be performed until sampling of the water has been completed and the results analyzed for hazardous materials. If there is the accidental discharge of water, immediate action is required by contacting the U. S. COAST GUARD SPILL RESPONSE HOTLINE or U. S. COAST GUARD MSO District Charleston.
- If not already in place, an on-call contract with a pollution remediation contractor should be established for quick response to any hazardous materials concerns. This contractor should be familiarized with all shipboard areas of concern.

5.4. Repair/Maintenance of the Vessel's Impressed Current Cathodic System

The cathodic protection system is one of the most critical tools for corrosion prevention, so maintenance of this system is vital to the ship's long term structural integrity. The purpose of the cathodic protection system is to eliminate the rusting or corrosion to the ship's hull which occurs when the ship's hull is immersed in water. When properly installed and functioning, the system will greatly reduce the rate of corrosion on the hull, rudders and propellers. The system only offers limited protection of hull openings and recesses such as sea chests and intake and discharge ports. Zincs are often used in these areas to act as sacrificial anodes for the appropriate protection.

The vessel currently has five (5) integral CAPAC impressed cathodic system rectifiers aboard that are operational. Readings taken during the structural survey by Miller silver-silver chloride probe showed that the hull is protected even though some of the paint system at the wind/waterline has deteriorated. The results of these readings are presented in Appendix C of the Task 1 and 3 report. The hull is freely eroding at the waterline (although minimally) where the paint system has been breached.

PPDA contracts with a corrosion engineer for maintenance of the existing impressed current cathodic protection system and it is our understanding that quarterly testing of the system is performed by the cathodic engineer.

Maintenance of the cathodic protection system should continue to be performed, with the following tasks performed by PPDA staff:

- Readings of galvanic potential on the rectifiers should be recorded on a weekly basis. Readings should be between .75 and 1.00 volts DC. The readings should be recorded on paper and transposed to a computer data base. The results of these readings should be presented to the Operations Director on a quarterly basis or when any potential readings outside the boundaries noted above are recorded.
- All rectifiers and sensors should be maintained in proper operating condition.

USS YORKTOWN

Task 7: Interpretation of the Structural Assessment and Repair Recommendations

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1. COST ANALYSIS, REPAIRS, STEM TO FRAME 50

1.1. DISCUSSION

Following is the order-of-magnitude cost estimate for the structural repairs for the portions of the vessel assessed in Tasks 1 through 5. This order-of-magnitude estimate is based on the team's experience with similar projects. Construction costs vary and Collins does not provide any warranty, express or implied, for construction costs. A permanent or semi-permanent/portable cofferdam offers the best choice to allow 'below waterline' repairs to the vessel's shell plating; the cost of either a portable or permanent cofferdam is not included in this estimate.

1.2. MOBILIZATION & DEMOBILIZATION

MOBILIZATION		
	Labor	**2,500,000.00**
	Materials	**325,000.00**
DEMOBILIZATION		
	Labor	**750,000.00**
	Materials	**50,000.00**
BONDS & INSURANCE 2.0%		
		494,510.00

1.3. EXTERIOR SHELL PLATING

STEM to FRAME 50. Properly remediate all outboard spaces and tankage adjacent to the shell plating for red lead issues from 4th Deck to keel, 9,600 sq. ft.		
	Labor	**1,500,000.00**
	Materials	**125,000.00**
STEM to FRAME 50. Have Marine Chemist certify all spaces as 'Safe for Entry, Safe for Hot Work'.		
	L/S	**20,000.00**
STEM to FRAME 50. Crop out original plating, dress frames and bulkheads and insert 11,000 sq. ft of 20# (1/2") A-36 mild steel plating @ $ 20.00/lb		
	L/S	**4,200,000.00**
	Materials	**110,000.00**

1.4. BULKHEADS

4TH DECK, 1ST PLATFORM, 2ND PLATFORM, HOLD, THIRD BOTTOM & DOUBLE BOTTOM – Replace watertight and oil tight bulkheads as fitted at Frame #4, with 200 sq. ft. of 20# (1/2") steel plate.		
	L/S	**100,000.00**
	Materials	**10,000.00**
4TH DECK, 1ST PLATFORM, 2ND PLATFORM, HOLD, THIRD BOTTOM & DOUBLE BOTTOM – Replace watertight and oil tight bulkheads as fitted at Frame #8, with 330 sq. ft. of 20# (1/2") steel plate.		
	L/S	**165,000.00**
	Materials	**16,500.00**

4TH DECK, 1ST PLATFORM, 2ND PLATFORM, HOLD, THIRD BOTTOM & DOUBLE BOTTOM – Replace watertight and oil tight bulkheads as fitted at Frame #15, with 500 sq. ft. of 20# (1/2") steel plate.

	L/S	**250,000.00**
	Materials	**25,000.00**

4TH DECK, 1ST PLATFORM, 2ND PLATFORM, HOLD, THIRD BOTTOM & DOUBLE BOTTOM – Replace watertight and oil tight bulkheads as fitted at Frame #15, with 500 sq. ft. of 20# (1/2") steel plate.

	L/S	**250,000.00**
	Materials	**25,000.00**

4TH DECK, 1ST PLATFORM, 2ND PLATFORM, HOLD, THIRD BOTTOM & DOUBLE BOTTOM – Replace watertight and oil tight bulkheads as fitted at Frame #19, with 750 sq. ft. of 20# (1/2") steel plate.

	L/S	**375,000.00**
	Materials	**37,500.00**

2ND PLATFORM, HOLD, THIRD BOTTOM & DOUBLE BOTTOM – Replace watertight and oil tight bulkheads as fitted at frame #26, with 580 sq. ft. of 20# (1/2") steel plate.

	L/S	**290,000.00**
	Materials	**29,500.00**

4TH DECK, 1ST PLATFORM, 2ND PLATFORM, HOLD, THIRD BOTTOM & DOUBLE BOTTOM – Replace watertight and oil tight bulkheads as fitted at Frame #32, with 1,300 sq. ft. of 20# (1/2") steel plate.

	L/S	**520,000.00**
	Materials	**65,000.00**

2ND PLATFORM, HOLD, THIRD BOTTOM & DOUBLE BOTTOM – Replace watertight and oil tight bulkheads as fitted at frame #39, with 1,120 sq. ft. of 20# (1/2") steel plate.

	L/S	**448,000.00**
	Materials	**55,100.00**

1ST PLATFORM, 2ND PLATFORM, HOLD, THIRD BOTTOM & DOUBLE BOTTOM – Replace watertight and oil tight bulkheads as fitted at Frame #44, with 1,200 sq. ft. of 20# (1/2") steel plate.

	L/S	**480,000.00**
	Materials	**60,000.00**

2ND PLATFORM, HOLD, THIRD BOTTOM & DOUBLE BOTTOM – Replace watertight and oil tight bulkheads as fitted at frame #50, with 800 sq. ft. of 20# (1/2") steel plate.

	L/S	**400,000.00**
	Materials	**40,000.00**

1.5. FRAMES

HOLD, THIRD BOTTOM & DOUBLE BOTTOM, Frames F.P TO Frame 4.
Repair/sister existing transverse web frames with 11# (.275") plate by sistering three transverse frames to existing structure.

	L/S	**85,000.00**
	Materials	**25,000.00**

HOLD, THIRD BOTTOM & DOUBLE BOTTOM, Frames 4 – 50 (45 frames).
Repair/sister existing transverse web frames with 18# (.450") plate by sistering forty (40) 3/8" x 4" x 6" X 15' T-stock transverse frames to existing structure.

	L/S	**600,000.00**
	Materials	**20,000.00**

1.6. 4TH DECK

A-401A – Remediate space for red lead.

	Labor	**48,000.00**
	Materials	**4,800.00**

A-401A – Remove old deck and insert 200 sq. ft of 15# (3/8") floor plate.

	L/S	**105,000.00**
	Materials	**10,500.00**

A-402A – Remediate space for red lead.

	Labor	**48,000.00**
	Materials	**4,800.00**

A-402A – Remove old deck and insert 420 sq. ft of 15# (3/8") floor plate.
Replace gaskets, threaded studs, nut & washers for the pair of bolted hatches on floor.

	L/S	**200,000.00**
	Materials	**17,500.00**

A-403A – Remediate space for red lead.

	Labor	**48,000.00**
	Materials	**4,800.00**

A-403A – Remove old deck and insert 420 sq. ft of 15# (3/8") floor plate.

	L/S	**210,000.00**
	Materials	**21,000.00**

1.7. 1st PLATFORM

Frames 4 – 15 – 1st PLATFORM, 2ND PLATFORM & HOLD – Properly de-water and contain hazmat (if present for all spaces and tankage in this area).

	L/S	**74,000.00**

Frames 4 – 15 – 1st PLATFORM, 2ND PLATFORM & HOLD - Remove old deck between 1st & 2nd Platform & 2nd PLATFORM AND HOLD and insert 900 sq. ft of 15# floor plate.

	L/S	**337,500.00**
	Materials	**45,000.00**

Frames 4 – 15 – 1st PLATFORM, 2ND PLATFORM & HOLD - Crop out and replace thirty eight (38) ¼" x 4" x 6" x 30' T-stock transverse frames.		
	L/S	**570,000.00**
	Materials	**19,000.00**
A-501A – Properly remediate space for red lead concerns.		
	Labor	**48,000.00**
	Materials	**4,800.00**
A-501A – Crop out and replace 100. Sq. ft. of 15# (3/8") A-36 mild steel deck.		
	L/S	**37,500.00**
	Materials	**5,000.00**
A-502A, A-503A – Properly remediate spaces for red lead concerns.		
	L/S	**45,000.00**
	Materials	**5,000.00**
A-502A, A-503A – Crop out and replace 506 Sq. ft. of 15# (3/8") A-36 mild Steel deck.		
	L/S	**203,000.00**
	Materials	**22,770.00**
A-504A – Properly remediate space for red lead concerns.		
	Labor	**48,000.00**
	Materials	**4,800.00**
A-504A – Crop out and remove old deck and insert 800 sq. ft of 15# floor plate.		
	L/S	**300,000.00**
	Materials	**40,000.00**
A-504A – Crop out and replace 4' lower sections of sixteen (16) ¼" x 4" x 5" T-stock transverse frames.		
	L/S	**64,000.00**
	Materials	**8,000.00**
A-504A – Crop out and replace bottom 3' of main transverse web frame.		
	L/S	**6,500.00**
	Materials	**2,500.00**
A-506A – Properly remediate space for red lead concerns.		
	Labor	**48,000.00**
	Materials	**4,800.00**
A-506A – Remove and install new inserted 500 sq. ft of 15# deck plating.		
	L/S	**185,000.00**
	Materials	**25,000.00**
A-506A – Properly remediate tanks A-5F, A-6F & A-9E for oil concerns.		
	Labor	**144,000.00**
	Materials	**14,400.00**
A-506A – Crop out and replace twelve (12) ¼" x 4" x 5" x 10' T-stock transverse frames.		
	L/S	**180,000.00**
	Materials	**12,000.00**

1ST PLATFORM, 2ND PLATFORM & HOLD - Frames 15 – 50.

Properly remediate oil tankage inboard of these frames which includes: A-3F, A-4F, A-7F, A-8F, A-19F, A-20F, A-20 1/2F, A-21F, A-21 1/2F, A-24F, A-25F, A-26F, A-27F.

	Labor	**494,000.00**
	Materials	**40,000.00**

1.8. 2ND PLATFORM

2ND PLATFORM & HOLD - Frames 32 – 39. Remove old deck between 2nd Platform and Hold and insert 590 sq. ft of 15# floor plate.		
	L/S	**221,250.00**
	Materials	**29,000.00**
2ND PLATFORM & HOLD, Frames 32 – 39 - Crop out and replace twelve (12) ¼" x 4" x 5" x 17' T-stock transverse frames.		
	L/S	**180,000.00**
	Materials	**24,000.00**
CHAIN LOCKER, Frame 7 – 12 1/2– Remove & return anchor chain from both lockers.		
	L/S	**24,000.00**
CHAIN LOCKER, Frame 7 – 12 1/2, – Remove & return anchor chain pens from sides and bottoms of lockers.		
	L/S	**20,000.00**
CHAIN LOCKER, Frame 7 – 12 1/2 – Crop and replace eighteen (18) ¼" x 4" x 5" x 10' T-stock transverse frames.		
	L/S	**270,000.00**
	Materials	**30,000.00**
CHAIN LOCKER, Frame 7 – 12 1/2 – Crop out and replace 150 sq. ft. of 20# (½") plate for forward bulkhead.		
	L/S	**75,000.00**
	Materials	**7,500.00**
CHAIN LOCKER, Frame 7 – 12 1/2 – Crop out and replace 180 sq. ft. of 20# (½") plate for aft bulkhead.		
	L/S	**90,000.00**
	Materials	**9,000.00**
A-602A – Properly remediate space for red lead concerns.		
	Labor	**48,000.00**
	Materials	**4,800.00**
A-602A – Crop and replace six (6) ¼" x 4" x 5" x 10' T-stock transverse frames.		
	L/S	**90,000.00**
	Materials	**12,000.00**
A-602A – Crop out and replace 200 sq. ft. of 20# (½") plate for aft bulkhead.		
	L/S	**100,000.00**
	Materials	**10,000.00**
A-602A – Properly remediate space for red lead concerns.		
	Labor	**48,000.00**
	Materials	**4,800.00**

A-603A – Crop and replace twelve (12) ¼" x 4" x 5" x 10' T-stock transverse frames.		
	L/S	**140,000.00**
	Materials	**20,000.00**
A-603A – Crop out and replace 240 sq. ft. of 20# (½") plate for aft bulkhead.		
	L/S	**120,000.00**
	Materials	**12,000.00**
A-605 1/2A – Properly remediate space for red lead concerns.		
	Labor	**48,000.00**
	Materials	**4,800.00**
A-605 1/2M – Replace 160 sq. ft of 20# (½") aft bulkhead.		
	L/S	**80,000.00**
	Materials	**8,000.00**
A-605 1/2M – Replace eleven (11) 3/8" x 4" x 9" T-stock intermediate side shell transverse frames,		
	L/S	**165,000.00**
	Materials	**20,000.00**
A-605 1/2M – Replace bottom 3' x 22' (66 sq. ft.) of 20# (½") centerline bulkhead,		
	L/S	**33,000.00**
	Materials	**3,300.00**
A-605 1/2M – Replace on four (4) vertical stanchions the bottom 4' of ½" x 10" O.D. pipe on centerline bulkhead,		
	L/S	**60,000.00**
	Materials	**4,000.00**
A-605 1/2M – Replace four (4) ½" x 12" x 12' base & top pads for the repaired vertical stanchions,		
	L/S	**12,000.00**
	Materials	**2,000.00**
A-605 1/2M – Replace ½" x 3" x 22' flat bar shelf for deck beams on overhead,		
	L/S	**20,000.00**
	Materials	**2,000.00**
A-605 1/2M – Replace thirteen (13) 3/8" x 4" x 6" x 12' T-stock deck beams on overhead,		
	L/S	**140,000.00**
	Materials	**20,000.00**
A-605 1/2M – Replace 200 sq. ft. of ½" steel deck,		
	L/S	**100,000.00**
	Materials	**10,000.00**
A-605 1/2M – Replace watertight dogging door frame; consider replacement for dogging hatch,		
	L/S	**30,000.00**
	Materials	**12,000.00**
A-605 1/2M – Replace 100 sq. ft. of 20# (1/2) plating for centerline bulkhead where it jogs to meet watertight dogging hatch.		
	L/S	**50,000.00**

	Materials	15,000.00
A-605A – Properly remediate space for red lead concerns.		
	Labor	48,000.00
	Materials	4,800.00
A-605A – Replace 140 sq. ft 20# (½”) forward bulkhead,		
	L/S	70,000.00
	Materials	7,000.00
A-605A – Replace 160 sq. ft 20# (½”) aft bulkhead,		
	L/S	80,000.00
	Materials	8,000.00
A-605A – Replace eleven (11) 3/8” x 4” x 9” T-stock intermediate side shell transverse frames,		
	L/S	165,000.00
	Materials	20,000.00
A-605A – Replace ½” x 3” x 22’ flat bar shelf for deck beams on overhead,		
	L/S	20,000.00
	Materials	2,000.00
A-605A –Replace thirteen (13) 3/8” x 4” x 6” x 12’ T-stock deck beams on overhead,		
	L/S	195,000.00
	Materials	16,000.00
A-605A – Replace 200 sq. ft. of 20# (½”) steel deck,		
	L/S	100,000.00
	Materials	10,000.00
A-605A – Replace watertight dogging door frame; consider replacement for dogging hatch,		
	L/S	30,000.00
	Materials	8,000.00
A-605A – Replace 140 sq. ft. of 20# (1/2) bulkhead where space is jogged to meet watertight dogging hatch.		
	L/S	70,000.00
	Materials	7,000.00
A-607E – Properly remediate space for red lead concerns.		
	Labor	48,000.00
	Materials	4,800.00
A-607E – Replace 150 sq. ft. of 20# (1/2”) steel deck.		
	L/S	75,000.00
	Materials	7,500.00
A-611M – Determine source of standing water and seal. Prep/prime and paint affected deck and bulkheads.		
	L/S	20,000.00

1.9. HOLD

A-708E – Space is inboard of outboard voids and adjacent lube oil tanks & a pump room. Properly remediate piping and all spaces for standing water/oil and make ‘Safe for Entry & Safe for Hot Work.		
	Labor	48,000.00

	Materials	4,800.00
A-708E – Consider removal of all piping, seal all bulkheads with 3/8" steel blanks at piping penetrations.		
	L/S	3,000.00
A-708E – Crop out old deck and replace with 500 sq. ft of 15# (3/8") steel.		
	L/S	250,000.00
	Materials	25,000.00
A-708E – Crop out bulkheads and replace with 1,000 sq. ft of 15# (3/8") steel.		
	L/S	400,000.00
	Materials	40,000.00
A-708E – Repair/replace watertight dogging hatches (2) and gaskets.		
	L/S	30,000.00
	Materials	12,000.00
A-709M – Space is inboard of outboard voids and adjacent lube oil tanks & a pump room. Properly remediate piping and all spaces for standing water/oil and make 'Safe for Entry & Safe for Hot Work.		
	Labor	60,000.00
	Materials	6,800.00
A-709M – Consider removal of all piping, seal all bulkheads with 3/8" steel blanks at piping penetrations.		
	L/S	3,000.00
A-709M – Crop out old deck and replace with 500 sq. ft of 15# (3/8") steel.		
	L/S	187,500.00
	Materials	20,000.00
A-709M – Repair/replace watertight dogging hatches (2) and gaskets.		
	L/S	30,000.00
	Materials	12,000.00
A-711T, A-712T – Properly remediate space for red lead concerns.		
	Labor	48,000.00
	Materials	4,800.00
A-711T, A712T – Replace existing deck with 25 sq. ft. of ½" A-36 steel plate		
	L/S	8,000.00
	Materials	750.00

1.10. VERTICAL KEEL

Frame 5 – 50. Sister the center vertical keel with 20# (1/4) A-36 mild steel on both sides relying on welding to old plate and bolting plates where appropriate. Sister keel side support gussets on every other gusset from Frame 5 – 50 with 15# (3/8" A-36 mild steel plate welding and bolting to existing structure.		
	L/S	685,000.00
	Materials	50,000.00

1.11. PAINTING

It is recommended that all plating receive two (2) coats of International 300V primer/finish coat. Costs below are tabulated for the area encompassing the 4th Deck to Keel, stem to Frame 50 including decks and bulkheads.

45,576 sq. ft. x 2 sides x $ 9.00/sq. ft. x 2 coats		
	L/S	1,640,736.00

1.12. TOTAL ESTIMATED REPAIR COSTS

Total Estimated Cost	**25,220,016.00**
15% Contingency	**3,783,002.00**
Total	**29,003,018.00**

2. COST ANALYSIS, FRAME # 50 TO STERN

2.1. MOBILIZATION

Labor	**1,500,000.00**
Materials	**325,000.00**

DEMOBILIZATION

Labor	**500,000.00**
Materials	**50,000.00**

BONDS & INSURANCE 2.0%	**195,330.00**

2.2. 1st PLATFORM

A-523M – Perform remediation on red leaded surfaces where cuts to be made.		
	Labor	**48,000.00**
	Materials	**4,800.00**
A-523M – Crop out and replace deck with 600 sq. ft. of 15# (3/8”) steel plating.		
	L/S	**225,000.00**
	Materials	**15,000.00**
A-525 1/2T – Perform remediation on red leaded surfaces where cuts to be made.		
	Labor	**48,000.00**
	Materials	**4,800.00**
A-525 1/2T – Replace 50 sq. ft. of 15# (3/8”) steel plate for floor.		
	L/S	**18,750.00**
	Materials	**3,000.00**
A-525 1/2T – Crop out and replace bottom 18” of bulkheads with 18” x 48’ (72 sq. ft.) of 15# (3/8”) steel plate.		
	L/S	**27,000.00**
	Materials	**3,000.00**
A-541ET – Perform remediation of lower frames and deck to allow cut/burn fabrication.		
	Labor	**48,000.00**
	Materials	**4,800.00**

A-541ET – Crop out and repair base 6" of bottom bases of six (6) 3/8" x 4" of vertical tapered frames.

	L/S	**11,000.00**
	Materials	**4,000.00**
A-541ET – Crop out and replace 110 sq. ft. of 15# (3/8") of deck.		
	L/S	**41,250.00**
	Materials	**5,000.00**
C-516A – Remove all debris from compartment. Properly remediate all surfaces where cutting/burning anticipated.		
	Labor	**48,000.00**
	Materials	**4,800.00**
C-516A – Crop out and replace Main longitudinal beam: Depth = 20 7/8-in, Flange width = 8 ½in W, Flange thickness = 5/8in. Length 10' (1).		
	L/S	**9,000.00**
	Materials	**2,200.00**
C-516A – Crop out and replace Secondary longitudinal beam: Depth = 10 3/8in, Flange width = 4in, Flange thickness = ¼in x 10' (2).		
	L/S	**18,000.00**
	Materials	**2,500.00**
C-516A – Crop out and replace Transverse beams: Depth = 6in, Flange width = 3 1/8-in, Flange thickness = 1/8in. x 10' (2)		
	L/S	**18,000.00**
	Materials	**3,000.00**
C-516A – Crop out and replace on all lower space scantlings sized 3/8" x 3" x 4" L-stock X 4' (8)		
	L/S	**24,000.00**
	Materials	**7,800.00**
C-516A – Replace 100 sq. ft. of 15# (3/8") steel deck.		
	L/S	**37,500.00**
	Materials	**4,000.00**
C-518E – Perform remediation for red lead and oil in compartment.		
	Labor	**40,000.00**
	Materials	**6,000.00**
C-518E – Install welded steel case around packing gland and rudder head foundation to seal the packing gland.	**L/S**	**12,000.00**
	Materials	**3,000.00**

2.3. 2ND PLATFORM

A-613ET WT – Properly remediate A-617E JP-5 Pumping Room of all flammable substances and A-613ET WT space for standing oil, water and red lead issues.

	Labor	**48,000.00**
	Materials	**4,800.00**

A-613ET WT – Crop out and replace with 100 sq. ft. of 15# (3/8") A-36 steel

plating for deck.

	L/S	**37,500.00**
	Materials	**4,000.00**
A-613ET WT – Crop out and replace 40' x 12" of 15# (3/8") A-36 steel bulkhead plating.		
	L/S	**15,000.00**
	Materials	**2,000.00**
C-605E – Properly de-fuel all piping and components within this compartment and have all surrounding tankage (outboard voids, Cofferdam C-9V and Fuel Tank C-5A & Fuel Tank C-6V, tankage below in Hold) properly remediated and declared 'Safe for Entry & Safe for Hot Work' by Marine Chemist.		
	Labor	**150,000.00**
	Materials	**15,000.00**
C-605E – Crop out and replace existing deck with 160 sq. ft. of new 15# (3/8") A-36 steel deck.		
	L/S	**60,000.00**
	Materials	**8,500.00**
C-607A – Perform remediation for red lead and oil in compartment.		
	Labor	**48,000.00**
	Materials	**4,800.00**
C-607A – Properly de-fuel all piping and components within this compartment and have all surrounding tankage (outboard voids, Cofferdam C-9V, C-605E JP-5 Pump Room and Fuel Tank C-5A & Fuel Tank C-6V, tankage below in Hold) properly remediated and declared 'Safe for Entry & Safe for Hot Work' by Marine Chemist.		
	Labor	**250,000.00**
	Materials	**58,000.00**
C-607A – Crop out and replace existing deck with 120 sq. ft. of new 15# (3/8") A-36 steel deck.		
	L/S	**45,000.00**
	Materials	**3,000.00**
C-607A – Crop out and replace bottom 1' x 40' of bulkhead around compartment with new 15# (3/8") A-36 steel plate.		
	L/S	**20,000.00**
	Materials	**1,800.00**

2.4. HOLD

Forward AMR B-1-1 – Crop out and replace existing deck with 1568 sq. ft. of new 15# (3/8") A-36 steel deck.		
	L/S	**784,000.00**
	Materials	**70,560.00**
Forward AMR B-1-1 – Crop out and replace bottom 4' x 224' of bulkhead around compartment with new 15# (3/8") A-36 steel plate.		
	L/S	**112,000.00**
	Materials	**10,080.00**

2.5. WIND/WATERLINE PORT

Perform remediation for red lead and oil in Blister Tanks across 600' (or 150 frames/bulkheads) of compartments.

Labor	**1,248,000.00**
Materials	**80,000.00**

Install 4' x 600' x ¾" A-36 mild steel plating inserted plating.

Labor	**1,470,000.00**
Materials	**24,000.00**

2.6. WIND/WATERLINE STARBOARD

Perform remediation for red lead and oil in Blister Tanks across 100' (or 25 frames/bulkheads) of compartments.

Labor	**228,000.00**
Materials	**18,000.00**

Install 4' x 100' x ¾" A-36 mild steel plating inserted plating.

Labor	**245,000.00**
Materials	**18,000.00**

2.7. INBOARD PORT SHAFT ALLEY

Have industrial dive team jet and airlift mud away from shaft annulus, clean areas between shaft and inner side of annulus.

Install LINK SEALS in shaft annulus to stop leakage past packing gland. Perform remediation for red lead and oil in compartment.

Remove deteriorated catwalk and support stanchions.

Crop out and replace 800 sq. ft. of floor with 3/8" A-36 mild steel plating.

If LINK SEALS hold back water from packing gland, remove old flax packing and repack gland.

Tighten packing gland into the stops.

Labor	**380,000.00**
Materials	**28,000.00**

2.8. OUTBOARD PORT SHAFT ALLEY

Have industrial dive team jet and airlift mud away from shaft annulus, clean areas between shaft and inner side of annulus.

Install LINK SEALS in shaft annulus to stop leakage past packing gland.

If LINK SEALS hold back water from packing gland, remove old flax packing and repack gland.

Tighten packing gland into the stops.

Labor	150,000.00
Materials	6,000.00

2.9. INBOARD STARBOARD SHAFT ALLEY

Have industrial dive team jet and airlift mud away from shaft annulus, clean areas between shaft and inner side of annulus.

Install LINK SEALS in shaft annulus to stop leakage past packing gland.

If LINK SEALS hold back water from packing gland, remove old flax packing and repack gland.

Tighten packing gland into the stops.

Labor	150,000.00
Materials	6,000.00

2.10. OUTBOARD STARBOARD SHAFT ALLEY

Have industrial dive team jet and airlift mud away from shaft annulus, clean areas between shaft and inner side of annulus.

Install LINK SEALS in shaft annulus to stop leakage past packing gland.

If LINK SEALS hold back water from packing gland, remove old flax packing and repack gland.

Tighten packing gland into the stops. .

Labor	150,000.00
Materials	6,000.00

2.11. PAINTING

It is recommended that all plating receive two (2) coats of International 300V primer/finish coat.

9,100 sq. ft. x 2 sides x $ 9.00/sq. ft. x 2 coats

L/S	315,000.00

2.12. Totals

Total Estimated Cost	9,961,810.00
15% Contingency	1,494,271.00
Total Cost	11,456,081.00

3. TOTAL REPAIR COST ESTIMATE

Total for F. P. to Frame 50	**29,003,019.00**
Total for Frame 50 to Stern	**11,456,081.00**
Total Repair Cost Estimate	**40,459,100.00**

USS YORKTOWN

Supplemental Findings

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1. Introduction

While performing the Task 5 assessments, Collins observed structural deficiencies to portions of the vessel that were outside of the scope of the assessment. These structural deficiencies were observed at the following areas:

1. The catwalk adjacent to and just below the flight deck along the port side of the vessel.
2. The elevator along the starboard side of the ship used as the main entrance platform for the vessel.
3. The crane and sponson along the starboard side of the vessel aft of the main entrance area.
4. The framing at the forward end of the main entrance along the starboard side of the vessel.

2. Catwalk, adjacent to port side of Flight Deck

A steel catwalk was constructed on the port side of the ship along the edge of the flight deck. The catwalk was constructed outboard of the safety barriers installed along the edge of the flight deck, approximately 6-ft below the level of the flight deck. The catwalk may be accessed from the 02 Deck and from stairs leading down from the flight deck. Access is typically restricted by signs and barrier gates; however, Collins observed several unlocked gates in the safety barrier along the edge of the flight deck which could be opened to obtain access to the catwalk.

The supporting structure of the catwalk was constructed with cantilevered steel structural beams of various sizes which were welded to the outboard surfaces of the 02 Deck compartments. Two types of steel plate were used along the catwalk. Approximately 70% of the deck is constructed with perforated steel plating (Figure 2.2) while the remaining approximately 30% was constructed with steel grating (Figure 2.3). The inboard edge of the deck is supported by steel plates welded to the hull which serve as a ledge for bearing of the perforated plate or steel grating. Steel angles which span between the cantilevered steel beams support the outboard edge of the deck.

Structural Observations

- Numerous areas of moderate-to-heavy corrosion were observed on the steel deck of the catwalk at both the perforated plate and grating portions. (Figure 2.4)
- Several areas of severe corrosion with up to 100% loss of section (LOS) were observed on the catwalk deck. (Figure 2.5-2.7)
- Heavy-to-severe corrosion was observed along portions of the steel plate supporting the inboard edge of the catwalk deck. (Figure 2.8)
- Areas of severe corrosion with up to 100% LOS were observed on the steel beams which support the catwalk. (Figure 2.9-2.15)

Additional Observations

- Peeling and/or failed paint was observed over the entire surface of the catwalk deck, and on isolated sections of the catwalk support framing.

Figure 2.1 Location of catwalk along port edge of flight deck

Figure 2.2 Gate at edge of flight deck leading to catwalk, port side

Figure 2.3 Open gate leading to catwalk from flight deck, port side

Figure 2.4 Perforated steel plate decking on catwalk

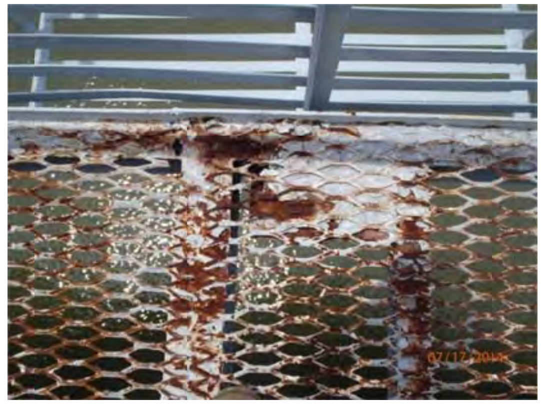

Figure 2.5 Expanded metal mesh decking on catwalk

Figure 2.6 Corrosion of steel catwalk deck

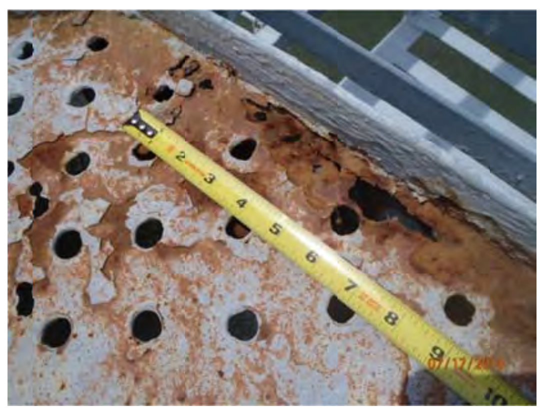

Figure 2.7 Corrosion with 100% loss of section on catwalk deck

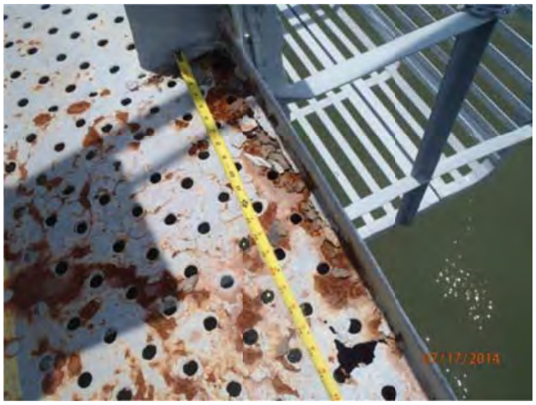

Figure 2.8 Corrosion with 100% loss of section on catwalk deck

Figure 2.11 Corrosion with 100% loss of section on catwalk support framing

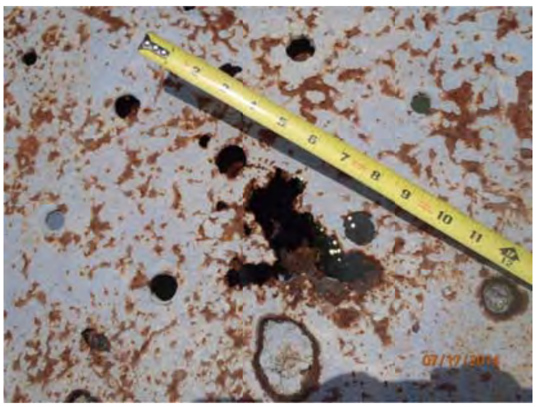

Figure 2.9 Corrosion with 100% loss of section on catwalk deck

Figure 2.12 Corrosion with 100% loss of section on catwalk support framing

Figure 2.10 Corrosion of steel plate supporting catwalk deck

Figure 2.13 Corrosion with 100% loss of section on catwalk support framing

Figure 2.14 Corrosion with 100% loss of section on catwalk support framing

Figure 2.16 Corrosion with 100% loss of section on catwalk support framing

Figure 2.15 Corrosion with 100% loss of section on catwalk support framing

Figure 2.17 Corrosion with 100% loss of section on catwalk support framing

3. Starboard Aircraft Elevator / Main Entrance Platform

The main access to the ship's hangar deck for visitors is via the starboard aircraft elevator platform, which is now permanently fixed in a lowered position level with the hangar deck. This elevator platform was added during the ship's 1955 "SCB-125" upgrade and is supported by a frame of steel tubing and the mechanical systems used to operate the elevator.

Structural Observations

- Severe corrosion with up to 100% loss of section (LOS) was observed on the tubular frame members which support the elevator platform. (Figure 3.1-3.9)
- Heavy-to-severe corrosion was observed on the portions of the elevator mechanism directly attached to the outer surface of the ship's hull. (Figure 3.10)
- The cables which previously supported the elevator platform were observed to be in significantly deteriorated condition, with multiple failed strands in the cable at the aft end of the platform. (Figure 3.11)
- Steel plates have been added to supplant the cables which previously supported the elevator platform; the lower attachment points for these steel plates were found to be heavily corroded with up to 100% loss of section. (Figure 3.12)

Figure 3.1 Location of starboard elevator / entrance platform

Figure 3.2 Corrosion with 100% loss of section on entrance platform support framing

Figure 3.3 Corrosion with 100% loss of section on entrance platform support framing

Figure 3.4 Corrosion on entrance platform support framing

Figure 3.7 Corrosion on entrance platform support framing

Figure 3.5 Corrosion on entrance platform support framing

Figure 3.8 Corrosion on entrance platform support framing

Figure 3.6 Corrosion with 100% loss of section on entrance platform support framing

Figure 3.9 Corrosion on entrance platform support framing

Figure 3.10 Corrosion with 100% loss of section on entrance platform support framing

Figure 3.12 Failure of cables supporting entrance platform

Figure 3.11 Corrosion on entrance platform support framing

Figure 3.13 Severe corrosion of lower attachment points for support members

4. Crane, Crane Mount and Sponson, Starboard side of ship

During the ship's 1955 "SCB-125" upgrade, a steel sponson structure was added to the starboard side of the ship to house one of the 5-inch guns previously located on the flight deck. This gun was later removed and a steel crane system was mounted in its place on the sponson.

Structural Observations

- Numerous areas of heavy-to-severe corrosion and 100% loss of section were observed in the structure of the crane arm. (Figure 4.2-4.4)
- Pockets of severe corrosion were observed on the crane arm in the multiple areas where water stand after rainstorms. (Figure 4.5-4.9)
- Moderate corrosion was observed on the base of the crane structure and in the bolts and plates securing the crane to its mount. (Figure 4.10)
- The sponson to which the crane is mounted shows evidence of corrosion, with previous repairs to the exterior of the structure. (Figure 4.11-4.12)

Figure 4.1 Location of crane and sponson

Figure 4.2 Corrosion of crane arm structure

Figure 4.3 Corrosion of crane arm structure

Figure 4.4 Corrosion of crane arm structure

Figure 4.7 Corrosion at base of crane mount

Figure 4.5 Corrosion of crane arm structure

Figure 4.8 Corrosion of crane arm structure

Figure 4.6 Corrosion of crane arm structure

Figure 4.9 Corrosion of crane arm structure

Figure 4.10 Corrosion at base of crane mount

Figure 4.11 Previous repair to exterior of sponson

Figure 4.12 Interior view of sponson showing peeling paint and corrosion

Figure 4.13 Interior view of sponson showing peeling paint and corrosion

5. Framing at forward end of main entrance door, starboard side of vessel

Structural Observations

- Severe corrosion, with up to 100% loss of section, was observed throughout the lower areas of the framing at the forward end of the main entrance door.

Figure 5.1 Location of main entrance platform/door

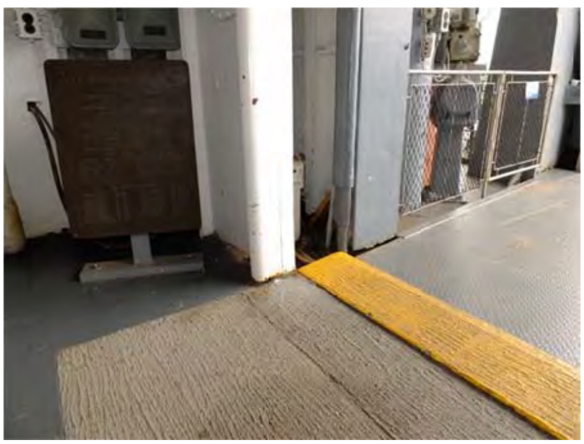

Figure 5.2 Overall view of framing at forward end of main entrance door

Figure 5.3 Severe corrosion and 100% loss of section on lower portions of framing

HISTORY

The fourth Yorktown (CV-10) was laid down on 1 December 1941 at Newport News, Va., by the Newport News Shipbuilding & Drydock Co. as Bon Homme Richard; renamed Yorktown on 26 September 1942; launched on 21 January 1943; sponsored by Mrs. Eleanor Roosevelt; and commissioned on 15 April 1943 at the Norfolk Navy Yard, Capt. Joseph J. ("Jocko") Clark in command.

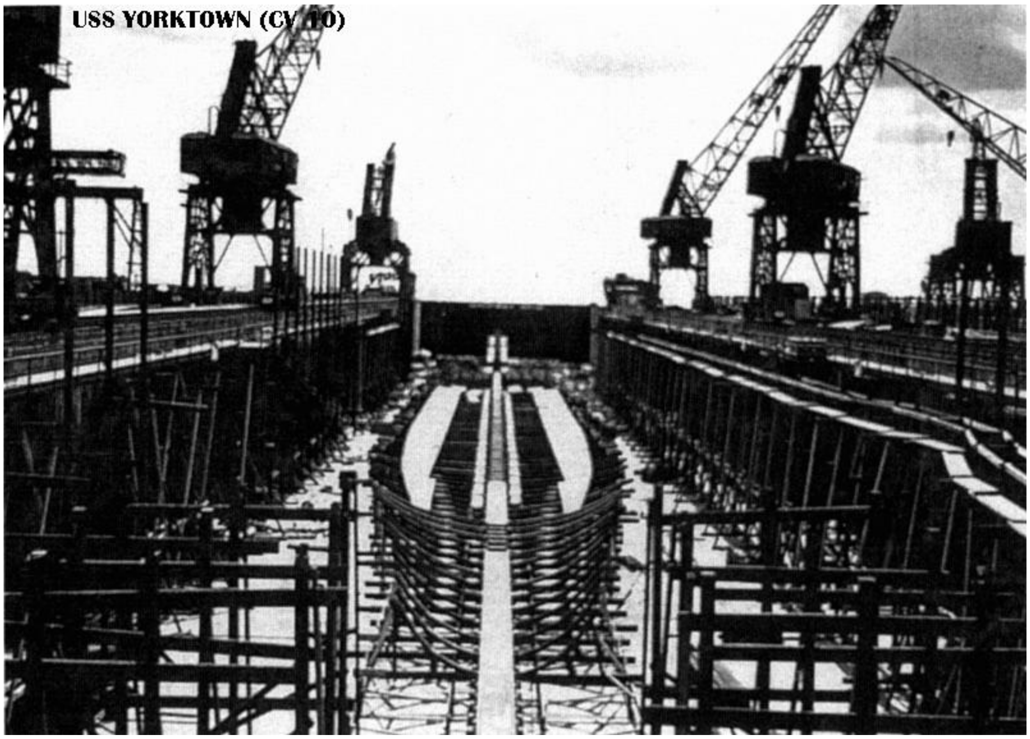

Figure 1.1 Keel of U.S.S. YORKTOWN laid in drydock of Newport News Shipbuilding, 1 December 1941.

Figure 1.2 On the launching ways just prior to christening.

The new USS YORKTOWN (See adjacent column) Acme

New Yorktown Launched—The new Aircraft Carrier YORKTOWN, already equipped with many of the mechanisms usually added later at a fitting basin, was in such a hurry to get down the ways and into action that she jumped the gun at her recent launching.

However, the occasion went through without a mishap—due, in part, to Mrs. Franklin D. Roosevelt's swiftly stepping up and smacking the bow with the wine bottle. She had christened the first YORKTOWN seven years ago.

Figure 1.3 Newspaper account of launch of U.S.S. YORKTOWN (CV-10).

Yorktown remained in the Norfolk area until 21 May at which time she got underway for shakedown training in the vicinity of Trinidad. She returned to Norfolk on 17 June and began post-shakedown availability. The aircraft carrier completed repairs on 1 July and began air operations out of Norfolk until the 6th.

Figure 1.4 Loading planes aboard, at NOB Norfolk, prior to departure for South Pacific.

On the latter day, she exited Chesapeake Bay on her way to the Pacific Ocean. She transited the Panama Canal on 11 July and departed Balboa on the 12th. The warship arrived in Pearl Harbor on 24 July and began a month of exercises in the Hawaiian Islands. On 22 August, she stood out of Pearl Harbor, bound for her first combat of the war. Her task force, TF 15, arrived at the launching point about 128 miles from Marcus Island early on the morning of 31 August. She spent most of that day launching fighter and bomber strikes on Marcus Island before beginning the retirement to Hawaii that evening.

Figure 1.5 Launching a Grumman F6F-3 Hellcat from the hangar deck catapult.

The aircraft carrier reentered Pearl Harbor on 7 September and remained there for two days.

Figure 1.6 U.S.S. YORKTOWN at sea late 1943.

Figure 1.7 Launching TBM AVENGER torpedo bomber from the Hangar Deck catapult off Trinidad, 1943. The pair of Hangar Deck catapults were later removed before operations in the South Pacific.

On the 9th, she stood out to sea, bound for the west coast of the United States. She arrived in San Francisco on 13 September, loaded aircraft and supplies, and returned to sea on the 15th. Four days later, the aircraft carrier reentered Pearl Harbor. After 10 days in the Hawaiian Islands, Yorktown returned to sea to conduct combat operations on the 29th. Early on the morning of 5 October, she began two days of air strikes on Japanese installations on Wake Island. After retiring to the east for the night, she resumed those air raids early on the morning of the 6th and continued them through most of the day. That evening, the task group began its retirement to Hawaii. Yorktown arrived at Oahu on 11 October and, for the next month, conducted air training operations out of Pearl Harbor.

On 10 November, Yorktown departed Pearl Harbor in company with Task Force (TF) 50—the Fast Carrier Forces, Pacific Fleet—to participate in her first major assault operation, the occupation of certain of the Gilbert Islands. On the 19th, she arrived at the launch point near Jaluit and Mili and, early that morning, launched the first of a series of raids to suppress enemy airpower during the amphibious assaults on Tarawa, Abemama, and Makin. On the 20th, she not only sent raids back to the airfield at Jaluit, but some of her planes also supported the troops wresting Makin from the Japanese. On 22 November, her air group concentrated upon installations and planes at Mili once again. Before returning to Pearl Harbor, the aircraft carrier made passing raids on the installations at Wotje and Kwajalein Atolls on 4 December. The warship reentered Pearl Harbor on 9 December and began a month of air training operations in the Hawaiian Islands.

Figure 1.8 Hellcats and Avengers warm up on deck prior to launch.

On 16 January 1944, the warship exited Pearl Harbor once again to support an amphibious assault—-Operation "Flintlock," the Marshall Islands operation. Her task group, Task Group (TG) 58.1, arrived at its launching point early on the morning of 29 January, and its carriers —

Figure 1.9 At sea late 1943. Notice her foredeck numbering facing forward for pilot recognition.

Yorktown, Lexington (CV-16), and Cowpens (CVL-25)—began sending air strikes aloft at about 0520 for attacks on Taroa airfield located on Maloelap Atoll. Throughout the day, her aircraft hit Maloelap in preparation for the assaults on Majuro and Kwajalein scheduled for the 31st. On the 30th, Yorktown and her sister carriers shifted target to Kwajalein to begin softening one of the targets itself. When the troops stormed ashore on the 31st, Yorktown aviators continued their strikes on Kwajalein in support of the troops attacking that atoll. The same employment occupied the Yorktown air group during the first three days in February. On the 4th, however, the task group retired to the Fleet anchorage at recently secured Majuro Atoll.

Over the next four months, Yorktown participated in a series of raids in which she ranged from the Marianas in the north to New Guinea in the south. After eight days at Majuro, she sortied with her task group on 12 February to conduct air strikes on the main Japanese anchorage at Truk Atoll. Those highly successful raids occurred on 16 and 17 February. On the 18th, the carrier set a course for the Marianas and, on the 22nd, conducted a single day of raids on enemy airfields and installations on Saipan. That same day, she cleared the area on her way back to Majuro. The warship arrived in Majuro lagoon on 26 February and remained there, resting and replenishing until 8 March. On the latter day, the carrier stood out of Majuro, rendezvoused with the rest of TF 58,

and shaped a course for Espiritu Santo in the New Hebrides. She reached her destination on 13 March and remained there for 10 days before getting underway for another series of raids on the Japanese middle defense line. On 30 and 31 March, she launched air strikes on enemy installations located in the Palau Islands; and, on 1 April, her aviators went after the island of Woleai. Five days later, she returned to her base at Majuro for a week of replenishment and recreation.

Figure 1.10 Capt. 'Jocko' Clark, first skipper of the ship departs YORKTOWN after being promoted to Rear Admiral and given command of Task Group 58.1 under Adm. Marc Mitscher.

On 13 April, Yorktown returned to sea once more. On this occasion, however, she laid in a course for the northern coast of New Guinea. On 21 April, she began launching raids in support of General Douglas Mac Arthur's assault on the Hollandia area. That day, her aviators attacked installations in the Wakde-Sarmi area of northern New Guinea. On the 22nd and 23rd of April, they shifted to the landing areas at Hollandia themselves and began providing direct support for the assault troops. After those attacks, she retired from the New Guinea coast for another raid on Truk lagoon, which her aircraft carried out on 29 and 30 April. The aircraft carrier returned to Majuro on 4 May; however, two days later she got underway again, bound for Oahu. The warship entered Pearl Harbor on 11 May and, for the next 18 days, conducted training operations in the Hawaiian Islands. On 29 May, she headed back to the Central Pacific. Yorktown entered Majuro lagoon again on 3 June and began preparations for her next major amphibious support operation—the assault on the Marianas.

Figure 1.11 An SB2C-4 HELLDIVER dive bomber takes off from U.S.S. YORKTOWN.

On 6 June, the aircraft carrier stood out of Majuro with TF 58 and set a course for the Mariana Islands. After five days steaming, she reached the launch point and began sending planes aloft for the preliminary softening of targets in preparation for the invasion of Saipan. Yorktown aircrews concentrated primarily upon airfields located on Guam. Those raids continued until the 13th when Yorktown, with two of the task groups of TF 58, steamed north to hit targets in the Bonin Islands. That movement resulted in a one-day raid on the 16th before the two task groups headed back to the Marianas to join in the Battle of the Philippine Sea. Task Force 58 reunited on 18 June and began a short wait for the approaching Japanese Fleet and its aircraft.

On the morning of 19 June, Yorktown aircraft began strikes on Japanese air bases on Guam in order to deny them to their approaching carrier-based air and to keep the land-based planes out of the fray. Duels with Guam-based aircraft continued until mid-morning. At about 1017, however, she got her first indication of the carrier plane attacks when a large bogey appeared on her radar screen. At that point she divided her attention, sending part of her air group back to Guam and another portion of it out to meet the raid closing from the west. Throughout the battle, Yorktown's planes continued both to strike the Guam airfields and intercept the carrier raids. During the first day of the Battle of the Philippine Sea, Yorktown aircraft claimed 37 enemy planes destroyed and dropped 21 tons of bombs on the Guam air bases.

On the morning of the 20th Yorktown steamed generally west with TF 58 while search planes groped for the fleeing enemy task force. Contact was not made with the enemy until about 1540 that afternoon when a Hornet (CV-12) pilot spotted the retiring Combined Fleet units. Yorktown launched a 40-plane strike between 1623 and 1643 and sent it winging after the Japanese. Her planes found Admiral Ozawa's force at about 1840 and began a 20-minute attack during which they went after Zuikaku on whom they succeeded in scoring some hits. They, however, failed to sink that carrier.

Figure 1.12 Japanese carrier ZUIKAKU maneuvering while under attack by dive bombers from YORKTOWN, June 1944.

They also attacked several other ships in the Japanese force, though no records show a confirmed sinking to the credit of the Yorktown air group. On 21 June, the carrier joined in the futile stern chase on the enemy carried out by TF 58 but gave up that evening when air searches failed to contact the Japanese. York-town returned to the Marianas area and resumed air strikes on Pagan on the 22 and 23 June. On the 24th, she launched another series of raids on Iwo Jima. On 25 June, she laid in a course for Eniwetok and arrived there two days later. On the 30th, the aircraft carrier headed back to the Marianas and the Bonins. She renewed combat operations on 3 and 4 July with a series of attacks on Iwo Jima and Chichi Jima. On the 6th, the warship resumed strikes in the Marianas and continued them for the next 17 days. On 23 July, she headed off to the west for a series of raids on Yap, Ulithi, and the Palaus. She carried out those attacks on 25 July and arrived back in the Marianas on the 29th.

On the 31st, she cleared the Mariana Islands and headed—via Eniwetok and Pearl Harbor—back to the United States. Yorktown arrived in the Puget Sound Navy Yard on 17 August and began a two-month overhaul. She completed repairs on 6 October and departed Puget Sound on the 9th. She stopped at the Alameda Naval Air Station from 11 to 13 October to load planes and supplies and then set a course back to the western Pacific. After a stop at Pearl Harbor from the 18th to the 24th, Yorktown arrived back in Eniwetok on 31 October. She departed the lagoon on 1 November and arrived at Ulithi on the 3rd. There, she reported for duty with TG 38.4. That task group left Ulithi on 5 November, and Yorktown departed with it.

Figure 1.13 YORKTOWN departing Puget Sound Naval Shipyard with new dazzle camouflage Measure 33/10A profile.

On 7 November, the aircraft carrier changed operational control to TG 38.1 and, for the next two weeks, launched air strikes on targets in the Philippines in support of the Leyte invasion. Detached from the task force on 23 November, Yorktown arrived back in Ulithi on the 24th. She remained there until 10 December at which time she put to sea to rejoin TP 38. She rendezvoused with the other carriers on 13 December and began launching air strikes on
targets on the island of Luzon in preparation for the invasion of that island scheduled for the second week in January. On the 17th, the task force began its retirement from the Luzon strikes. During that retirement, TF 38 steamed through the center of the famous typhoon of December 1944. That storm sank three destroyers—Spence (DD-512), Hull (DD-350), and Monaghan (DD-354)—and Yorktown participated in some of the rescue operations for the survivors of those three destroyers. She did not finally clear the vicinity of Luzon until the 23rd. The warship arrived back in Ulithi on 24 December.

The aircraft carrier fueled and provisioned at Ulithi until 30 December at which time she returned to sea to join TF 38 on strikes at targets in the Philippines in support of the landings

Figure 1.14 Departing Pearl Harbor, 1944.

at Lingayen. The carriers opened the show on 3 January 1945 with raids on airfields on the island of Formosa. Those raids continued on the 4th, but a fueling rendezvous occupied York-town's time on the 5th. She sent her planes against Luzon targets and on anti-shipping strikes on the 6th and 7th. The 8th brought another fueling rendezvous; and, on the 9th, she conducted her last attack—on Formosa—in direct support of the Lingayen operation. On 10 January, Yorktown and the rest of TF 38 entered the South China Sea via Bashi Channel to begin a series of raids on Japan's inner defenses. On 12 January, her planes visited the vicinity of Saigon and Tourane Bay, Indochina, in hopes of catching major units of the Japanese fleet. Though foiled in their primary desire, TF 38 aviators still managed to rack up a stupendous score—44 enemy ships of which 15 were combatants. She fueled on the 13th and, on the 15th, launched raids on Formosa and Canton in China. The following day, her aviators struck at Canton again and paid a visit to Hong Kong. Fueling took up her time on 17, 18, and 19 January. On the 20th, she exited the South China Sea with TF 38 via Balintang Channel. She participated in a raid on Formosa on the 21st and another on Okinawa on the 22nd before clearing the area for Ulithi. On the morning of 26 January, she reentered the Ulithi lagoon with TF 38.

Figure 1.15 Flight operations, launching a Hellcat.

Yorktown remained at Ulithi arming, provisioning, and conducting upkeep until 10 February. At that time, she sortied with TF 58, the 3rd Fleet becoming the 5th Fleet when Spruance relieved Halsey, on a series of raids on the Japanese and thence to support the assault on and occupation of Iwo Jima. On the morning of 16 February, the aircraft carrier began launching strikes on the Tokyo area of Honshu. On the 17th, she repeated those strikes before heading toward the Bonins. Her aviators bombed and strafed installations on Chichi Jima on the 18th. The landings on Iwo Jima went forward on 19 February, and Yorktown aircraft began support missions over the island on the 20th. Those missions continued until the 23rd at which time Yorktown cleared the Bonins to resume strikes on Japan proper. She arrived at the launch point on the 25th and sent two raids aloft to bomb and strife airfields in the vicinity of Tokyo. On the 26th, Yorktown air crewmen conducted a single sweep of installations on Kyushu before TG 58.4 began its retirement to Ulithi. Yorktown reentered the anchorage at Ulithi on 1 March.

Figure 1.16 Ulithi Lagoon in the Caroline Islands. Murderer's Row consisting of the carriers Wasp (CV 18), Yorktown (CV 10), Hornet (CV 12), and Hancock (CV 19) anchored at Ulithi Atoll Dec 1944.

She remained in the anchorage for about two weeks. On 14 March, the aircraft carrier departed the lagoon on her way to resume raids on Japan and to begin preliminary support work for the Okinawa operations scheduled for 1 April. On 18 March, she arrived in the operating area off Japan and began launching strikes on airfields on Kyushu, Honshu, and Shikoku. The task group came under air attack almost as soon as operations began. At about 0800, a twin-engine bomber, probably a "Frances," attacked from her port side. The ship opened fire almost immediately and began scoring hits quickly. The plane began to burn but continued his run, passing over Yorktown's bow and splashing in the water on her starboard side. Just seven minutes later, another "Frances" tried his luck; but he, too, went down, a victim of the combined fire of the formation. No further attacks developed until that afternoon; in the meantime, Yorktown continued air operations. That afternoon, three "Judy's" launched attacks on the carrier. The first two failed in their attacks and were shot down for their trouble. The third succeeded in planting his bomb on the signal bridge. It passed through the first deck and exploded near the ship's hull. It punched two large holes through her side, killed five men, and wounded another 26. Yorktown, however, remained fully operational, and her antiaircraft gunners brought the offender down. She continued air operations against the three southernmost islands of Japan on the 19th but retired for fueling operations on the 20th.

Figure 1.17 Starboard quarter view of YORKTOWN, early 1945.

On the 21st, she headed for Okinawa, on which island she began softening-up strikes on the 23rd. Those attacks continued until the 28th when she started back to Japanese waters for an additional strike on the home islands. On the 29th, the carrier put two raids and one photographic reconnaissance mission into the air over Kyushu. That afternoon, at about 1410, a single "Judy" made an apparent suicide dive on Yorktown. Her antiaircraft gunners opened up on him and scored numerous hits. He passed over the ship, very near to her "island," and splashed about 60 feet from her portside.

On 30 March, Yorktown and the other carriers of her task group began to concentrate solely on the island of Okinawa and its surrounding islets. For two days, the 30th and 31st, they pounded the island in softening-up strikes. On 1 April, the assault troops stormed ashore; and, for almost six weeks, she sent her planes to the island to provide direct support for the troops operating ashore. About every three days, she retired to the east to conduct fueling rendezvous or to re-arm and re-provision. The only exception to that routine came on 7 April when it was discovered that a Japanese task force built around the elusive battleship, Yamato, was steaming south for one last, desperate offensive. Yorktown and the other carriers quickly launched strikes to attack that valued target. Air Group 9 aviators claimed several torpedo hits on Yamato herself just before the battleship exploded and sank as well as at least three 500-pound bomb hits on light cruiser Yahagi before that warship followed her big sister to the bottom. The pilots also made strafing runs on the escorting destroyers and claimed to have left one afire in a sinking condition. At the conclusion of that action, Yorktown and her planes resumed their support for the troops on Okinawa. On 11 April, she came under air attack again when a single-engine plane sped in on her. Yorktown's antiaircraft gunners proved equal to the test, however, and splashed him just inside the 2,000 yard range. Sporadic air attacks continued until her 11 May departure from the Ruykyus, but Yorktown sustained no additional damage and claimed only one further kill with her antiaircraft battery. On 11 May, TG 58.4 was detached to proceed to Ulithi for upkeep, rest, and relaxation.

Figure 1.18 Japanese battleship YAMATO explodes during air attacks in April 1945 off Okinawa.

Yorktown entered the lagoon at Ulithi on 14 May and remained there until 24 May at which time she sortied with TG 58.4 to rejoin the forces off Okinawa. On 28 May, TG 58.4 became TG 38.4 when Halsey relieved Spruance and 5th Fleet again became 3rd Fleet. That same day, the carrier resumed air support missions over Okinawa. That routine lasted until the beginning of June when she moved off with TF 38 to resume strikes on the Japanese homeland. On 3 June, her aircraft made four different sweeps of airfields. The following day, she returned to Okinawa for a day of additional support missions before steaming off to evade a typhoon. On the 6th and 7th, she resumed Okinawa strikes. She sent her aviators back to the Kyushu airfields and, on the 9th, launched them on the first of two days of raids on Minami Daito Shima. After the second day's strikes on the 10th, Yorktown began retirement with TG 38.4 toward Leyte. She arrived in San Pedro Bay at Leyte on 13 June and began replenishment, upkeep, rest, and relaxation.

The warship remained at Leyte until 1 July when she and TG 38.4 got underway to join the rest of the fast carriers in the final series of raids on the Japanese home islands. By 10 July, she was off the coast of Japan launching air strikes on the Tokyo area of Honshu. After a fueling rendezvous on the 11th and 12th, she resumed strikes on Japan, this on the southern portion of the northernmost island—Hokkaido. Those strikes lasted from the 13th to the 15th. A fueling retirement and heavy weather precluded air operations until the 18th at which time her aviators returned to the Tokyo area. From the 19th to the 22nd, she made a fueling and underway replenishment retirement and then, on the 24th, resumed air attacks on Japan. For two days, planes of her air group pounded installations around the Kure naval base. Another fueling retirement came on the 26th, but the 27th and 28th found her planes in the air above Kure again. On the 29th and 30th, she shifted targets back to the Tokyo area before another fueling retirement and another typhoon took her out of action until the beginning of the first week in August. On 8 and 9 August, the carrier launched her planes at northern Honshu and southern Hokkaido. On the 10th, she sent them back to Tokyo. The 11th and 12th brought another fueling retirement and a typhoon evasion, but, on the 13th, her aircraft hit Tokyo for the last time. On the 14th, she retired to fuel destroyers again, and on the 15th, Japan agreed to capitulate so that all strikes planned for that day were cancelled.

From 16 to 23 August, Yorktown and the other carriers of TF 58 steamed around more or less aimlessly in waters to the east of Japan awaiting instructions while peace negotiations continued. Then, on the 23rd, she received orders to head for waters east of Honshu where her aircraft were to provide cover for the forces occupying Japan. She began providing that air cover on the 25th and continued to do so until mid-

September. After the formal surrender on board Missouri (BB-63) on 2 September, the aircraft carrier also began air-dropping supplies to Allied prisoners of war still living in their prison camps. On 16 September, Yorktown entered Tokyo Bay with TG 38.1. She remained there, engaged in upkeep and crew recreation, through the end of the month. On 1 October, the carrier stood out of Tokyo Bay on her way to Okinawa. She arrived in Buckner Bay on 4 October, loaded passengers on the 5th, and got underway for the United States on the 6th.

After a non-stop voyage, Yorktown entered San Francisco Bay on 20 October, moored at the Alameda Naval Air Station, and began discharging passengers. She remained at the air station until 31 October at which time she shifted to Hunters Point Navy Yard to complete minor repairs. On 2 November, while still at the navy yard, she reported to the Service Force, Pacific Fleet, for duty in conjunction with the return of American servicemen to the United States. That same day, she stood out of San Francisco Bay, bound for Guam on just such a mission. She arrived in Apra Harbor on 15 November and, two days later, got underway with a load of passengers. She arrived back in San Francisco on 30 November and remained there until 8 December. On the latter day, the warship headed back to the Far East. Initially routed to Samar in the Philippines, she was diverted to Manila en route. She arrived in Manila on 26 December and departed there on the 29th. She reached San Francisco again on 13 January 1946. Later that month, she moved north to Bremerton, Wash., where she was placed in commission, in reserve, on 21 June. She remained there in that status through the end of the year. On 9 January 1947, Yorktown was placed out of commission and was berthed with the Bremerton Group, Pacific Reserve Fleet. Yorktown remained in reserve for almost five years. In June of 1952, she was ordered reactivated, and work began on her at Puget Sound. On 15 December 1952, she was placed in commission, in reserve, at Bremerton. Her conversion continued into 1953 and she conducted post-conversion trials late in January. On 20 February 1953, Yorktown was placed in full commission, Capt. William M. Nation in command. The aircraft carrier conducted normal operations along the west coast through most of the summer of 1953. On 3 August, she departed San Francisco on her way to the Far East. She arrived in Pearl Harbor and remained there until the 27th at which time she continued her voyage west. On 5 September, the carrier arrived in Yokosuka, Japan. She put to sea again on the 11th to join TF 77 in the Sea of Japan. The Korean War armistice had been signed two months earlier; therefore, the carrier conducted training operations rather than combat missions. She served with TF 77 until 18 February 1954 at which time she stood out of Yokosuka on her way home. She made a stop at Pearl Harbor along the way and then moored at Alameda once more on 3 March. After a brief repair period at Hunters Point Naval Shipyard, Yorktown put to sea to serve as a platform for the filming of the movie "Jet Carrier." She conducted further, more routine, operations along the west coast until 1 July at which time she headed back to the Orient. She stopped at Pearl Harbor from 8 to 28 July before continuing on to Manila, where she arrived on 4 August.

Figure 1.19 U.S.S. SICILY at left and U.S.S. YORKTOWN at Yokosuka, Japan, 1954.

Yorktown operated out of the Manila-Subic Bay area, conducting 7th Fleet maneuvers, for the duration of the deployment. She did, however, take periodic breaks from that schedule to make frequent port visits to Yokosuka and, during the Christmas holidays, she made a liberty call at Hong Kong on the Chinese coast. In January of 1955, she was called upon to help cover the evacuation of Nationalist Chinese from the Tachen Islands located near the communist-controlled mainland. Yorktown entered Yokosuka for the last time on 16 February 1955 but departed again on the 18th to return home. After an overnight stop at Pearl Harbor on 23 and 24 February, she resumed her voyage east and arrived in Alameda on 28 February. On 21 March 1955, she was placed in commission, in reserve, at the Puget Sound Naval Shipyard where she was to receive extensive modifications—most significantly, an angled flight deck to increase her jet aircraft launching capability. She completed her conversion that fall and, on 14 October, was placed back in full commission.

Figure 1.20 YORKTOWN with new angled flight deck, 1956.

The aircraft carrier resumed normal operations along the west coast soon after recommissioning. That assignment lasted until mid-March 1956. On the 19th, she stood out of San Francisco Bay on her way to her third tour of duty with the 7th Fleet since her reactivation in 1953. Yorktown stopped at Pearl Harbor from 24 March to 9 April and then continued her voyage west. She arrived in Yokosuka, Japan, on 18 April and departed again on the 29th. The warship operated with the 7th Fleet for the next five months. During that time, she conducted operations in the Sea of Japan, the East China Sea, and the South China Sea. She also visited such places as Sasebo, Manila, Subic Bay, and Buckner Bay at Okinawa. On 7 September, the aircraft carrier stood out of Yokosuka and pointed her bow to the east. After a non-stop voyage, she arrived back at Alameda on 13 September. She resumed west coast operations for about two months. On 13 November, she embarked upon a round-trip to Pearl Harbor, from which she returned to Alameda on 11 December. Yorktown resumed normal operations out of Alameda upon her return and remained so employed until March of 1957. On 9 March, she departed Alameda for yet another tour of duty in the Far East. She made stops at Oahu and Guam along the way and arrived at Yokosuka on 19 April. She put to sea to join TF 77 on 25 April and served with that task force for the next three months. On 13 August, the warship departed Yokosuka for the last time, made a brief pause at Pearl Harbor, and arrived in Alameda on the 25th.

Figure 1.21 Douglas SKYRAIDER on aft starboard elevator.

On 1 September, her home port was changed from Alameda to Long Beach, and she was reclassified an antisubmarine warfare (ASW) aircraft carrier with the new designation CVS-10. On the 23rd, she departed Alameda and, four days later, entered the Puget Sound Naval Shipyard for overhaul and for modification to an ASW carrier. That yard period lasted until the beginning of February 1958. She departed the naval ammunition depot at Bangor, Wash., on 7 February and entered Long Beach five days later. For the next eight months, Yorktown conducted normal operations along the west coast. On 1 November, she departed San Diego to return to the western Pacific. After a stop at Pearl Harbor from the 8th to the 17th, Yorktown continued her voyage west and arrived in Yokosuka on the 25th. During that deployment, the aircraft carrier qualified for the Armed Forces Expeditionary Medal on three occasions. The first time came on 31 December and 1 January 1959 when she participated in an American show of strength in response to the communist Chinese shelling of the offshore islands, Quemoy and Matsu, held by Nationalist Chinese forces. During January, she also joined contingency forces off Vietnam during internal disorders caused by communist guerrillas in the southern portion of that country. That month also saw her earn the expeditionary medal for service in the Taiwan Strait. The remainder of the deployment—save for another visit to Vietnamese waters late in March—consisted of a normal round of training evolutions and port visits. She concluded that tour of duty at San Diego on 21 May. The warship resumed normal operations along the west coast, and that duty consumed the remainder of 1959.

In January of 1960, Yorktown headed back to the Far East via Pearl Harbor. During that deployment, she earned additional stars for her Armed Forces Expeditionary Medal for duty in Vietnamese waters at various times in March, April, May, and June. She returned to the west coast late in the summer and, late in September, began a four-month overhaul at the Puget Sound Naval Shipyard.

Yorktown emerged from the shipyard in January 1961 and returned to Long Beach on the 27th. She conducted refresher training and then resumed normal west coast operations until late July. On 29 July, the aircraft carrier stood out of Long Beach, bound once again for the Orient. She made an extended stopover in the Hawaiian Islands in August and, consequently, did not arrive in Yokosuka until 4

September. That tour of duty in the Far East consisted of a normal schedule of anti-air and anti-submarine warfare exercises, as well as the usual round of port visits. She concluded the deployment at Long Beach on 2 March 1962. Normal west coast operations occupied her time through the summer and into the fall. On 26 October, the warship left Long Beach in her wake and set a course for the Far East. During that deployment, she served as flagship for Carrier Division (CarDiv) 19. She participated in a number of ASW and AAW exercises, including the SEATO ASW exercise, Operation "Sea Serpent." The deployment lasted until 6 June 1963 at which time the carrier set a course back to Long Beach.

Yorktown arrived back in her home port on 18 June and resumed normal operations for the remainder of the year. Those operations continued throughout most of 1964 as well. However, on 22 October, she pointed her bow westward again and set out for a tour of duty with the 7th Fleet. Another period of operations in the Hawaiian Islands delayed her arrival in Japan until 3 December. The 1964 and 1965 deployment brought Yorktown her first real involvement in the Vietnamese civil war. In February, March, and April, she conducted a series of special operations in the South China Sea in waters near Vietnam—presumably ASW services for the fast carriers conducting air strikes against targets in Vietnam in support of the increased American involvement in the civil war in that country. She concluded her tour of duty in the Far East on 7 May 1965 when she departed Yokosuka to return to the United States. The carrier arrived in Long Beach on 17 May.

Figure 1.22 U.S.S. YORKTOWN and destroyer U.S.S. HOPEWELL steaming in 1957.

For the remainder of her active career, Yorktown's involvement in combat operations in Vietnam proved a dominant feature of her activities. After seven months of normal operations out of Long Beach, she got underway for the western Pacific again on 5 January 1966. She arrived in Yokosuka on 17 February and joined TF 77 on Yankee Station later that month. Over the next five months, the aircraft carrier spent three extended tours of duty on Yankee Station providing ASW and sea-air rescue services for the carriers of TF 77. She also participated in several ASW exercises, including the major SEATO exercise, Operation "Sea Imp." The warship concluded her last tour of duty on Yankee Station early in July and, after a stop at Yokosuka, headed home on the 15th. She disembarked her air group at San Diego on 27 July and reentered Long Beach that same day. She resumed normal operations—carrier qualifications and ASW exercises—for the remainder of the year and during the first two months of 1967. On 24 February 1967, Yorktown entered the Long Beach Naval Shipyard for a seven-month overhaul. She completed repairs early in October and, after refresher training, resumed normal west coast operations for most of what remained of 1967. On 28 December, she stood out of Long Beach, bound for her last tour of duty in the western Pacific.

After a stop at Pearl Harbor, she arrived in the Far East late in January. Instead of putting in at a Japanese port for turnover, Yorktown headed directly to the Sea of Japan to provide ASW and search and rescue (SAR) support for the contingency force assembled in the wake of the North Korean capture of Pueblo (AGER-2). She remained on that assignment for 30 days. On 1 March, she was released from that duty, and the warship headed for Subic Bay in the Philippines. During the remainder of the deployment, the aircraft carrier did another three tours of duty with TF 77 on Yankee Station. In each instance, she provided ASW and SAR support for the fast carriers launching air strikes on targets in Vietnam. She concluded her last tour of duty in Vietnamese waters on 16 June and set a course for Yokosuka where she stopped from 19 to 21 June before heading back to the United States.

Yorktown arrived back in Long Beach on 5 July and entered the Long Beach Naval Shipyard that same day for almost three months of repairs. She completed repairs on 30 September and resumed normal operations.

Late in November and early in December, she served as a platform for the filming of another movie, "Tora! Tora! Tora!," which recreated the Japanese attack on Pearl Harbor. In December, she served as one of the recovery ships for the Apollo 8 space shot. The two unique missions mentioned above were conducted out of Pearl Harbor.

She departed Pearl Harbor on 2 January 1969 and, after a two-week stop in Long Beach, continued her voyage to join the Atlantic Fleet. Steaming all the way around South America, the aircraft carrier arrived in her new home port—Norfolk, Va.—on 28 February. She conducted operations along the east coast and in the West Indies until late summer. On 2 September, Yorktown departed Norfolk for a northern European cruise and participation in the major fleet exercise Operation "Peacekeeper." During the exercise, she provided ASW and SAR support for the task force. The exercise ended on 23 September, and Yorktown began a series of visits to northern European ports. After a visit each to Brest, France, and Rotterdam in the Netherlands, Yorktown put to sea for a series of hunter/killer ASW exercises between 18 October and 11 November. She resumed her itinerary of port visits on 11 November at Kiel, Germany. After that, she stopped at Copenhagen, Denmark, and at

Portsmouth, England, before getting underway for home on 1 December. She reentered Norfolk on 11 December and began her holiday leave period.

Figure 1.23 YORKTOWN, 1964.

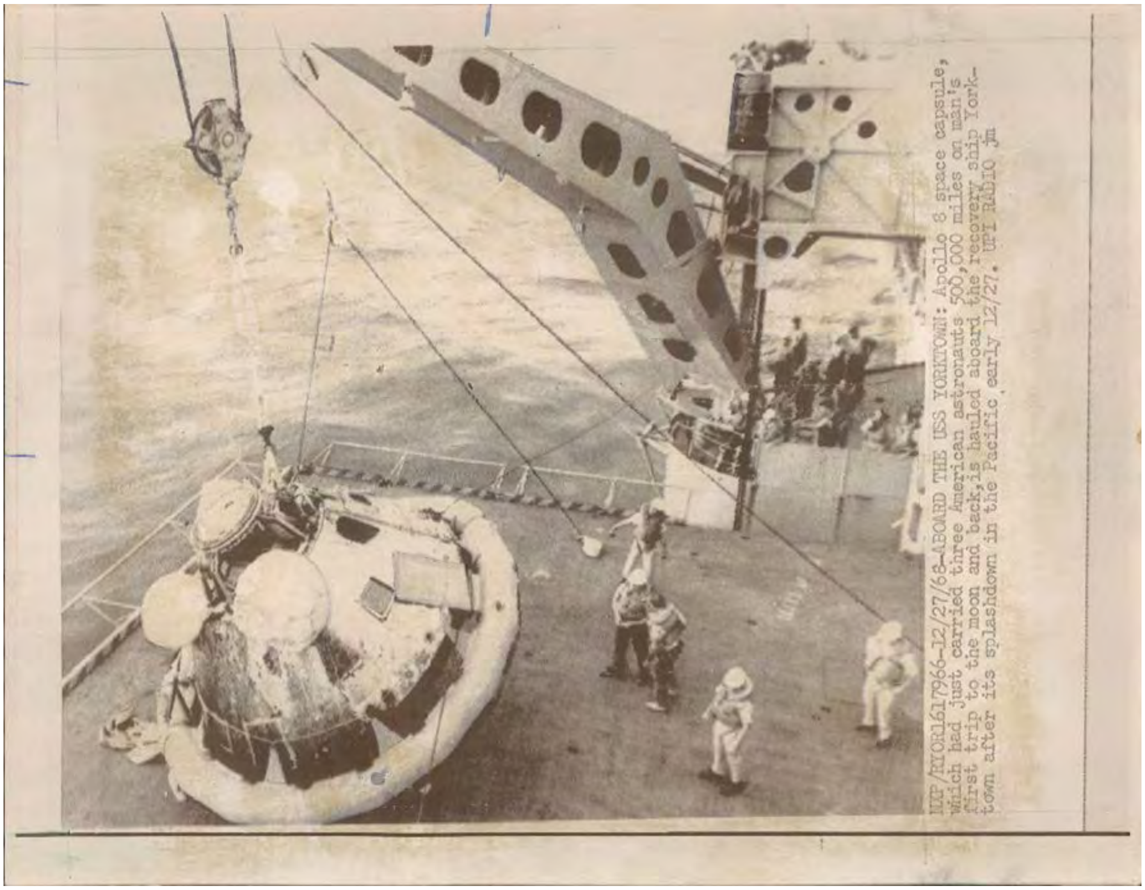

Figure 1.24 Apollo 8 capsule recovered at sea, 1968

During the first half of 1970, Yorktown operated out of Norfolk and began preparations for inactivation. On 27 June 1970, Yorktown was decommissioned at Philadelphia, Pa., and was berthed with the Philadelphia Group, Atlantic Reserve Fleet. She remained there almost three years before her name was struck from the Navy list on 1 June 1973.

During 1974, the Navy Department approved the donation of Yorktown to the Patriot's Point Development Authority, Charleston, S.C. She was towed from Bayonne, N.J., to Charleston, S.C., in June of 1975. She was formally dedicated as a memorial on the 200th anniversary of the Navy, 13 October 1975.

Yorktown (CV-10) earned 11 battle stars and the Presidential Unit Citation during World War II and five battle stars for Vietnam service.[i]

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Figure 1.2 On the launching ways just prior to christening. 1
Figure 1.3 Newspaper account of launch of U.S.S. YORKTOWN (CV-10). 2
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[i] http://www.history.navy.mifs/

DESIGN HISTORY

1. Evolution of the ESSEX-CLASS FLEET CARRIERS

If there is any single point upon which most historians agree, it is the role naval aviation played in winning World War Two. And if any single class of ship can be said to have played the most important part in that war, that warship has to be the Essex-class fleet carriers which gave Naval aviation the mobility, stamina and punch needed to wrest control of the Pacific from the far-flung legions and fleet of the Imperial Japanese Army and Navy.

Up to the time of Japan's dramatic sneak attack on Pearl Harbor, the strategy and tactics for use of carrier-borne air armadas was largely a theoretical debate conducted by naval planners, politicians and a few far-sighted air power visionaries. Though the US Navy possessed seven aircraft carriers, which were fast being outmoded by the size and requirements of the aircraft they were to operate, the battleship was still regarded as the citadel of seapower; the aircraft carrier in the pre-radar era principally serving as the floating airfield from which to launch and recover scout and assault aircraft of unproven effectiveness. Indeed, in the opening actions of WWII, there was little cause for carrier advocates to celebrate when some of the first major warship losses to the British were the sinkings of the carriers Courageous (1939), Glorious (1940) and Ark Royal (1941) at the hands of an enemy which did not possess a single aircraft carrier or battleship!

Pearl Harbor was not only cause for national trauma, but the genesis for a complete turnaround in naval thinking. Overnight, the aircraft carrier, not the battleship, became the capital ship of the fleet, and what little American seapower remained in the Pacific suddenly focused on the vital importance of the Navy's floating airfield.

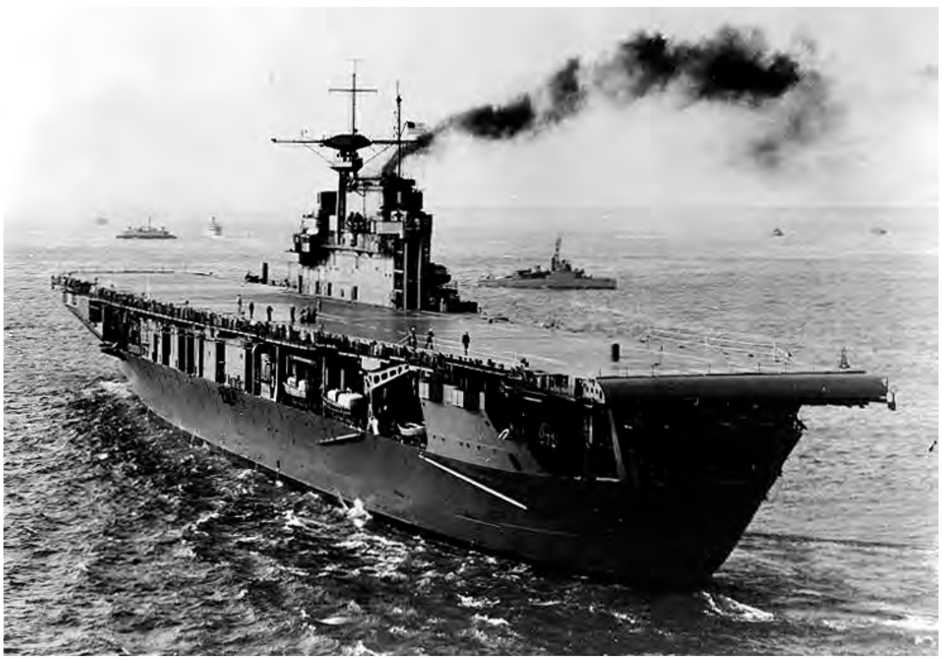

Figure 1.1 U.S.S. HORNET (CV-8) in Hampton Roads shortly before commissioning in November 1941.

The inadequacy of our prewar carriers and the obsolescence of their aircraft were tragically demonstrated in the early sea battles of 1942 when the veteran Lexington, Yorktown, Wasp and Hornet were lost in uneven contests against superior Japanese airpower. Though the Battles of the Coral Sea and Midway were hailed as American victories, their outcome did little more than stem the tide of Japanese conquest eastward across the Pacific at tremendous cost in men and ships to the US Navy. Had Americans at home known late in 1942 that for several weeks Enterprise was the only carrier in the Pacific, their jubilation over the Doolittle raid on Tokyo, launched in April from the Hornet, would have blanched considerably.

It would be the better part of a full-year's wait before the new Naval theology became a reality with the first major Naval airborne attacks against land targets launched from the new Essex-class fleet carriers Lexington and Yorktown in the fall of 1943. Aided by the new light carriers of the Independence class, which had been hastily converted from the cruiser hulls, US Navy airpower seemed to have emerged overnight in a miraculous rebirth that for the first time in the Pacific War saw our Navy taking the offensive in a manner Nav-Air visionaries had promised years earlier. Their effectiveness hailed in print and in deed, the new Essex-class carriers were majestic capital war ships that quickly captured both the Navy and the public's fancy. Their appearance at such a critical period in the Pacific War was little short of a true miracle and was a tribute not to divine providence but the production skills of American industry and the dogged tenacity of carrier advocates who pressed home the need for modern carriers years before Pearl Harbor.

Figure 1.2 U.S.S. LEXINGTON (CV-2) OFF Long Beach, California, 1936.

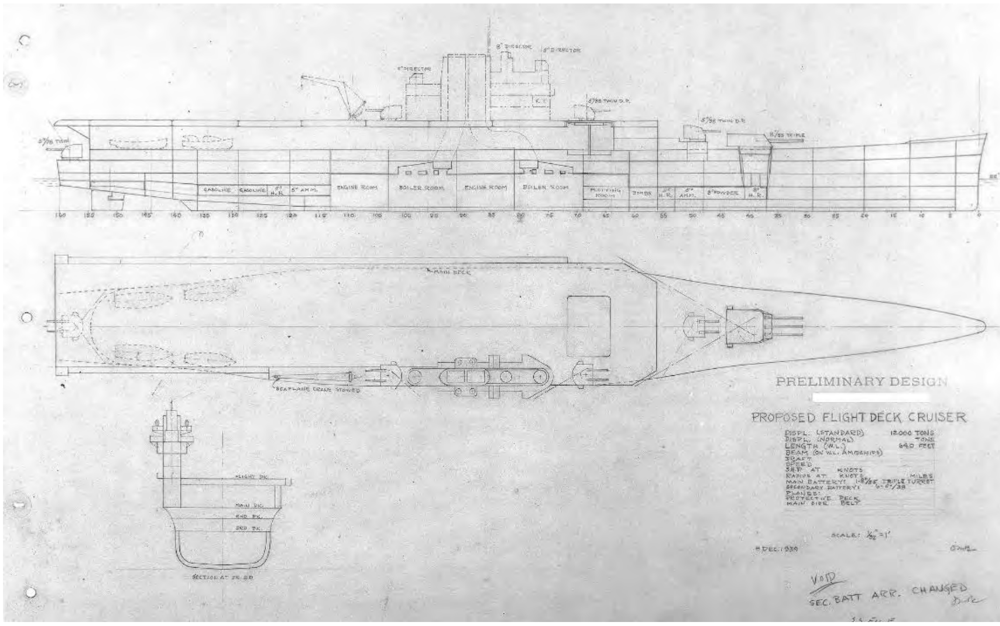

Figure 1.3 Preliminary design of a flight deck cruiser of 1939.

As war in Europe seemed ever more a reality and Japan's expansionist goals became more self-evident in the late 1930s, more attention was gradually paid to the Navy's carriers. Even with the commissioning of the new Yorktown-class in 1936, the inadequacy of these 19,900-ton goliaths became all-too-soon apparent for it was clear that the size, weight and performance of new naval aircraft then on the drawing boards mandated the need for still larger, more efficient and better armored carriers. Lessons learned in the construction and operation of the early carriers were outlined in the requirements for these new sophisticated warships in design studies commenced in 1937 through the encouragement of the pro-Navy Roosevelt administration. By May 1938, new Naval construction tonnage had been increased 20-percent providing for the building of the Hornet and a 20,000-ton allocation for a new carrier which was to become the CV-9, later Essex-class. Clearly, the major design prerequisites were a serious problem for Naval architects, for the Navy wanted a lot of ship packed into a 20,000-ton hull, including the following:

A. Foremost in a long list of requirements was a larger flight deck to handle an additional squadron of aircraft, for a total of five squadrons of 18 aircraft each;
B: Larger hull in order to stow the 240,000-gal of avgas, as opposed to the Yorktown's 178,000-gal. capacity. Naval aircraft burned an average of 37-gph in 1939 as opposed to 24-gph in 1936;
C: More and better stowage of aircraft munitions;
D: Increased armor belt to 4-in on the waterline, 3-in on major bulkheads, 1.5-in on the main deck and, for the first time, 3-in armor on the hangar deck; the result being an additional 100-tons;
E: Increased propulsion from the Yorktown's 120,000-shp to 150,000-shp to maintain the required 30-kt speed;
F: Increased hangar deck for the storage of replacement aircraft parts, engines and components amounting to 25-percent of the air wing aircraft composition;
G. Increased defensive firepower for the ship itself.

Luckily, as the beat of war drums lapsed most treaty restrictions, BuShips was allowed to enlarge on the initial concept. By 1940, the CV-9 project had progressed through six transformations that ended with a 28-percent increase in displacement over the first proposal.

The result was a ship of 27,500-tons displacement, with a length-to-beam ratio of 8.8:1, in which every single ton had its planned purpose. It was heavier than the Yorktowns but lighter than the Lexingtons of the same length. It followed the lead of all its predecessors - with the exception of Lexington - in that the hangar, built over the main deck, was not part of the load-bearing structure, and the outer skin only connected the hull, the island and the superstructure on the starboard side near the island. The flight deck (886-ft 1-in by 89-ft 10-in) was wood planked as before, and had only very light armor plating, as had the main deck. In the interests of faster takeoff operations, propeller-driven aircraft had to be able to warm up in the hangar, and this necessitated adequate hangar ventilation; the hangar openings were protected against the weather by roll doors. The dimensions of the hangar were 580-ft by 70-ft 10-in by 18-ft. The gallery deck, "suspended" beneath the flight deck, although not running the entire length, contained standby rooms and living quarters for the aircraft crews, who could therefore reach their machines as quickly as possible. In this design there were two central elevators and a deck edge elevator; the latter could be folded down vertically, thus enabling the ships to navigate the Panama Canal. The side elevator incidentally, was a replacement for a third central elevator, which was included in a preliminary design in 1940. The central elevator shafts extended down to one deck below the hangar/main deck. The arrester wires, initially nine at the stern and six at the bows, could stop aircraft with a landing weight of 5.4-tons. The arrester systems were later reinforced. The passive defense improvements largely consisted of the division of the hull into a much greater number of watertight compartments than had been the case in the older carriers; the success of this system can be measured by the fact that no Essex-class carrier had to be written off as a total loss, despite some of the units suffering severe damage. In spite of the increased heavy AA armament (twelve barrels), there were only two Mk 37 directors, which meant that only part of the gun armament could be radar controlled at any one time. As on all US Navy ships, a considerable number of 40mm and 20mm AA guns were installed during the course of the war, but the number of weapons varied from ship to ship and from one refit to the next.

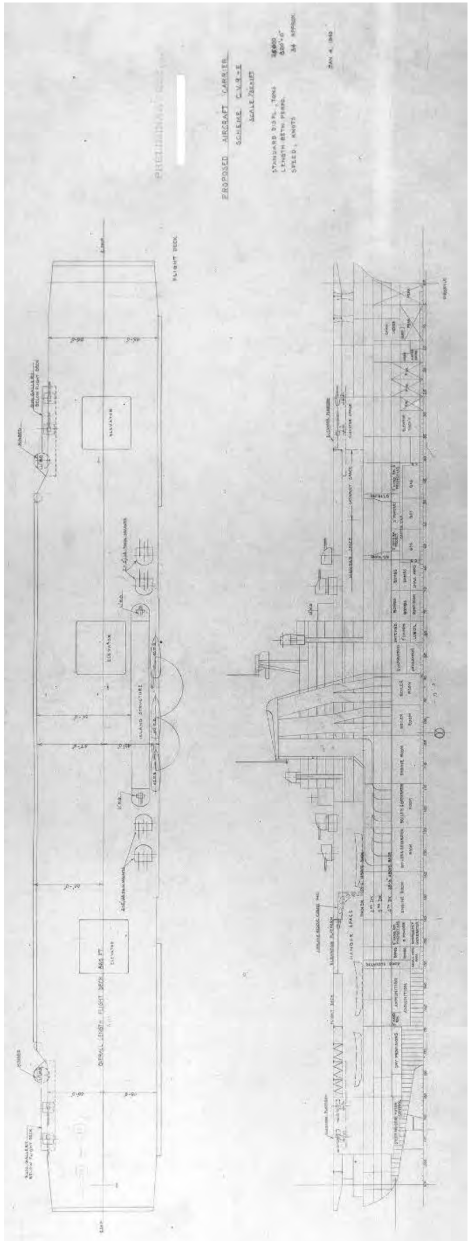

Figure 1.4 CV-9 Preliminary design, 1940. Very near the final design chosen.

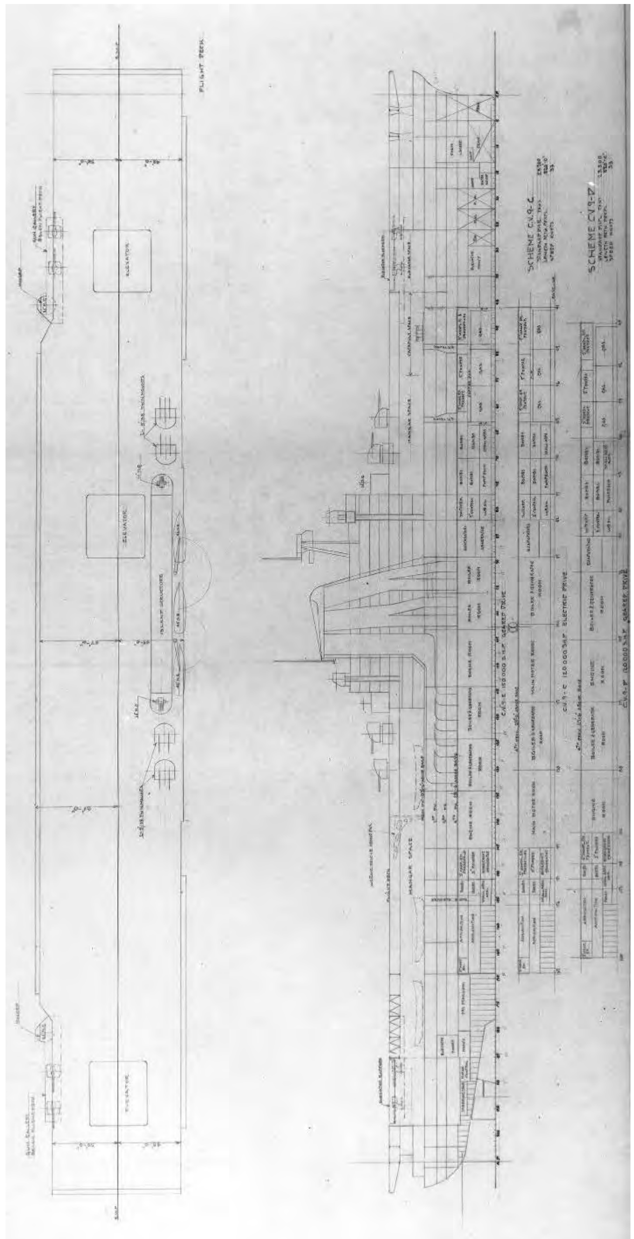

Figure 1.5 Preliminary CV-9E arrangement, 1939

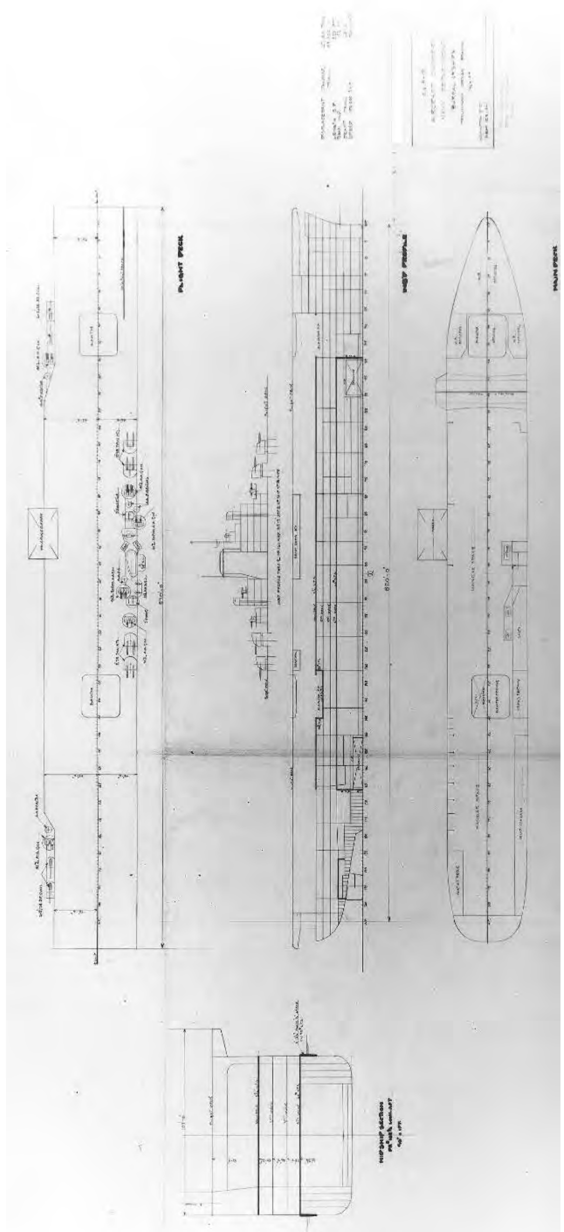

Figure 1.6 Final CV-9 Class final arrangement as put forth by the General Board, early 1941.

The construction of a total of 32 ships of the class was authorized, starting in 1940; 24 of them were completed, of which seven came too late to take part in WWII. The construction of Oriskany (CV-34) was suspended after launching and the ship was eventually completed in 1951. The carriers of this class joined the fleet just when they were most needed. Together with the two veterans Enterprise and Saratoga, the nine smaller carriers of the Independence-class and the main body of the escort aircraft carriers, destroyed the aerial superiority of the Japanese.

In number of ships, the Essex-class was the largest class of fleet carriers ever constructed and, as such, could also claim to be the largest group of capital ships constructed during the steam age. The FY40 (Financial Year 1940) program provided for eleven, of which five - Essex (CV-9), Yorktown (CV-10), Intrepid (CV-11), Lexington (CV-16) and Bunker Hill (CV-17) - were begun prior to the outbreak of war. The remaining six, together with two more provided under FY41 and an additional 13 provided under the wartime FY42 (ten units) and FY43 (three units), were laid down during the war. Another six ships were included in FY44 but these were subsequently canceled and were never laid down.

The size of this class, and indeed the great size of the entire US war construction effort, reflected not only the enormous industrial capacity of the United States, but also its ability to mastermind cooperative effort and the simplification of production requirements and methods.

Early in the war it was decided to concentrate on the construction of existing warship designs; hence the Essex-class represented the entire war production of fleet carriers. Another class, the Midways, was begun in 1943 but none saw service during the war. Cruisers were largely represented by the 6-in gun Cleveland-class (of which no less than 52 were ordered) and the 8-in Baltimore-class, destroyers by the Fletcher- and Gearing-classes, etc. By concentrating on such standardized designs, building yards could streamline production which resulted in remarkably short construction times. Intrepid was built in 20-months, while one Essex, the Franklin (CV-13), was completed in just under 14-months.

This system was applied to material and equipment as well as ship design, and a high degree of standardization was adopted for such things as steel sections and plates, ship fittings, machinery and armaments. Production of AA weapons was almost entirely concentrated on the 5-in/38, the 40mm Bofors and the 20mm Oerlikon for air defense.

The building of Essex-class carriers covered a good five years and, as might be expected, external and internal alterations were made, some of them while the ships were still on the stocks; experience during the war dictated some of these changes. There were also minor differences in the amount of oil and aviation fuel carried. The more obvious, external alteration was the ships' division into ten "short hull" and 13 "long hull" types. One group had a stem with very little rake which was overhung by the flight deck; the bows were so narrow that only one 40mm quadruple could be fitted. The other group had a stem of greater rake, which led to an increase in the ships' overall length and also permitted the fitting of two 40mm quadruples side by side. The new bow shape did have a detrimental effect on ship handling in high waves and heavy seas; the forecastle had to take heavy punishment in these conditions.

A further variation concerned the starboard side of twelve units (CV-10, -11, -12, -13, -14, -15, -16, -17, -18, -19, -31 and -37), which in 1944, received three 40mm AA mounts fitted below the island on detachable sponsons that could be removed to transit the Panama Canal, and two more toward the stern, below right deck level.

One of the design requirements built into the Essex-class was "expandability" - a factor that was to pay off handsomely not only in the war but later as these ships became the initial test-beds for jet aircraft. Taking aboard the hulking size of the Curtiss SB2C Helldiver posed no problem either on the hangar or flight deck as these brutish dive-bombers joined the fleet in 1944. Of course every ship has only so much "stretch" built into it and as the size of wartime complements grew due to the increased number of aircraft crews, gunners and plane handlers, conditions became extremely crowded. By 1945, typical figures for an Essex were 50-percent over the number anticipated by BuShips with 382 officers, including 175 aviation and 3060 enlisted men with 2790 handling the ship and deck operations while the rest served the Air Group or flag.

In contrast to modern carriers, the Essex-class ships were equipped to handle aircraft landing over the bows - exactly as with the Yorktown while the carrier was running astern at up to 20-kts. The ship's stern was suitably shaped for this type of operation, and the rudder was also strengthened. The arrester system consisted of numerous thick steel wire ropes, between nine and 16 of them at the aft end. The practice of landing over the bow did not, however, prove successful and was discontinued during the wars, as was the launching of aircraft from the hangar deck catapults installed at 90-degrees to the ship's longitudinal axis; the small number of hangar catapults installed on CV-9 to -13 were replaced by a second flight deck catapult. This was 86-ft 7-in long and, with its thrust of 7.3-tons, could accelerate an aircraft to a speed of 90 mph. The later catapults (thrust 6.5-tons) could accelerate machines up to 100-mph; they were more than twice as powerful as the catapults on Yorktown (CV-5). Hangar stowage provided for 120 aircraft; with another 80 on the flight deck, the total transport capacity was 200 aircraft.

By today's standards, the cost of building an Essex was a bargain at 70 million dollars each, and even that number was intensified by the labor costs of keeping workers on an around-the-clock, three-shift basis. The result was extremely short building times, especially considering the complexity of the vessel.

The war resulted in many developments not envisaged when the ships were designed - the most obvious being the proliferation of radar and AA weapons which required larger crews. This resulted in both substantially increased top weight and overcrowding. Consequently, the Essex-class, and practically all other US warship types, were by 1945 suffering from a substantial reduction in their level of stability and, hence, survivability in the event of damage.

Prewar US design emphasized offensive over defensive qualities, as had those of the Royal Navy prior to the First World War. While this proved a less than successful policy in Britain's naval war against Germany, it resulted in a close to ideal group of ships for the war against the Japanese. In aircraft carrier development, this manifested itself in the provision of ships in which a large air group and its efficient operation took priority over passive defense. The logic behind this was that the aircraft were the carrier's principal means of both offense and, defense and if operated efficiently, few, if any, enemy aircraft would reach the ship itself, however, even then, they would have to penetrate the ship's AA barrage before they could inflict any damage. Thus, the hull was provided with sufficient armor and watertight subdivision to ensure survivability under all but the severest of circumstances. However, the remainder of the ship - that is everything above the main deck, which included her hangar and flight deck - was completely unprotected, except for the splinter plating applied to the bridge and gun positions.

The alternative was that employed by the Royal Navy in the Illustrious-class, in which the flight deck and hangar were armored, but, on a given displacement, this degree of protection could be achieved only by a considerable sacrifice in the air group - US prewar doctrine required carriers with hangar accommodation for 72 aircraft, whereas the Illustrious-class carried 36. It affected its carrier operation as well, as US carriers with their open hangars could start and warm up aircraft engines while they were still in the hangar, and thus speed up the rate of launch. This was not possible with a closed hangar.

A large air group meant accepting the risk of a carrier being put out of action by damage to her flight deck or hangar. This proved a greater risk than imagined prewar, at which time it was assumed that any bomb hole in the comparatively light flight deck could easily be repaired aboard ship. This proved to be the case with some of the less severe instances of damage, however, it did not take into account the inherent vulnerability of the hangar contents - aircraft, their gasoline, and munitions - and, in many cases, US carriers suffered severely from fires and secondary explosions caused by a bomb or kamikaze hit. In this respect, the kamikaze proved to be the most dangerous weapon used against the Essex-class; although it was a form of attack that could not, of course, have been envisaged at the design stage. Essentially a piloted bomb, it stood a high chance of success but, fortunately, aircraft have poor penetrating power and were typically stopped by the flight deck - although their bombs, and occasionally their engines, penetrated to the hangar. However, the alternative to the Essex design, the following Midway-class, which had a 3.5-in armored flight deck and many other improvements including a larger air complement, displaced 47,000-tons, nearly twice the tonnage of the previous class.

The Essexes were part of the last generation of US warships to be designed without major provision for radar. The problems this caused included cramped antennas topside, with all their problems of mutual interference and smoke damage; radar rooms (and radar personnel) in a ship whose design was already tight; and a CIC. On the other hand, radar was the solution to the problem of a carrier fighter defense - only it could provide sufficient warning and information to bring airborne or deck-launched fighters into position to intercept an incoming raid. Radar operation required the integration of information from all available sources in a CIC, generally adjacent to (but not included in) a fighter direction office. Those sources would include both the ship's own radars and her lookouts, occasionally her ECM warning receivers, and information from other ships of the fleet. The CIC concept predated the Essex-class, and ships were completed with relatively cramped CIC's in their island structures. Ultimately, however, these functions were moved to larger spaces in the gallery deck, which offered considerable spaces but, unfortunately, no protection from bomb or kamikaze attack.

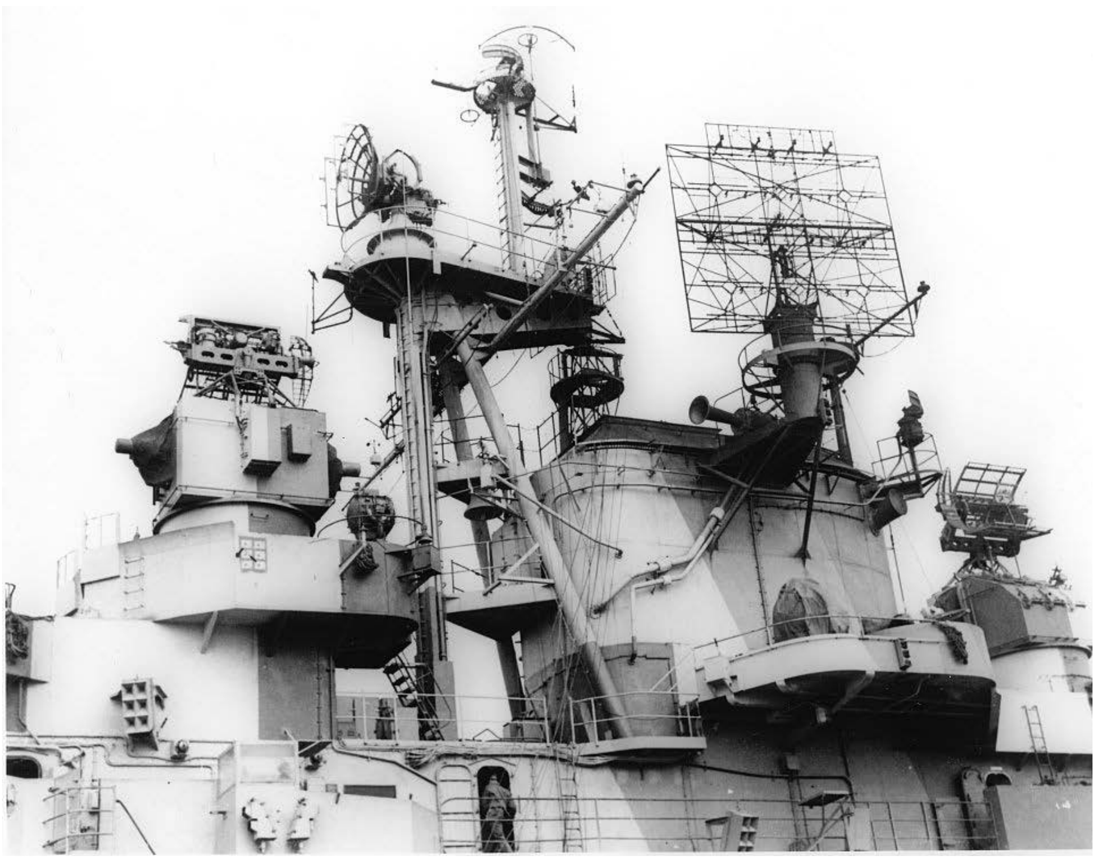

Figure 1.7 U.S.S. YORKTOWN'S topside island superstructure, showing newly installed radars and directors, 1944.

The Essex-class radar arrangements were complex and so individualistic, that ships can often be identified in photographs by their radar installations. At first, the single massive tripod carried an SK for long-range air search, an SG for surface search, and the usual aircraft homing antennas. However, the failure of the Yorktown's airsearch radar during the Battle of the Coral Sea led to a demand for a second air-search set as insurance against a similar failure in the future. In an Essex-class carrier, that meant the provision of a second (often lattice) mast sponsoned outboard from the single compact funnel, which carried a smaller air-search set, generally an SC-2. A second SG often was provided abaft the funnel, to account for the blind spots represented by the major radars. There were also the usual 5-in fire-control sets. This was hardly enough, as it was soon discovered that efficient fighter controls needed accurate height information. Requirements for a height finder were formulated in the spring of 1942, and the prototype

SM (CXBL) was installed aboard the carrier Lexington in March 1943; production sets were installed aboard the Bunker Hill in September and the Enterprise in October 1943.

The other major external change to the Essex-class during WWII was the explosive growth of their antiaircraft battery, occassionaly at the expense of aviation assets. Throughout the fleet, the quadruple 1.1-in machine cannon and the .50-cal machine gun were ordered replaced by, the 40mm Bofors and the 20mm Oerlikon respectively in August 1941.

These weapons were not yet available, but production would begin the following year; a twin Bofors weighed about as much as the quadruple 1.1s. Ships as large as the carriers could accommodate quadruple Bofors in place of the 1.1s. As of August 1941, an additional pair of twin Bofors was planned, one in the bows and one offset to port aft under the overhang of the flight deck. At this time, a total of 44 20mm guns were planned, including six located outboard of the island at the first level above the flight deck. The rest were to be on walkways 4.5-ft below flightdeck level, on platforms that could be removed for passage through the Panama Canal. The very large number of 20mm guns, compared to the light .50-cal battery originally contemplated, reflects the prestige this weapon had already developed in British service; a prestige it would not lose until its failure against kamikaze attack in 1944-1945.

Figure 1.8 Quad 40MM Bofors anti-aircraft battery. Tanker alongside in background is U.S.S. CIMMARON (AO-22).

By the time the first ships had been completed, the bow and stern mounts had been made quadruples, so that there were eight in all; they carried a total of 46 single 20mm Oerlikons.

By late 1943, combat experience had shown the need for an even greater battery of medium- and close-range AA weaponry to augment the twelve 5-in guns used against distant attackers. The number of 40mm Bofors kept increasing until they totaled 68, with an additional 55 20mm Oerlikons.

As aircraft grew larger, counterbalancing certain critical areas and strengthening of portions of the flight deck itself became necessary. The widely-used Grumman F6F Hellcat at 13,800-lbs gross weight outweighed its F4F predecessor by 40-percent. The Grumman TBF Avenger was a hulking 16,700-lbs and the already mentioned Curtiss Helldiver flew at 16, 29-lbs.

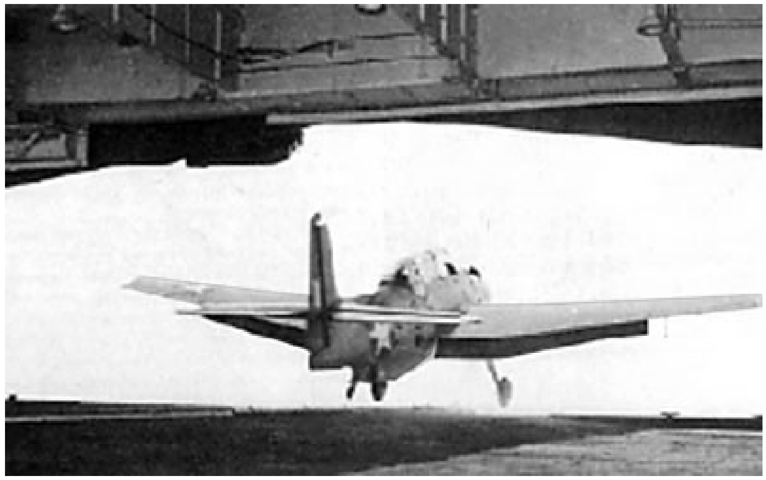

Figure 1.9 Launching a TBF Avenger torpedo bomber from hanger deck catapult, 1943.

These heavier aircraft had to be accommodated in larger numbers than had originally been expected. The Essex was commissioned with a "double" fighter squadron of 36 aircraft, plus single scout (dive-bomber), bomber (dive-bomber), and torpedo-bomber squadrons, each of which had numbered 18 aircraft; she also had an extra dive-bomber for liaison, for a total of 91 operational aircraft, plus nine more (three of each type) in reserve. As radar developed, the need for specialized scouts was reduced, such that by 1944, the "scoutbomber" and dive-bomber squadrons had typically been amalgamated, for a total of 24 such aircraft. The slack was taken up by the fighters, which included specialized night interceptors and photoreconnaissance aircraft. For example, in October 1944, the new carrier Shangri-La accommodated a total of 49 day fighters (F4U-4s), four night-fighting Hellcats, and two photo-reconnaissance Hellcats. By that time, however, fighter-bombers were beginning to displace the pure dive-bombers. By the summer of 1945, the typical Essex air group included one large fighter squadron of 36 or 37 aircraft, a fighter-bomber squadron of similar size, and reduced dive- and torpedo-bombers of 15 aircraft each, for a total of 103 aircraft; the fighter squadron included specialist aircraft.

The heavier aircraft landed faster and required new arresting gear, a late-war modification that alone was credited with adding about 125tons, all of it high in the ship.

Figure 1.10 Grumman Hellcat fighter preparing for launch 1944.

All inserted photographs: http://www.navsource.org/archives/02/10.htm

Bomb loads also increased and by the spring of 1945, in common with most other US warships of wartime construction, the Essexes were weight critical; in January, BuShips warned that "the margins of stability possessed by the earlier vessels of the CV-9 class have completely disap-peared on CV-21, CV-31-40, 45-47 and that the Bureau will require complete weight and mo-ment compensation for any changes or alterations requested or directed on these vessels in the future. It is believed that the ships which have been in service for some time compare unfavora-bly with new ships because of a general accumulation of weight of all kinds."

The yard's inventory revealed that there was on board in topside locations an average of 800 rounds of 40mm ammunition per gun barrel, and 4076 rounds of 20mm ammunition per gun. The total weight was 247-tons, about 50-percent of the weight of the ship's complement of air-craft. "The Franklin has adequate stability in the intact condition [but] the ability of the ship to survive damage has been seriously impaired because of loss of freeboard and stability...The ship with one torpedo hit would take about the same list as the Essex, as originally built, with two torpedo hits..."In July, after the Franklin and the Bunker Hill had very nearly been lost in action, the Bureau imposed severe restrictions of ready-service light ammo to 500 rounds per 40mm barrel and 1420 per 20mm gun.

In invasion after invasion and attack after attack, the Essex-class carriers proved themselves in battle. The carrier task force concept was honed to a fine art that, with minor variations, is still used today. As battle after battle made history in the Pacific sea war, the awesome effect of naval airpower altered the face of naval warfare forever. By late 1944, Pacific carriers were able to launch 1000 plane raids against Japanese targets. The great Marianas "Turkey Shoot" alone had virtually broken the back of Japan's air might, spelling largely the end to conventional airborne attack, and helped to foster the desperate use of the kamikaze suicide squadron.

The Essex-class carriers were far from being perfect ships, but in the regimen of the Pacific War they were virtually custom-tailored to the task of putting men, planes and ordnance on an enemy target. Had they not been so handsomely designed and efficiently utilized, the course of the Pacific War would at best have drawn out to a more grueling, protracted conflict requiring the conquest of still more land bases from which to launch air attacks at the Japanese home islands. They could give and take tremendous punishment and the proof of their mobility and expansibility is the truism that in highly modified forms they remained the numerical backbone of carrier aviation for well over 35-years.

Just after the end of WWII, 19 carriers of this class were taken out of service, "mothballed" and placed in the reserve fleet. Only the four newest ships, CV-21, 32, 45 and 47, remained on active service, and their aircraft fought out the first aerial battles of the Korean War from 1950 onward; most of their sister-ships were subsequently reactivated one after another and completely modernized.

Design: The Essex design was in general superb. The ships were able to absorb massive increases in AA guns, ammunition allowances, aircraft munitions and equipment, etc. Postwar they could accommodate rebuilds that allowed them to operate modern jet aircraft throughout the Cold War. The only real weakness in the design was the wooden, unarmored flight deck, which made the ships very vulnerable to aircraft attack. This was considered an acceptable tradeoff, compared to the RN's armored flight decks and much smaller air wings. One flaw in the design was the ventilation system, which allowed smoke to rapidly spread throughout the ship. This problem was fixed during postwar reconstruction.

Variations: Some units were completed with athwartships catapults in the forward hangar bay, but these were soon removed in favor of additional AA guns. Postwar reconstructions led to major variations within the class and within each rebuild configurations.

Modifications: Numbers of .50 cal, 20 mm, 1.1 inch and 40 mm weapons varied throughout the war; therefore only the ultimate numbers of guns are listed. Some ships were completed with .50 cal and 1.1 inch guns, but these were replaced with 20 mm and 40 mm guns early in the war. Postwar the 20 mm guns were removed; in ships remaining active into the 1950's, dual 3/50 AA mounts replaced quad 40 mm guns. As time went on the gun batteries were gradually reduced until the ships carried little, if any, gun armament.

Modernization: Following WWII most ships underwent extensive upgrades under several programs.

SCB 27A: First major upgrade program applied to Essex class. This was a general, all-around upgrade, including a completely rebuilt and reconfigured island, new arresting gear and hydraulic catapults, new aircraft fueling arrangements, and all deck-level 5 inch guns removed. The gun armament was reduced to 8 single 5/38 DP and 12-to-14 dual 3/50 AA; the gun battery was gradually reduced over time. The rebuild did not include an angled flight deck. Displacement was 40,600 tons.

SCB 27C: This program replaced the SCB 27A and went slightly further. Most details were the same as SCB 27A, but the ships carried steam catapults, rather than hydraulic, and had only 4 5/38 guns. The change to steam catapults was a major operational improvement and allowed the ships to operate much larger and heavier aircraft. Displacement was 43,600 tons.

"Ultimate" Reconstruction: This was a never-realized program to upgrade Essex class ships to a final, completely modern configuration. The SCB 27A/27C programs were seen as a temporary measure pending development of an "ultimate" configuration for the class. Ships of this config-uration would have operated with the "supercarrier" United States in large nuclear-strike groups. The design would have been completely flush-decked, with no island at all. With the death of United States and the development of the angled deck, the "ultimate" plan was reconfigured but probably stayed alive. It is unclear when it was realized that the "ultimate" modernization of Essex class ships should be dropped in favor of SCB 125 and new construction. Two ships were excluded from other modernization programs to make them available for the "ultimate" conversion -- Bunker Hill and Franklin. These ships had been heavily damaged near the end of the war, fully repaired, and laid up in excellent condition. Ultimately they went to the breakers unmodified.

SCB 125: This program was applied to ships already modernized under the SCB 27A/27C pro-grams. The principal change under SCB 125 was the addition of an angled flight deck to replace the old axial deck arrangement. Other features of the ship, including the hydraulic/steam catapult separation between SCB 27A and SCB 27C, were not changed. In some cases this modernization was performed at the same time as an SCB 27A/27C conversion, leading to confusion between the two programs. The prototype conversion for this program was applied to an otherwise unmodified ship, yielding an odd ship with all her WWII features intact, but with an angled deck.

SCB 125A: This was a slightly more advanced version of the SCB 125A program, the main difference being use of an aluminum flight deck to replace the old wooden deck. This modern-ization also included replacement of the SCB 27A's hydraulic catapults with the steam catapults of SCB 27C.

CVS Conversion: This conversion was applied to SCB 27A and SCB 27C ships as they left the front-line fleet and assumed ASW duties. Conversion, which was not always done at the same time as redesignation to CVS, included outfitting the ships with an ASW command center, additional communications, support facilities for ASW aircraft and helicopters, etc. The early CVS conversions, from unmodified axial-deck (non-SCB) ships, were far less extensive and are best classed as a refit rather than a full conversion.

LPH Conversion: This conversion was applied to unmodified, axial deck ships that had previ-ously served as CVSs. Most guns and radars were removed, 4 of the 8 boilers were deactivated, and troop berthing spaces and equipment storage spaces were added. Speed was 25 knots; most ships carried 2 dual and 2 single 5/38 DP.

FRAM II: This was a general update and life extension overhaul applied to some late CVSs and LPHs. The CVSs received a hull-mounted sonar, and all ships had their service lives extended by 5 years.

Classification: Initially classed CV; all reclassed CVA in 1952. Various ships reclassied CVS or LPH as they were modified; some changed to CVS while in reserve. Unmodified ships laid up in reserve eventually became aircraft transports (AVT). Some ships remaining as CVAs in 1975 were reclassed CV, but no change of role resulted.

Other Notes: During the 1980's reactivation of one or more mothballed Essex class ships was considered, but the idea did not proceed. The ships were considered to be too old and in poor condition, and there were few aircraft suitable for operation from their small decks.

The following summarizes the construction and modernization history of the Yortown: Built by Newport News. Laid down 1 Dec 1941, renamed to honor **CV 5** 26 Sept 1942, launched 21 Jan 1943, commissioned 15 April 1943.

Served with the Carrier TF until replaced by Franklin and sent to Bremerton Navy Yard for refit 8/1944 to 10/1944. Decommissioned to reserve 9 Jan 1947.

SCB 27A reconstruction at Bremerton Navy Yard started 5/1951, completed and recommis-sioned 2 Jan 1953. Redesignated as an attack carrier (**CVA 10)** 1 October 1952 while in overhaul. SCB 125 angled deck modernization at Bremerton Navy Yard 3/1955 to 15 Oct 1955.

Redesignated as an ASW carrier (**CVS 10**) 1 September 1957. Scheduled for FRAM II life extension in 1966, but cancelled due to ship's poor condition. Decommissioned to reserve 27 June 1970, stricken for disposal 1 June 1973. Preserved as a museum at Patriot's Point (Charleston), SC.[2]

[2] **Owen Gault, Sea Classics, Nov 30, 2007**

1.1. VESSEL DATA & STABILITY

The following representative data for the so-called "short hull" series was taken from the U .S. Navy Bureau of Ships General Information Book for Lexington (CV-16) and Bunker Hill (CV-17), 1943 edition. Data for CV-16 only are shown because of space constraints. Data for the so-called "long hull" series was taken from the General Information Book for Princeton (CV-37), 1946 edition. Information has been compiled for initial characteristics as built, with some information provided on wartime changes in selected features. Emphasis is given to the engineering plant and to aviation features. Postwar changes are not included.

The waterline used as a basis for measurements was the designer's waterline, specifically the normal waterline corresponding to the designed normal load and draught. This waterline was 26-ft. 6-in. above the molded baseline.

The fore perpendicular (F.P.) was taken at the forward extremity of the designer's waterline.

The middle perpendicular (M.P.) was taken midway between the forward and aft perpendiculars.

The aft perpendicular was taken at the aft extremity of the designer's waterline.

The molded baseline is 1 7/8” above the bottom of the flat keel plate. There are no projections below the keel.

Length overall (main hull molded)	855-ft. 10-in.
Length overall (including flight deck overhang)	879-ft. 2-in.
Length between perpendiculars	820-ft. 0-in.
Length of flight deck	862-ft. 0-in.
Projection of bow forward of F.P.	13-ft. 0-in.
Projection of stern aft of A.P.	22-ft. 10-in.
Total projection forward of F.P.	19-ft. 1 ¾-in.
Breadth, molded, at designed W.L. at Frame 102 ½	93-ft. 0-in.
Breadth, extreme gallery deck at Frame 155	123-ft. 0-in.
Half Breadth, extreme at 40-mm sponson (Frame 821/2 starboard Fo’c’sle Deck	65-ft. 10 ¾-in.
Half Breadth, extreme at 40-mm sponson (Frame 171 port Gallery Deck)	81-ft. 2 ¾-in.
Depth, molded, at side, to Main Deck (Frame 102 ½)	54-ft. 6 ¼-in.
Depth, molded, at centerline to Flight Deck	81-ft. 8-in.
Depth, of inner bottom, molded, at C.L. of vessel	2-ft. 9-in.
Midship section, aft of Frame 102	2-ft. 0-in.
Number of frames (at 4-ft. intervals)	205
Frame spacing (throughout)	4-ft.
Freeboard at bow above Designed W.L.	36-ft. 7-in.
Freeboard at stern above Designed W.L.	28-ft. 2 1/8-in.
Draught, molded, to Designed W.L.	26-ft. 6-in.
Bottom of keel below molded baseline	0-ft. 21-in.
Approximate full load capacity of fuel oil	6,933 tons
Approximate capacity of gasoline, net (+46.6 tons S.W.)	632 tons
Approximate capacity of fresh water	620 tons

Approximate capacity of reserve feed water	503 tons
Approximate capacity of aviation lubricating oil	83 tons
Approximate capacity of diesel oil	162 tons
Area of rudder	429 sq. ft.
Displacement, standard	27,100 tons
Displacement to Designed W.L.	33,292 tons
Highest point on ship	161-ft. 9 7/8-in.
Freeboard at bow, above designed W.L.	36-ft. 7-in.
Freeboard at stern above designed W.L.	28-ft. 2 1/8-in.
Approximate full load capacity of fuel oil	1,971, 133 gal.
Approximate capacity of gasoline	199,356 gal.
Approximate capacity of fresh water	157,591 gal.
Approximate capacity of reserve feed water	135,374 gal.
Approximate capacity of aviation lubricating oil	21,683 gal.
Approximate capacity of diesel oil	50,965 gal.

Calculated Data at Design Draft 26-ft. 6-in. WL as Built:

Tons per inch immersion	132.7
Area of waterplane	55,800 sq. ft.
C.G. of waterplane aft of Frame 102	38.72-ft.
Moment to change trim one inch	5600 ft. tons
Center of Buoyancy above bottom of keel	14.89-ft.
Center of Buoyancy above bottom of keel	10.15-ft.
Transverse metacenter above C.B.	27.86-ft.
Longitudinal metacenter above C.B.	1667-ft.
Area of midship section	2416-sq.ft.
Wetted surface	87,400-sq.ft.
Ratio, length BP to beam, molded	8.82:1
Block coefficient	.577
Prismatic coefficient	.980
Waterplane coefficient	.732

Calculated Data for YORKTOWN as she is currently configured:

The following weights are for the light ship and components as of the SCB 27C conversion at time of inclining experiment:

Light displacement	29,547 tons
Full displacement	41,370 tons
Hull	21,425 tons
Machinery	3,474 tons
Hull fittings	3,240 tons
Armament	135 tons
Protection (armor)	295 tons
Equipment & outfit	669 tons

Aeronautics (including aircraft)	125 tons
Margin tonnage	211 tons
Aircraft	900 tons
Ammunition	1,286 tons
Machinery liquids	241.5 tons
Stores & PW	1,739 tons
Lube oil (ship & aviation)	80 tons
RFW	503 tons
Fuel oil	5,954 tons
Diesel oil	160 tons
Avgas & side shell protection	2,354 tons
GM	9.5
GZ	9.59
Light KG	40.61
Light GM	9.83
Light LCG	16.93
Full KG	35.42
Full GMv	10.13
Full GM	15.90
Full TCG	0.06
Full LCG:	15.02
Tons per inch immersion (approx.)	110 tons/inch

Stability:

The Essex class ships experienced significant reduction in stability during the course of World War II. As designed, the Essex was intended to displace 25,100 tons in light condition (without aircraft), 37,367 tons in emergency (maximum) load condition, and have a metacentric height (GM) in optimum battle condition of 7.5 feet. Two of the first ships to be built were inclined and proved to have greater initial stability than designed:

Displacement in GM in Optimal

Ship	(Without Airplanes)	Emergency Condition	Battle Condition
Essex	23,400 tons	36,100 tons	8.9 ft.
Lexington	23,700 tons	36,500 tons	8.3 ft.

The resultant stability margin permitted further topside additions to be made, some of which were embodied in Ticonderoga (CV-14), the next ship to undergo an inclining experiment. That test showed the following data:

Ticonderoga	24,300 tons	37,400 tons	7.3 ft.

Succeeding ships showed further reductions in meta-centric height. "The Bureau recognized that the original design standards would not much longer be met and therefore undertook a review of the stability requirements in an effort to establish a criterion which would permit some additional urgent alterations without undue sacrifice of power of survival. The primary consideration was the question of list to be expected from underwater damage along the sides of the ship. Secondary considerations were the tenderness of the ships when turning at high speed and the ability of the ships to carry an accumulation of large scale fire-fighting water. The Bureau came to the conclusion that the GM in Optimum Battle Condition should not be less than 6.5 feet."

Subsequently, Intrepid (CV-11) and Franklin (CV-13) were inclined following repairs and alterations to check the condition of ships thus modified after a period of service. The results were practically the same for each vessel:

Intrepid/Franklin	25,700 tons	5.5 ft.

According to BuShips, "these results were entirely unexpected and the Bureau cannot offer satisfactory explanation of the development. The changes and alterations accomplished account for only about 50% of the increased displacement (Light Condition) over Essex, as built. Some of the alterations may have been heavier than estimated. There have no doubt been many additions of weight which have not been reported..." BuShips estimated the impact of this reduced stability as follows:

“Prediction of the number of torpedo hits which a ship will withstand cannot be made with definite assurance because of the number of variables involved, the most important being the location of the hits. It is estimated, however, that in the case of these ships with 5.5 feet GM there would be high probability of loss from three torpedo hits on one side; whereas with the GM increased to 6.5 feet the same probability of loss would be reached with four torpedo hits on one side. Two ships have returned after very severe topside damage and two have been torpedoed near their sterns, but in no case was the damage of such a nature that the ship de- pended upon stability for survival. It should be noted in passing, however, that Franklin developed symptoms of critical stability conditions due to firefighting water”

Declining stability margins led to a wide effort during the spring of 1945 to identify items of topside weight for removal. Representative items to be evaluated for potential removal included radio masts (10.7 tons net saving), one gasoline strainer from each gasoline station throughout the ship (4.2 tons), shore power connections, cables, reels, and platforms (3.1 tons), 36-in. searchlights (3 tons), strong backs for hoisting aircraft in the hangar (8.3 tons), etc. Likewise, authority was given to reduce all 30# (3/4-in thick) or above STS plating in the island to 25# weight, "taking into consideration additional stiffening where considered necessary." Mooring wires and reels also were considered for reduction, with the vessels to rely on shore facilities to provide needed mooring equipment. Deck edge elevator stowing machinery also was proposed for removal.

On 25 April 1945, the Bureau of Ships established a "limiting displacement of 38,500 tons as a guide against overloading, to be exceeded only when exigencies of a special situation justify the increased risk involved." The Bureau identified one representative set of loads that an average ship of the class could carry within this limiting displacement:

Airplanes	73VF, 15VTB, 15VSB	(Empty Weight 445 tons)
Complement	3000 Officers & Men	328
Ammunition	5 in./38, 6200 rounds	257
	40-mm, 110,000 rounds	347
	20-mm, 280,000 rounds	82
	Bombs	550
	Rockets	250
	Aircraft	300

	Torpedoes	75
	Miscellaneous	40
Provisions & Stores	Fresh & Refrigerated, for 42 days	202
	Dry provisions, for 112 days	435
	Miscellaneous	125
General Stores		350
Potable Water-Full Capacity		619
Reserve Feed-Full Capacity		505
Fuel Oil-Full Capacity		7035
Diesel Oil-Full Capacity		162
Gasoline-Full Capacity		685

The limiting displacement was roughly 1100 tons greater than the Emergency Condition for which the ships were designed. Armored freeboard was reduced nearly 50% at the limiting displacement, to only 11 inches. The logs of some ships completed during 1945 showed that some were loaded to as much as 39,500 tons. Further, vessels in the operating force were found to be exceeding normal topside loadings: "As an extreme example, one ship under overhaul had on board in topside locations an average of 800 rounds of 40-mm ammunition per barrel and 4076 rounds of 20-mm per barrel. This amounts to 247 tons and is nearly twice the usual allowance."

As a further specific example of overloading, Bunker Hill (CV-17) reported the following estimate of ship's loads:

Condition	Displacement	Draught
Condition II (Light Ships) Load	25,968	21-ft. 11 ½-in.
Aircraft	726	
Complement	369	
Ammunition	1839	
Provisions, stores, etc.	1586	
Potable water	620.7	
Reserve Feed Water	520.7	
Fuel Oil (95% capacity)	6933.3	
Diesel Oil	162.3	
Gasoline	632.2	
Total Loads	13371	
Condition VII	39339	30-ft, 4 ½-in.

Bunker Hill also reported that the ship drew 30-ft. 5-in upon departure from Uliti on March 14, 1945, giving credibility to this estimate.

Initial stability (metacentric height) data taken from a later edition of the Bunker Hill's ship Characteristics Card is as follows:

GM (feet)

	Card Date	Light	Intermediate	Full Load
Bunker Hill	20 Jul 46	3.25	6.17	7.03
Displacement		24,110 tons		39,000 tons
Draught				30-ft. 6-in.

Weights:

As described in the original 1941 edition of the Detail Specifications for construction, the light displacement was estimated as 25,400 tons; standard displacement, 27,100 tons; sea trials displacement about 33,900 tons; and maximum load displacement about 37,400 tons. Design weights by weight group naturally fluctuated as detailed design proceeded. The following table displays detail estimates of Light Ship Displacement in tons by individual weight group during the course of 1941:

Weight Group	USN BuShips 10 Jan. 1941	Bldr/NN SB & DD 29 Mar. 1941	Bldr/NN SB & DD 15 May 1941
Stem and Sternpost	10.67	50.47	50.47
Transverse Framing	555.90	536.39	531.83
Longitudinal Framing	623.96	594.21	522.50
Shell	2023.76	2042.64	2034.37
Inner Bottom & 3rd Skin	377.92	418.38	413.35
Bulkheads	2861.22	2865.11	2804.18
Fo'c'sle Deck	96.94	97 .36	96 .11
Main Deck	2517.82	2514.30	2514.30
Second Deck	766.91	779.17	779.19
Third Deck	409.27	417.47	417.47
Fourth Deck	1446.25	1466.92	1437.28
Flightdeck	2251.54	2297.21	2284.59
Platforms	242.62	251.78	294.33
Flats & Floors	40.27	39.59	41.65
Superstructure	245.37	246.70	246.69
Stanchions	47.63	47 .63	46 .00
Armor Connections	16.80	16.80	11.52
2ndary Battery Foundations	14.81	15.17	24.03
Machinery Foundations	318.24	330.22	292.63
Misc. Foundations	22.60	25.26	25.26
Trunks, Insulation, etc.	635.79	626.32	643.50
Rivets, Weldments, etc.	498.01	498.01	480.00
Paint & Cement	300.00	288.32	288.32
Misc. Woodwork	22.60	25.26	25.26
Steering Gear	108.31	115.00	115.00
Pumping & Draining	519.68	564.46	546.19
Ventilation	182.43	188.33	181.35

Weight Group (cont.)	USN BuShips 10 Jan. 1941	Bldr/NN SB & DD 29 Mar. 1941	Bldr/NN SB & DD 15 May 1941
Anchor Handling	82.50	101.53	101.53
Warp & Tow Gear	46.82	38.32	38.32
Boat & Plane Stowage	682.86	679.91	679.91
Ammunition Handling/Stowage	313.85	339.53	320.90
Masts & Spars	19.77	26.25	26.25
Handrails & Stanchions	32.56	26.35	26.35
Airports	12.16	11.00	11.00
Doors & Hatches	96.30	125.69	125.69
Ladders	23.34	22.66	22.66
Voice Tubes	18.43	24.48	24.48
Misc. Fittings	338.56	360.33	360.33
Boats	100.23	100.23	100.23
Furniture	229.91	227.86	227.86
Ground Tackle	124.94	124.94	124.94
Rigging, etc.	46.59	52.84	52.84
Fabrics	20.62	20.76	20.76
Misc. Equipment	217.07	222.93	222.93
Armor	968.50	966.08	966.08
Machinery	3401.48	3615.00	3495.46
Aero Equipment	593.97	595.31	595.27
xx Margin	247.81	248.21	267.53
TOTAL	25350.00	25830.00	25500.00

As construction proceeded in early 1942, the Navy's Supervisor of Shipbuilding ("SupShip"), Newport News, reported increases of 834 tons over the design light displacement of 25,350 tons. Substitution of steel for all aluminum added 548 tons; changes in the island and addition of 20-mm guns added 164 tons; while other miscellaneous changes added 122 tons. On the other hand, a variety of reductions which totaled up to 426 tons seemed to be possible, leaving the net increase (by SupShip estimate) at 122 tons.

The Navy had difficulty keeping close track of shipbuilding weights. As an "emergency war measure," the final weight report for hull and machinery for Lexington (CV-16), the lead ship built by Bethlehem Steel at Quincy, was waived. Experienced personnel were limited and some were drafted away from the builders. SupShip Quincy reported "the operations of the Selective Service System are presently taking eight men out of 32 now in the contractor's Returned Weights Section, two of the eight being key men of long experience in this specialized work . . ." Designers in the Bureau of Ships lamented the impact of these problems; however Lt. Comdr. C. D. Wheelock noted as follows:

"We are suffering now in connection with compiling weights for CV-41 (Midway, lead ship of a new class) from the Newport News' failure to comply with specification requirements for weights on plans. We have no indication how well or much they are doing with the weighed weights and reports. This information is vital to design and we don't have it. Quincy should certainly not be relieved of making the reports until it is definitely established that the Newport News weights are well made and will be promptly furnished."

The requirement to weigh all weights placed aboard in CV-31 through 40 was waived in late 1942.

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VESSEL CONSTRUCTION

The specifications for construction of the vessel describe the basic structure as follows:

"The envelope of the ship as a whole consisting of spaces below the forecastle deck forward, main deck elsewhere shall be made watertight. It is the intent of this requirement that a continuous and complete upper boundary be established. In addition to the upper envelope, individual spaces shall be made fume-tight unless specifically designated otherwise and except where movable wires and cables of special equipment penetrate the boundaries, the maximum degree of tightness will be required without use of clamps or other fittings which would interfere with operation of the equipment . . . . . . The third deck will be the "Damage Control Deck."

The ship was assembled using a mix of welded and riveted construction. Structure was welded forward of Frame 26 and aft of Frame 166. In between, however, a complex mix of methods was employed. For example, longitudinals were riveted to the bottom shell plating and to the third skin but were welded to floors and transverse bulkheads. All structure above the main deck was welded.

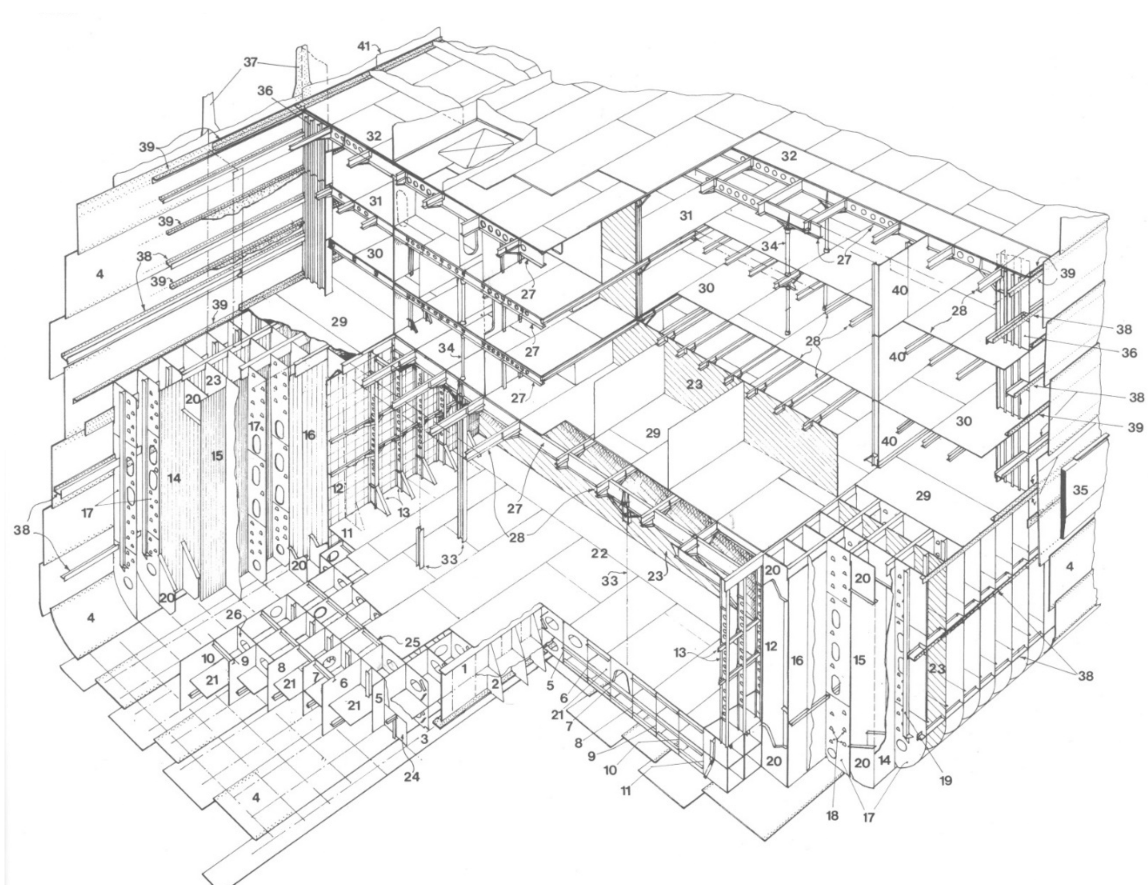

Figure 1.1 Typical midship sectional drawing showing construction details

B16 TYPICAL BELT ARMOUR PLATE (4in Class 'B'. 1/75 scale)

1 Length 26ft
2 Depth 10ft (maintained as a uniform vertical depth through length of belt hence at ends, where hull was at an angle, actual depth of plate was increased)
3 Position of armour bolt holes
4 Keyways for securing butts of adjacent plates

B17 BELT, ARMOUR BOLT (no scale)

1 Armour belt
2 Armour backing compound
3 Skin plating
4 Mild steel cap, welded to skin
5 Nickel steel bolt
6 Nickel steel nut
7 Washer
8 Canvas grommet
9 Stainless steel sleeve
10 Welds to lock washer
11 Welds on washer to lock nut

B18 SIDE ARMOUR ENDS

1 Armour belt
2 Armour bulkhead
3 Armour backing compound
4 Flat bar strip to support edge of armour bulkheads
5 Fairwater plate
6 Welds
7 Skin plating

B19 MIDSHIPS STRUCTURE (at No 3 fire room)

1 Centre vertical (CV) keel
2 Keel docking brackets (between frames)
3 Outer flat keel
4 Outer bottom (skin) plating
5 1st longitudinal
6 2nd longitudinal
7 3rd longitudinal
8 4th longitudinal
9 5th longitudinal
10 6th longitudinal
11 7th longitudinal
12 Holding bulkhead (plates laid vertically)
13 Holding bulkhead support framing
14 Backing bulkhead No 1 (plates on all backing bulkheads laid vertically)
15 Backing bulkhead No 2
16 Backing bulkhead No 3
17 Support brackets to backing bulkhead (between skin and No 1 bulkhead and No 2 and No 3 bulkheads)
18 Foot and hand holds
19 Vertical 'T' stiffener
20 Brackets in open spaces between torpedo bulkheads
21 Inner bottom plating (laid between longitudinals)
22 3rd bottom plating (laid athwartships abreast main transverse bulkheads and fore and aft elsewhere)
23 Main transverse water-tight bulkhead
24 Water-tight floor (under water-tight bulkhead)
25 Non-tight open floor
26 Non-tight solid floor
27 Transverse deck beam (generally two under each deck per main water-tight section)
28 Longitudinal deck beams
29 4th deck plating (laid fore and aft amidships, laid athwartships between longitudinal bulkheads and sides)
30 3rd deck plating (laid fore and aft)
31 2nd deck plating (laid fore and aft)
32 Main (hangar deck) plating (two courses laid fore and aft)
33 'I' girder pillars (those in engine room on centre line)
34 Pillars
35 Armour belt
36 Frame under flight deck foundation (vertical 'T' stiffeners on side shown, horizontal 'T' stiffeners on far side)
37 Outer bracket of flight deck foundation
38 Stringers
39 Angle bar connections between skin plating and decks
40 Longitudinal bulkhead
41 Hangar side plating (laid vertically)

Figure 1.2 Information key for sectional drawing

The vertical keel was continuous throughout the length of the vessel. A rider plate was provided on top of the vertical keel from Frame 3 to Frame 26. It was contiguous with the inner bottom plating at Frame 26. Between Frames 4 and 23 ½ it was designed to be 21-lb plate 24-in wide, increasing to 72 inches wide at Frame 26 and reducing to 8 inches wide at Frame 3.

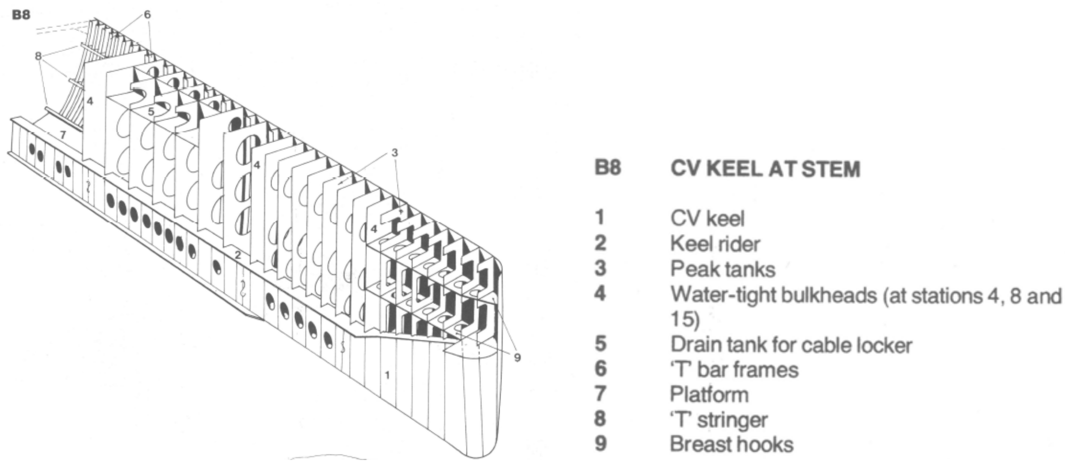

Figure 1.3 Keel and frame structure at stem of YORKTOWN

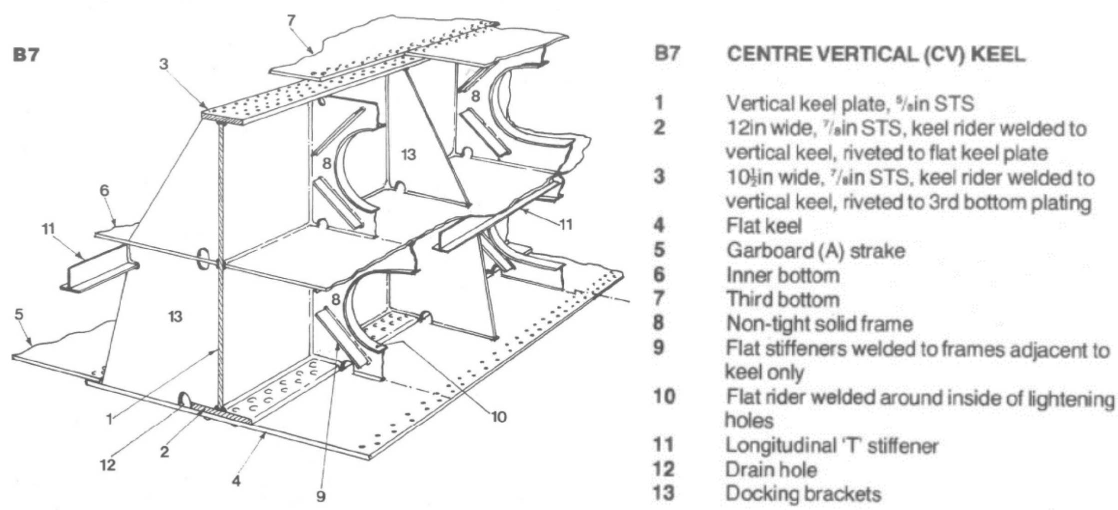

Figure 1.4 Center vertical keel details

Removable sections of deck plating were provided to permit removal of machinery units. The plating for these portions of the decks was to be riveted to maintain the strength and ballistic properties of the decks. Non-ballistic decks were allowed to have removable sections that could be burned out and welded back in place, in lieu of riveted sections.

Where transverse girders and web beams were welded to deck plating, the thickness of which was equal to or greater than the thickness of the flange of the girder or web beam, the upper flange of the girder or web beam was to be cut off.

In addition to the decks and platforms being designed to withstand the test pressures and provide adequate strength of the vessel as a whole, they were required to bear the following live loads at bending stresses not exceeding 20,000 lb. per square foot for medium steel and 25,000 lb. per square foot for high-tensile steel (HTS) :

Surfaces	**Pounds per square foot loading**
Living spaces, passages, offices above maindeck	75
Radio, motion picture, stowage spaces above maindeck	100
5-in. gun upper handing rooms	200
Maindeck	300
Decks & platforms below maindeck (personnel quarters)	100
Decks & platforms below maindeck (workshops)	200
Decks & platforms below maindeck, offices & control rooms	150
Decks & platforms below maindeck (magazines)	300

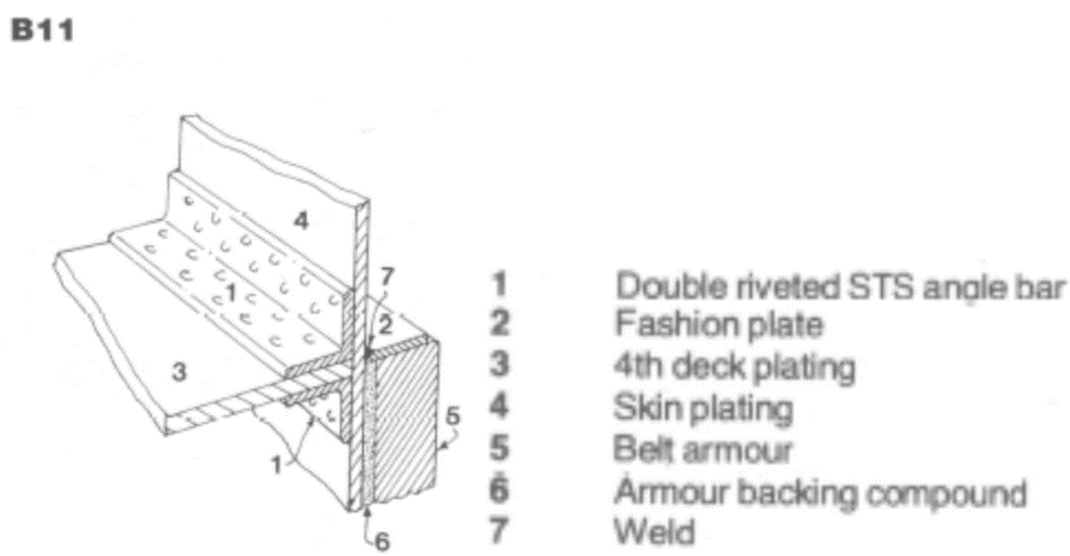

Figure 1.5 Connection of 4th Deck to side shell plating

Transverse riveted connections to the maindeck strength members within the three-fifths length amidships were to have rivets spaced not less than six diameters apart. Top and bottom flanges of longitudinals were to be continuous through transverses where longitudinals were riveted to the deck.

In general, the webs of deck longitudinals, girders, or beams six inches deep or greater were to be lightened (with lightening holes) except under the strength strakes of plating of the main and second decks between Frames 39 and 166, where continuous longitudinal members were not to be lightened. Lightening was to be effected through holes circular in shape and centered as close as possible to the neutral axis of the cross-section of the longitudinals.

All openings in strength decks and elsewhere were to have well-rounded corners. Doubler plating was not necessary around hatches, ventilation openings, hoists, or other openings in special treatment steel plating.

The main deck, second, and third decks were designed as the longitudinal strength decks of the vessel. World War II correspondence files do not show concern for general structural strength (there was concern over details, such as the flight deck overhang). In the original detail design, the following estimated main hull girder maximum stresses were assumed:

Hogging	**CV-9**	**CV-5/6**
Displacement (tons)	36,025	28,810
Deck tension, tons/sq. in.	9.13	10.42
Keel compression, tons/sq. in.	9.17	8.64
Sagging		
Displacement, tons	36,025	28,810
Deck compression	5.89	8.59
Keel tension, tons/sq. in.	9.21	9.86

Tension stresses for CV9 were increased by 25% and for CV5/6 by 17.6% to allow for rivet holes. (All tonnage figures are in 2240-lb. tons.) The hangar deck was to be watertight to the extent necessary to prevent spilled gasoline from reaching compartments below, as demonstrated by a hose test with water in way of openings.

The gallery deck was only partially employed for compartments and equipment when the ships were designed. Subsequently, additional compartments were added and the extent of gallery deck spaces enlarged. Unfortunately, the gallery deck was particularly vulnerable to damage because it was unprotected from above by the unarmored flight deck and from below the hangar deck level. Heavy loss of life in gallery and hangar deck spaces in air attacks late in the war led to major changes in gallery deck features being planned. Hull Change No. A l (19), Mod. 2 provided for numerous emergency escapes from the island and gallery deck. All dogged doors within the gallery deck were to be replaced with Quick-Acting (Q.A.) doors; numerous additional doors and scuttles were provided; additional passageways and ladders provided to the hangar deck; and hatchways to the flight deck were added. Further, Hull Change No. A1 (29) called for the relocation of the majority of the squadron ready rooms from the gallery deck to locations below armor on the second deck.

Newport News SB&DD Co. served as design agent in developing some of the contract and working plans for ship construction. Bethlehem Steel Co.'s Shipbuilding Div. at Quincy, Ma., also contributed plans.

A variety of detail changes were made as the contractors executed these construction drawings. For example, Newport News personnel recommended a minor increase in scantlings for the outer shell (third skin) and longitudinals due to the high stresses resulting from the combination of ship girder stresses and local bending stresses of the bottom structure. “We suggest . . . that in way of the machinery spaces a 17-lb. transverse strake of plating be fitted in the third skin from the keel rider plate to torpedo bulkhead No. 4 and extending one frame space on each side of the main transverse bulkheads. We also suggest . . . that longitudinals in way of the machinery spaces be made 17 lb. instead of 15 lb.” Bottom shell plating was increased from 14 lb. to 24 lb. in selected areas. The Bureau approved these changes in contract design specifications.

All design changes on CV9-21 plans were handled by Newport News, while all changes on CV31-40 plans were carried out by New York Navy Yard. Newport News assumed the responsibility of primary design agent for all CV9 class electrical plans during 1944. The total number of hull, machinery, and vendors plans for an Essex class ship was about 6775.

Amidships Sectional Drawing

The attached drawing shown in figure 6 shows YORKTOWN as she is presently, without the sideshell Class ‘B’ armor plating that was removed for installation of the blister tankage to support the new cantered flightdeck.

The midship section published here provides some introductory information about the structure of the ship's hull.

Plate thickness is given in the standard notation by weight (# indicates weight) in pounds per square foot, where a one-inch thick plate weighs 40.8 pounds per square foot. The type of steel used is indicated by type: armor ("class B" or homogenous armor, in the side belt); Special Treatment Steel (S.T.S,); High Tensile Steel (H.T.S.); and mild steel (all other not specifically identified).

The individual strakes of hull shell plating are identified by letter designations, beginning with "A" furthest inboard and extending around to the sheer strake "P" at second deck side. Shell plating ranged from 25-lb. to 45 lb. weight. Thus, strake "P" at 45 lb. was just over one inch thick. Longitudinal girders running inside the ship's bottom are identified by numbers from 1 to 7. Stringers (longitudinal girders running inside the ship's side and generally lighter than longitudinals inside the bottom plating) shown are numbered No. 6 to 11.

"I" beams and "T" bars supporting decks are indicated on the drawing. Their dimensions are shown, as well as their thickness (as measured in lb. per sq .ft.). The abbreviation "FLG" means "flange".

The tube shown at Frame 104 looking aft rising from the 4th deck up to the main deck protected fire control leads from an Mk37 gun director on the island superstructure. Foundations for a main condenser in the machinery room also are shown at Frame 104 (C.L. indicates "center line").

Lightening holes (many elliptical in shape) are shown in athwartship frames. Note the bilge keel.

The four torpedo defense bulkheads inboard of the shell can be seen. "Backing Bulkhead No. 1" was 15 lb. steel; "Backing Bulkhead No.2" was 25 lb.; No. 3 was 25 1b. and "Holding Bulkhead No. 1" inboard was 17.5 lb. Note the heavy (47-lb.) "I" beam bracing the inboard holding bulkhead. (See further details under "armor" below.)

The drawing identifies individual compartments or spaces shown at the frame station in question. Thus, space "B -33V" is a specific void within the side protection system. Voids generally were made minimally accessible for repair purposes through narrow "manholes" with bolted covers, though some voids were made inaccessible as a result of their particular construction.

Armor and Ballistic Plating

The side belt armor consisted of Class "B" armor, port and starboard, from Frame 39 to Frame 166. The upper and lower edges of the armor belt were level with the top of the 60# STS fourth deck plating or 30-ft. 7 1/2-in. above the molded baseline. The normal thickness of the belt was 4-in. above the 24-ft. 7 1/2-in molded waterline. Below this level, the plates uniformly tapered on the outside of the armor to a normal thickness of 2 1/2-in. at the bottom. The lower inner edge of the side armor was 20-ft. 7 1/2-in. above the molded baseline. The armor belt was comprised of 20 plates, port and starboard, all of which were as nearly rectangular in shape as practicable, with butts on the frame or half frame line. The space between the back side of the armor and the hull shell plating had a filler inserted, consisting of a mixture of one part of pine tar, one part of shellac, and one part of Portland cement (proportions by weight). The plates were secured by 11 in. diameter armor bolts.

The exterior belt armor was removed for the installation of the blister tankage to allow proper stability and support for the angled flight deck installed in the mid-1950s. No drawings have been found, either aboard the ship, in the national Archives, or aboard the other HNSA Essex Class carriers.

The athwartship armor bulkheads are located at Frames 39, 166,186 1/2, and 198, and were made of class "B" armor 4-in. thick. Bulkhead No. 39 extended from the double bottom to the 4th Deck and Bulkhead No. 166 extended from the 2nd Platform level to the 4th Deck, connecting the ends of the side armor belt. Bulkheads No. 186 ½ and from the 4th Deck down to the hull at Frame 198.

The longitudinal armor bulkheads were placed between Frames 186 1/2, and Frame 198 port and starboard, made up of 4-in. thick class "B" armor. Also for the protection of the steering gear and motor control room, these bulkheads extended from the 4th Deck down to the 1st Platform level.

The ships had the following protective decks:

Deck	**Longitudinal Extent**	**Weight of Plate**
Main	Frames 26-166	50# STS upper course 50# STS lower course
Second	Frames 131-145	75# STS upper course 25# STS lower course
Fourth	Frames 39-166 Frames 186 ½ - 198	60# STS 100# STS
1st Platform	Frames 39-50 ½ Frames 184-191 ½	25# STS 30# STS
2nd Platform	Frames 50 ½ - 79 Frames 150-166	25# STS 25# STS

The main deck consisted of an upper and lower course, extending from side to side of the ship and made watertight throughout. The second deck in way of the aft elevator pit consisted of an upper course of 75# STS and a lower course of 25# STS. The fourth deck was 60# STS from side to side of the ship and made watertight except in way of oil-tight spaces, where it was oil-tight. The fourth deck over the steering gear and motor control room also was made watertight.

A splinter bulkhead was fitted between the third and fourth decks, port and starboard, extending from Frame 39 to Frame 166, with a transverse bulkhead at each end. These splinter bulkheads were 25# STS watertight throughout, except in way of trunks, hoists, and bomb elevators, where they were 40# STS.

Ballistic protection was provided by longitudinal and transverse bulkheads that formed the aft elevator pit between the main and second decks, between Frames 131 to 145. These bulkheads were 50# STS. Between the outboard longitudinal splinter bulkheads, port and starboard, third to fourth decks, #40 STS was provided for ballistic longitudinal and transverse enclosure bulkheads, such as escape trunks, air intakes, the uptake enclosure, etc.

Bomb elevator trunks between Frames 65 to 67, port and starboard, and 150 to 152 port, fourth to second decks, were protected from splinters by 4- in. class "B" armor from the Fourth Deck to 18 inches above the Fourth Deck, with a uniform taper to 2 inches at 4-ft. 0-in. above the fourth deck.

In addition, 40# STS protection was provided for selected vent trunks, access trunks, ammunition hoist tubes, and elevator guides.

Four longitudinal torpedo defense bulkheads were fitted on each side of the ship below the Fourth Deck. They extended downward to intersect with the shell. Watertightness was maintained throughout except in way of oil spaces, where the bulkheads were oil-tight. The extent of this protection is shown as follows:

Bulkhead No.	**Longitudinal Extent**	**Plate**
1	Frames 54-166 P & S	15# mild steel
2	Frames 39-166 P & S	25# HTS
3	Frames 26-166 P & S	25# HTS
4	Frames 32-51 P & S	25# mild steel
5	Frames 51-166 P & S	17.5# mild steel

Ready service ammunition rooms on the flight deck and gallery deck were protected by STS plating. Radio I and Flag Radio spaces were protected by 30# STS. On the flag bridge level, starboard, the flag plot and staff officers' sea cabin were protected front and sides, between Frames 79 to 89, by 40# STS. Similar plating was provided for a number of other compartments in the island structure.

Early postwar study of potential design improvements included an effort accomplished by Cdr. W. W. Keller of BuShips to investigate the advisability of installing transverse STS bulkheads on the hangar deck. Elimination of aviation gasoline appeared to be the most promising measure to reduce fire risk, but was not yet in prospect at the time.

Such transverse protective bulkheads had been proposed by the Bureau of Aeronatics in October, 1941. 86 BuAer recommended that bulkheads be placed at Frames 79 and 131, creating hangar deck enclosures

160-ft., 208-ft., and 280-ft. long. Clear openings through access doors in each bulkhead also were recommended, 44-ft. wide. BuShips studied this possibility, developing estimates that these bulkheads could be installed for an additional weight of approximately 115 tons and a reduction in metacentric height of about 0.1-ft., "considered acceptable". However, these bulkheads were omitted.[1]

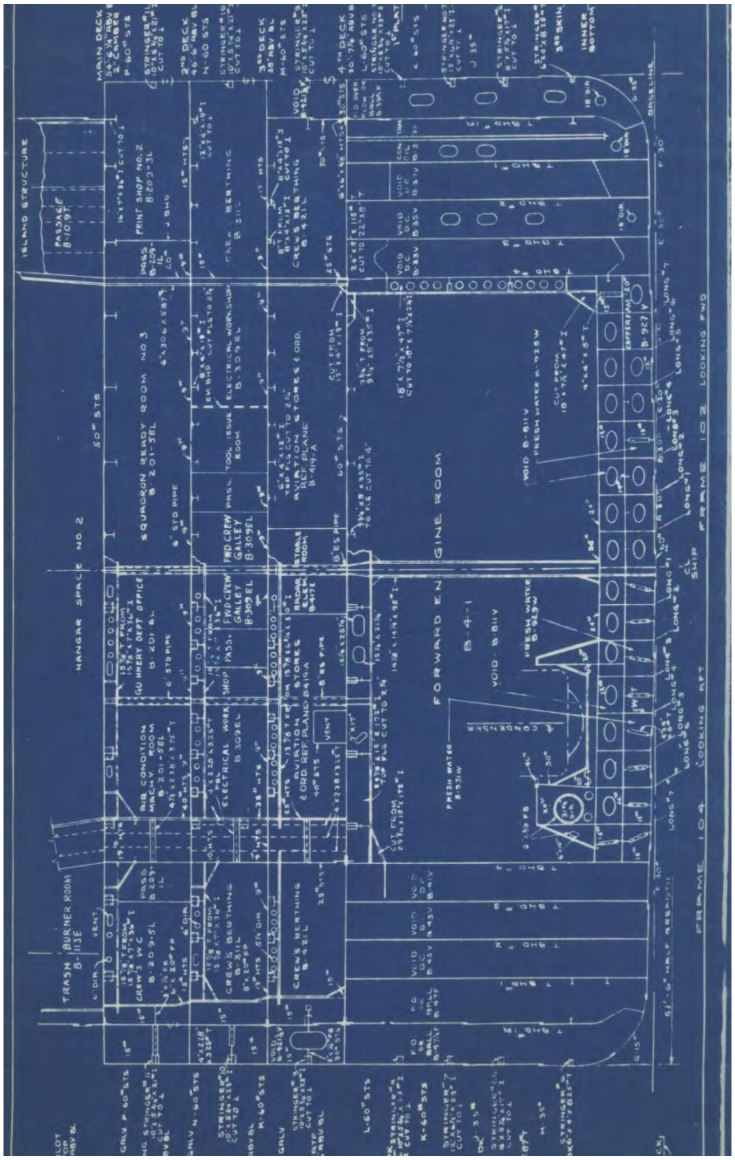

Figure 1.6 Midship Section Drawing

[1] *'Essex Class, Technical Annex'*, **C.C. Wright & William j. Jurens, Warship International, Vol. No. XXXVI, No. 4, 1999**

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ENGINEERING PLANT

The engineering plant is the one of the largest areas of the ship. It accounts for approximately 10% of the total weight of the fully loaded ship and significantly impacts the structure of the bottom of the vessel, including the foundations, piping and layout.

Much of this data is taken directly from the very thorough article written by Mr. Christopher C. Wright and published in “Warship International,” Vol. XXXVI, No. 4, 1999.

The following detailed description of the plant is derived from the National Archives, Box 790, Folder CV9 class/S-29-1 v. 1, Sup Ship Newport News memorandum CV9-15/S29-1 (2012) to Chief, BuShips dated 26 July 1941.

Due to space constraints, the flowing is a highly simplified summary of the boiler operation and it omits details of superheater functions, the management of water supply to the tube banks, reducing moisture carry over, etc. Much of the descriptive material presented in this summary was taken from USS Hornet (CVS-1 2) Engineering Department Instruction 3540. lA (Engineering Casualty Control Manual), edition of 14 July 1967. Some data was taken from SupShip Newport News, "Synopsis of Machinery and Hull Data," 14 Nov. 1942, copy in NA RG19 WWII Gen Cor, Box 775, folder CV9 class/ S8 and from the engineering publications and drawings aboard the U.S.S. YORKTOWN.

The description of turbines and reduction gears is highly simplified and omits important elements such details of thrust bearings, for which data was obtained from General Information Book CV-16/17.

The arrangement of main propulsion machinery is as shown in Figure 1 below:

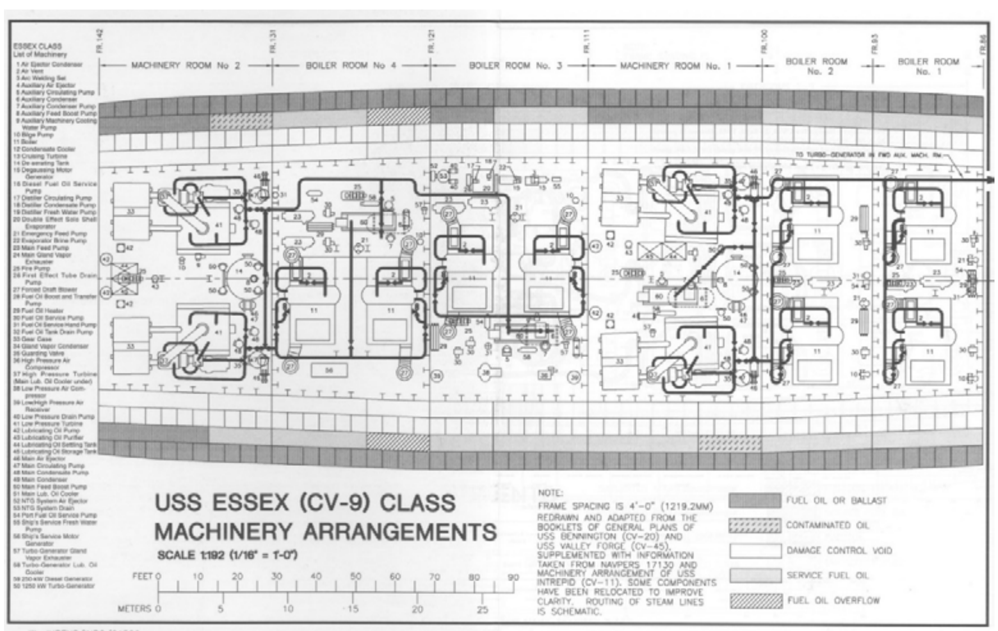

Figure 1.1 Main propulsion Machinery Arrangement

The estimated machinery weights were reduced somewhat as design proceeded. Specific weights were as follows:

	Category	14 Oct 1940	12 Nov. 1940	15 May 1941
	Main Propulsion units	559.0	477.99	467.14
I	Main shafting	273.0	267.11	268.35
II	Main shaft bearings	44.0	38.38	56.63
III	Lube oil system	49.0	36.47	45.58
IV	Fuel oil system	143.0	148.28	142.75
V	Main condenser & air ejectors	139.0	130.09	162.50
VI	Main circulating condensate	36.0	25.00	34.06
VII	& booster pumps			
	Propellers	58.0	51.61	49.55
VIII	Boilers	515.0	469.29	461.12
IX	Boiler fittings	0	22.37	21.56
X	Smoke pipes & uptakes	170.0	166.97	118.93
XI	Steam & exhaust	211.0	158.30	179.77
XII	Water & service piping	178.0	126.05	154.86
XIII	Insulation & lagging	96.0	83.66	92.04
XIV	Floors, ladders, etc.	83.0	72.99	74.11
XV	Auxiliaries	108.0	96.83	98.59
XVI	Fittings & gear	55.0	39.12	41.0
XVII	Tools, equipment	165.0	120.37	158.49
XIX	& spares			
	Misc. machinery	180.0	166.63	176.17
XX	Electrical	810.0	703.97	692.25
XXI	TOTAL MACHINERY, dry	3872.0	3401.48	3495.46
	Water (standard)	111.0	98.37	106.07
XVIII	Water (maximum)	160.0	111.96	135.40
XXII	TOTAL MACHINERY, max	4143.0	3611.81	3736.93

Figure 1.2 Specific weights of machinery.

Boilers. The Essex class ships each had eight boilers, located with two boilers in each of four firerooms. These boilers were Babcock & Cox Co. express-type, water tube, single uptake, divided furnace, air-cased boilers, with separately-fired super heaters, and fitted with economizers. Each boiler had one steam drum, one water drum, and two headers: the side wall header and the water screen header. The division of the firebox was effected by a wall of tubes called the water screen, in which the superheater was located. The water screen consisted of three rows of 2-in. tubes on the saturated side and three rows of 2-in. tubes on the superheater side. Please refer to Figure 3 below.

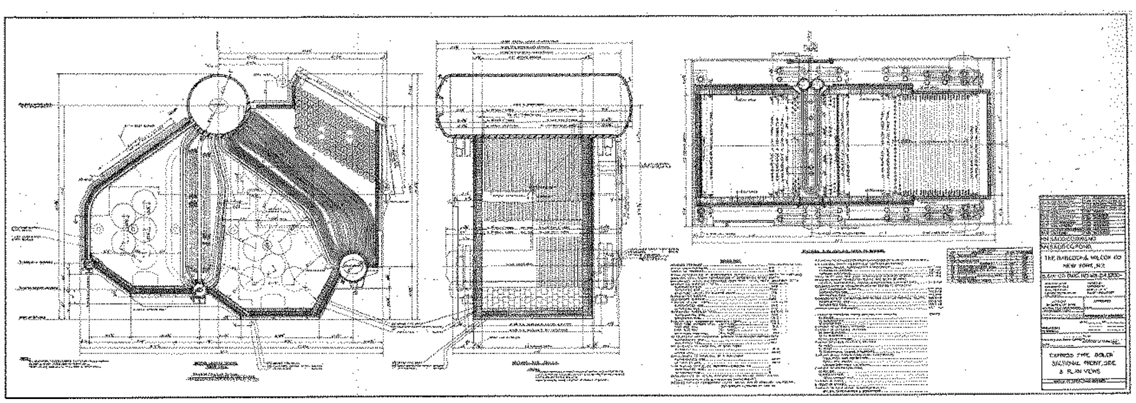

Figure 1.3 Express-type boiler, with sectional, front and plan views, as found on U.S.S. YORKTOWN (CV-10).

The superheater was a three-pass superheater, consisting of 298 U-tubes located in the water screen around the support tubes and superheater support tubes, and between the 2-in. tubes on the saturated side and the 2-in. tubes on the superheater side. The designed steam temperature at the superheater outlet was 850 degrees Fahrenheit.

There were six B&W Carolina type oil burners on the saturated side of each boiler and five on the superheater side. This type of burner was designed for boilers with double flow forced draught, and was intended to provide a relatively free flow of air past the wing burners to those located near the center of the furnace front plate. The burners were of mechanical pressure atomizing type, and were made of two principal parts, the mechanical pressure atomizer and the register. The atomizer was used to break up the liquid fuel into minute particles. The atomizer aided in forcing the oil at a high rotary velocity to the central chamber and breaking it up under the influence of centrifugal force as it emerged through the orifice. The register was a device that introduced air for combustion in such a way that it mingled efficiently with the oil spray.

Please refer to Figure 4 for the boiler data page form the USS Yorktown Engineering Manual.

DESCRIPTION

General:

The boiler plant for each vessel consists of eight B&W Express type, single uptake divided furnace, double cased, oil fired boilers, fitted with integral separately fired superheaters, economizers, soot blowers, and oil burners, all as described below:

Boiler Particulars (each unit):-

Boiler Type	B&W double cased, divided furnace, single uptake express
Boiler Location	Two boilers in each fireroom
Superheater Type	U-bend, three steam passes
Superheater Location	Between water screen tubes adjacent to water cooled stud tube division wall
Superheater Support	Water cooled
Superheater Control	Separately fired
Furnace Type	Divided, partition wall being of water cooled partial stud tube construction.
Economizer	Fin type, fitted with aluminum extended surface.
Economizer Location	In exit gas pass, saturated side only
Oil Burner Type	B&W Carolina
Number of Oil Burners	11 (6 under saturated side and 5 under superheater side)
Sprayer Plate Sizes	4815-D, 4215-D, 3715-D, 3112-D, 2912-D (All sizes dished and rounded)
Soot Blower Type	Diamond Power Specialty Corp., Type G9B and I.H. retractable

BOILER DATA

Designed Pressure	634 lbs. per sq. in.
Steam Drum Pressure	615 lbs. per sq. in.
Operating Pressure	565 lbs. per sq. in.
Boiler Safety Valve, Popping Pressures	644 & 639 lbs. per sq. in.
Reseating Pressures	625 & 620 lbs. per sq. in.
Safety Valve Pilot Actuator on Drum and pilot Actuated Safety Valve on Superheater, Popping Pressures	634 lbs. each
Reseating Pressures	615 lbs. each

Figure 1.4 Boiler data page from Engineering Plant manual aboard U.S.S. YORKTOWN (CV-10).

Two forced draught blowers were directly connected to each of the eight boiler air casings. These blowers discharged air into the air casing that was built around each boiler casing. The blowers were driven by saturated steam drive with seven-bladed propellers. The air intake for these blowers came from the blower intake rooms, located on the starboard side under the island structure. After the air entered the boiler air casing, it was directed by the casing to the front of the boiler and into the Carolina oil burner air doors. The funnel rose over 126-ft. above the boiler furnace floors.

The economizer in the first four ships of the class consisted of 12 elements composed of 1 1/2-in. studded U-tubes and was located in the base of the uptake above the generating tube bank. Feed water entered at the top header and flowed through the elements to the outlet header at the bottom. Hot gases flowed over the external surfaces of the boiler economizer elements, from the bottom to the top. In passing through the boiler economizer element, waste heat from the stack gases raised the temperature of the water to 330 °F.

Each boiler was fitted with eight soot blowers that produced jets of steam that blew soot off the tubes.

The rated working pressure was 615 lb. per sq. in. (psi) and the designed maximum superheater outlet temperature was 850 °F. The boiler production capacity was 153,600 lb. of steam per hour (130,000 lb. superheated plus 23,600 lb. saturated steam). Guaranteed boiler over-all efficiency was 81 .9%. Refer to Figure 5 for a diagram of the main steam system aboard the Yorktown.

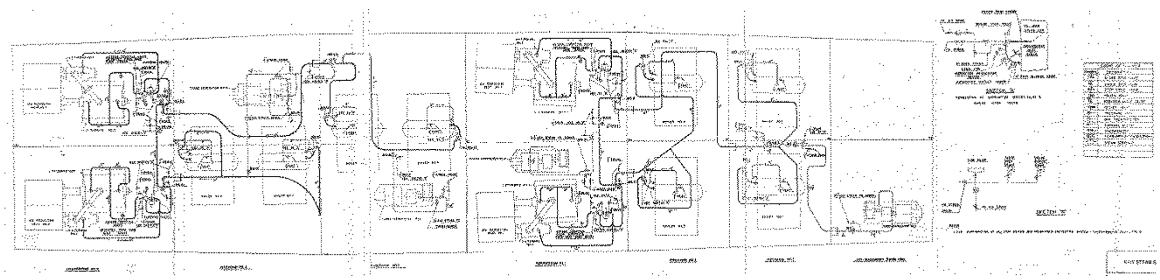

Figure 1.5 Main steam system aboard U.S.S. YORKTOWN (CV-10).

Two main feed (water) pumps were provided for each boiler. An emergency feed pump was provided in each fireroom as well. Each main feed pump could provide 535 gal. per minute (gmp) of fuel, while the emergency unit was limited to 180 gpm.

The boilers for the first four ships of the class were ordered from Babcock & Wilcox as their Job Nos. 1694- 1697, respectively. Heating surfaces per unit measured 5750 sq. ft. for the generating surface of the boiler, 1104 sq. ft. for the superheater, and 3483 sq. ft. for the economizer (total 10337 sq. ft.) The furnace volume was 770 cu. ft. (410 cu. ft. on the saturated side and 360 cu. ft. on the superheater side). Each boiler had outside dimensions over the frame of 11-ft. 9-in. in length and 21-ft. 7-in. wide. Identical boilers followed as Job Nos. 1704-1706 for CV- 13, -14, and -31; Job Nos. 1716-1719 for CV-16 to -19; Job No. 2145 for CV- 21; and Job No. 2212 for CV-20. Job Nos. 2837 through 2846 provided boilers for CV-15 and CV-32 to CV-40, respectively. Job No. 3784 supported CV-46, which was canceled. Job No. 4006 provided boilers for CV-45; Job No 4045 supported CV-47. Commencing with Job No. 2837, the boilers differed slightly from the initial design. The later units had 5720 sq. ft. of boiler heating surface, 1104 sq. ft. superheated area, and only 2341 sq. ft. for the economizer. The furnace volume remained un-changed. Manufacturer's data show the design pressures as 634 psi and the working pressure as 565 psi. The test pressure was 793 psi.

Turbines. The initial four Essex class ships had four sets (four High Pressure and four Low Pressure) of Turbines. The H.P. units were impulse single flow type with one Curtis and ten Rateau stages. The L.P. units were reaction double flow (astern-impulse) type with nine stages each (two Curtis stages each end of the L.P. units). Turbine speed was 5542 RPM (H.P.); 4301 RPM (L.P.); and 3019 RPM (astern).

The high pressure turbines were Westinghouse impulse single flow turbines, consisting of one Curtis element and ten Rateau stages. The Curtis element was a velocity-compound stage consisting of two rows of moving blades attached to the rotor and a row of stationary blades attached to the cylinder. The two rows of Rateau blading were attached to the cylinder. Nozzle diaphragms separated the rows of Rateau blading. This combination of Curtis and Rateau stages was called a pressure-velocity compound/impulse turbine. At full power the turbine turned at 5542 RPM and developed 17,770 SHP. See Figure 6 for the turbine and reduction gear arrangement.

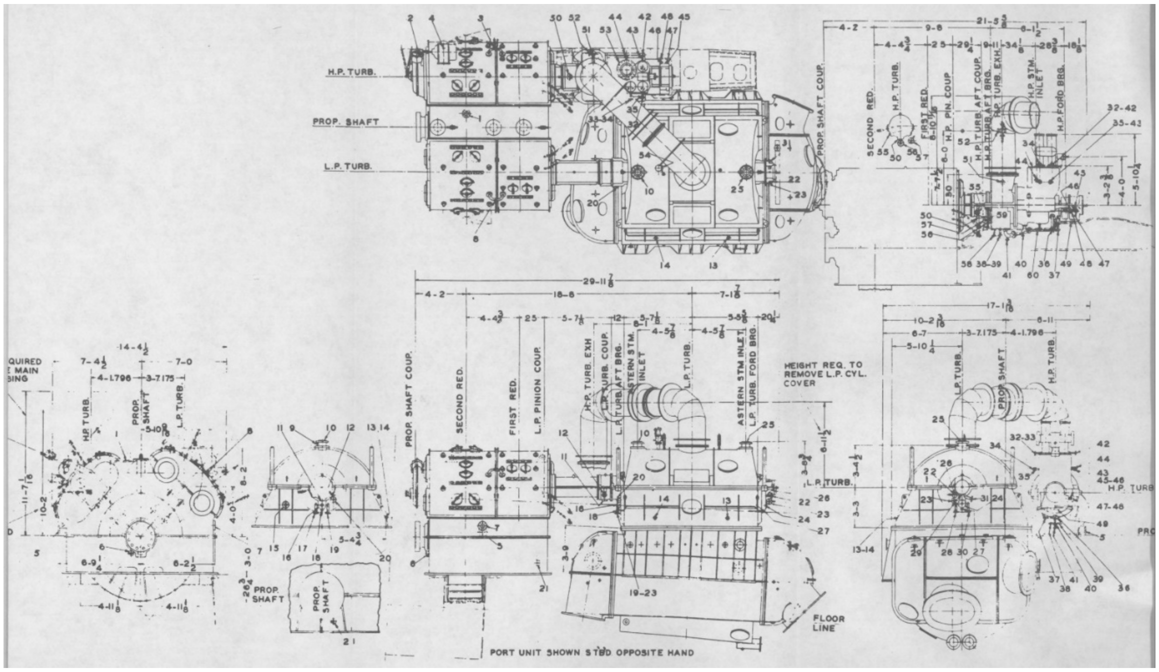

Figure 1.6 Turbines and reduction gear arrangement.

The low pressure turbine was a Westinghouse compound, reaction, double flow turbine consisting of nine rows of reaction blading attached to the turbine cover. At full power this turbine turned at 4301 RPM and developed 19,800 SHP.

The astern turbine, which was designed to operate on saturated steam, consisted of a Westinghouse impulse turbine mounted on each end of the L.P. rotor. The blading consisted of two Curtis stages in series. At normal full speed astern the astern turbine turned at 3019 RPM and developed space 12,000 SHP. Maximum RPM for the shafts in astern operation was 186 turns. The temperatures of main steam and the L.P. turbine had to be watched carefully while backing down. Pressures of 525 psi gage at 825 °F and 1.25 psi back pressure could be maintained for 15 minutes of continuous backing. For periods of longer than 15 minutes, the steam temperature had to be reduced to 675 °F. Backing could continue for a further 45 minutes at the lower temperature. For astern operations of greater than one hour, the speed of the turbines had to be reduced to avoid overheating the ahead sections of the blading.

Initial design work by General Electric indicated that separate astern turbines would be needed to produce the 12,000 SHP power sought. These studies had suggested that adding astern elements to the L.P. turbines would increase the length of these units to such an extent that they would not fit safely within the available space. The company agreed to investigate reducing ahead stages to accommodate astern elements in the same L.P. unit, which eventually proved possible. Provision was made for the installation of cruising turbines.

Reduction Gears. There were four double reduction gears of Falk-Westinghouse design. Each unit was of the locked-train type with double-helical cut gears. The main shaft thrust bearing (Kingsbury) was located in the gear housing, which was installed over the lubricating sump for the unit. The turbines were connected to the reduction gear with flexible couplings and quill shafts. Each turbine and reduction gear was lubricated from a common system, consisting of a cooler and two steam-driven lubricating oil service pumps.

At normal full power, approximately 525 gallons of lubricating oil was required per minute for proper lubrication of each turbine and gear unit. The oil was circulated through each turbine and gear unit under pressure and reused. Oil pumps took suction from sump tanks and pumped the oil under pressure through strainers and coolers to the various bearings of the main turbines and reduction gear. Roughly 350 gallons of oil typically would be found in the piping and coolers of each unit at any time. After passing through the system, the oil drained into sump tanks in the ship's structure under each main reduction gear. Each sump tank held 1,050 gallons of oil at normal operating level. Strict limits were placed on lubricating oil temperature.

Each main propulsion plant had three lubricating oil pumps; one turbine-driven, one motor driven, and the third driven by a chain and sprocket arrangement from the propeller shaft. The normal oil supply was provided by the chain drive pump, with the turbine driven pump in rolling standby status. The motor-driven pump served as an emergency backup. At speeds below 12 knots and when the ship was backing down, the turbine pump was the main oil supply source, As the ship's speed increased, the chain pump would deliver more oil to the engine than required. An automatic dump valve returned the excess quantity to the sump. An automatic cut-in would bring the motor-driven pump into service in event of failure of both the chain and turbine pumps, keeping the lubrication oil pressure within necessary levels.

Lubricating oil passed through duplex type, magnetic basket strainers upon leaving the pump, preventing foreign matter from being passed into the engines. There also was a 1500-gallon lubricating oil settling tank in each engine room, where lubricating oil could be pumped from the system. The settling tanks were used to pass oil to purifiers for use to renovate oil for continued use. The purifier was designed to operate continuously while the ship was underway, alternating between sumps. Its capacity was 225 gallons per hour when the oil temperature feed was 130 °F. There were also three 500-gallon lubricating oil storage tanks in each engine room.

Main Condenser. Each propulsion unit had one main condenser located under the L.P. turbine. These main condensers were single-pass, straight tube type units, with the tubes arranged in two banks with a wide wedge-shaped steam access lane between them. The condenser consisted of 7,213 tubes, each of 5/8- in. outside diameter, rolled on the inlet end and packed on the outlet end. Cooling water was supplied to the condenser through either of two valve injection pipes. Cooling water was supplied for standby, backing, or slow ahead speeds (10 knots or less) by a main circulating pump installed in one injector pipe. The second injection pipe was fitted with a scoop and a flapper check valve through of which cooling water from the sea was forced through the condenser.

The main circulating pumps were large, vertical impeller type pumps, driven by a single-stage steam turbine designed for 600 psi saturated steam and a single reduction helical gear. Each main circulating pump had a rated maximum capacity of 30,000 gal. per minute. Boiler feed water had to pass specific chemical standards to provide desired steam conditions. Properties of alkalinity/Phenolphthalein, hardness, Chloride, and conductivity would be measured regularly for this purpose. Feed water suitability criteria varied according to the stage of the steam cycle; for example evaporator distillate, makeup feed water, and condensate feed water all had differing standards to meet.

Shafting. The total length of inboard shafting was 185-ft 7 5/8-in and outboard shafting totaled 257 ft. 9 5/32-in. in length. Each shaft was comprised of several segments, a minimum length of approximately 19-ft. long to a maximum length of 45-ft. 4-in. for the final propeller shaft unit.

Propellers. There were four propellers, two right hand (to starboard) and two left hand (to port). They were solid 4-blade units with 14-ft. 7-in. diameter and a designed pitch of 15-ft. 3 1/2-in. They had a projected area of 99.42 sq. ft. and a developed area of 116.34 sq. ft. The immersion of the centerline of the hub was 19.33-ft. at designed trial draught. They weighed approximately 27,190-lb.

A three-shaft power plant was considered during the design process. The Taylor Model Basin (TMB) reported on 29 Feb. 1940 on the tests of a model examining power requirements for a three-shaft ship. The TMB found that "the three-screw arrangement can be used to advantage if the power per shaft is not too large and if the RPMs can be reduced, and if the projection of the center screw below the baseline can be accepted." Increased ship size later made adoption of a four-shaft arrangement necessary.

Initial Trials and Inspections. The Essex underwent builder's dock trials of main propelling and auxiliary machinery without casualties on 10 and 11 December 1942. The U.S. Navy Board of Inspection and Survey (INSURV) conducted an inspection and witnessed dock trials of the Essex at Newport News on 23 Dec. 1942. The INSURV Board found that "all trials were satisfactorily completed except as noted. Trials included operation of #1 and #4 main engines ahead at 140 rpm, #2 and #3 main engines ahead at 100 rpm, and of all main engines astern at 88 rpm. Main engine auxiliaries were operated as necessary during these trials. Excessive gland leakage was discovered at the forward end of #1 H.P. turbine and #3 L.P. turbine. Considerable steam leakage also occurred at the forward end of #4 H.P. turbine, with efforts to locate the source being unsuccessful." The Board thought a very bad gland leak or even a pipe joint leak concealed by lagging might be present. Overall, however, the Board was pleased: "On 31 December 1942 (the prospective delivery date) only slightly over twenty months will have elapsed since keel-laying, which is, in the opinion of the Board a record worthy of commendation. This indicates a high degree of co-operation between the Supervisor of Shipbuilding, the Newport News Shipbuilding and Dry Dock Company, and representatives of the officers and men of the ship's company."

Sea Trials. Contract requirements for the Essex were that the ship generate 150,000 SHP, 265 RPM and an estimated speed of 32.65 knots at 34,600 tons displacement. The ship called at Annapolis Roads on Friday, 26 Feb. 1943 to embark observers for sea trials and also to provide an opportunity for Washington, D.C.-based design personnel to visit the ship. Essex departed Annapolis on 28 February for trials. The most thorough report on these initial sea trials of the lead ship, Essex (CV-9), is provided in a "Memorandum Report of Travel" prepared by Capt. B. P. Ward USN , dated 1 March 1943.

The full text of that report follows:

"l. The data presented below were obtained during the full power trial run from 1500 to 1700, March 2, 1943. The average number of R.P.M. made by the four propeller shafts was 275.2. This speed was made with engine throttles wide open, but with additional boiler capacity still available. During the two hours of the run, the forward firerooms furnishing steam for the outboard shafts, consumed 12,180 gallons of oil, and the after firerooms, furnishing steam for the inboard shafts, used 13,200 gallons of oil. All eight boilers maintained steam drum pressure of 600 to 610 pounds, and all four engines received steam of substantially identical pressure and temperature. Condenser vacuum was also in close agreement for all engines, the average of which was 28.2. The barometer read 30.05 at 1500, and 29.91 at 1700. The pitometer log read 33.4 knots at 1500, 31.9 at 1600, and 32.5 at 1700. The pitometer log has not been calibrated. The maximum speed of the Essex, during the run, as reported by escorting destroyers was 34.2 knots.

2. The individual shaft horsepowers were measured by Siemens McNab torsion meters; the torsion meter results of shaft No. 3 are subject to question.

Listed below are the results for operation between 1500 and 1700:

SHAFT NO.	**1**	**2**	**3**	**4**
R.P.M.	277.5	273.7	273.7	275.9
S.H.P.	36,520	38,233	35,530	37,650
PRESSURE AT THROTTLE	530	528	525	540
TEMPERATURE AT THROTTLE	832	831	831	825
THROTTLE	832	831	831	825
OIL BURNED FOR TWO HOURS	5,730	6,440	6,780	6,450

3. The S.H.P. for the two outboard shafts are in fair agreement with each other. The inboard shafts, 2 and 3, though of identical R .P.M. do not agree on S.H.P. by about 8% which is considered excessive. Owing to the fact that the inboard and outboard propellers are identical, it is expected that the inboard shafts, at a given speed, will develop slightly more power than the outboard, because of the wake. This is further borne out by reference to paragraph 2 in which the oil consumption for the boilers supplying the inboard engines is higher than that for the outboard. Therefore, the low S.H.P. indicated above for shaft number 3 is probably incorrect.

If for the above S.H.P. for shaft number 3, that of shaft 2 is substituted, the ship's total S.H.P. is 150,636. The shafts were dragged on return to port for a check on zero readings, all of which were almost identical with the original, except for No. 1, which if accepted in preference to the original would increase its S.H.P. by about 1500.

4. There are several factors which enter into the accuracy of S.H.P. determination of this run. Torsion meter zero readings are usually determined just before and after being used; military conditions do not permit this procedure during wartime as it requires stopping the ship. During peacetime, shafting was calibrated for torsion, and its inside and outside diameters accurately calipered before its installation in the ship; expediting construction did not permit use of this additional time and labor for calibration in this case. Torsion meters did not have a wide reputation for good accuracy. A Westinghouse official in 1940 stated to Bureau officials "that as a result of recent trials it was evident that shaft horse power determinations by means of torsion meters could be inaccurate to an amount as much as 20%". A Newport News engineer stated "that no torsion meter that they had had any experience with was accurate within 5%". "Memorandum of Conference" held 15 July 1940 on CV9 main propulsion machinery, copy in Box 773, folder CV9 c1ass/S1-6 v.1.

5. The S.H.P.-R.P.M. curve determined on this run at a displacement of 34,600 tons lies between the clean bottom and overload Model Basin curves. It coincides almost exactly with the overload curve, Test 5, up to 30 knots. Above 30 knots the curve more closely approaches the clean bottom curve, Test 6, and coincides exactly at 275 R .P.M. and 150,000 S.H.P. It is considered that the designed shaft horsepower was met without margin.

6. Two runs were made with four and six boilers, respectively, on the main steam line to determine the J speed attainable with the boilers loaded to 120% of their designed rating. The first arrangement resulted in a ship speed of 27.5 knots and the second 31 knots.

7. The over speed control valves had operated unsatisfactorily since commissioning. The bonnet flange on the main valve leaked and the oil cylinder was so poorly machined that four men were required to operate the valve manually. Repairs were completed prior to getting underway for these trials. All previous operation underway had been held under the saturated steam condition in Chesapeake Bay. Operation under superheat conditions during the trials resulted in no leakage. The valves, however, will be changed from over speed control to manually operated valves and tightness of the bonnet flange ensured during the next Navy Yard availability period.

8. In general, the vibration of the ship at all speeds is considered satisfactory, as the fighting efficiency is not materially impaired by any vibration, except possibly the vibration of certain equipment in Radio III which is susceptible to local correction. The vibration of 5" guns No. 6 and No. 8 and 40-mm mounts No. 7 and No. 8, with their directors, is such as to make operation of these guns under director control difficult at high speeds, but probably not sufficient to prevent such operation. The only remedy for this condition is modification of the mounts themselves. No alteration to the foundations could materially improve conditions."

9. As usual, the frequency of the vibration is that of the propeller blades, i.e., four times per revolution. No other frequencies were observed anywhere. The principal locations and the amplitudes are as follows:

a. In the forward engine room, a longitudinal resonance was observed at about 140 R.P.M. with a maximum amplitude at the gear case of plus to minus 5 mils.

b. In the after engine space the longitudinal resonance appeared at 180 RPM with a maximum amplitude of plus 10 to minus 10 mils.

c. All other machinery in the engine spaces did not vibrate except for two steam pipes and an electrical switchboard, which were permanently braced by the ship's force during the trial, which resulted in a complete cure.

d. In the forward 5-in. director there was a slight vibration in the optical range finder, which did not interfere with proper operation. The radar antenna was steady. The radar train indicator box mounted on rubber shock absorbers came to resonance at about 185 propeller RPMs.

e. The after 5-in, director was generally quieter than the forward one. One gun, the radar train indicator box, and the Johnson rod vibrated badly.

Additional technical data on the 2 March 1943 trials was provided to the Bureau of Ships in 2 page forms submitted on results for the two-hour full power run; the "two hour 25-knot steady run"; the "two-hour 30 knot steady run"; the "4 boiler overload run"; and the "6-hour boiler overload run". The ship's draft was recorded at 26-ft 9-in. forward, 27-ft 9-in. aft and mean draft of 27-ft 3-in. at the start of the trials.

The corresponding displacement was stated to be 34.342 tons. The ship was 45 days out of drydock. Strong (Force 7) winds from astern and a heavy swell (Force 5) prevailed.

For the two-hour full power run, the average RPM made was 273.4 with speed through the water being stated as 32.2 knots average. Notes state, however, that this speed was estimated on the basis of an uncalibrated pitometer log. The ship was also unable to determine speed via navigational measurements. It was stated that "At full power, signal received from last of escorting destroyers to fall behind indicated ship making speed of 34.2 knots." Fuel used was an average of 394 gallons per mile.

Sustained full power astern continued to be an operational requirement even after the arresting gear forward was ordered to be removed. For example, Randolph's 1945 shakedown cruise included a rigorous trial of quick reversal and back down capability:

"While making 31 knots (245 RPM) with eight boilers on the line and superheat at 825 degrees (F), full astern was given to test the quick reversal ability of the ship from full power ahead. Astern operation was continued for one hour, making 186 RPM. After 15 minutes of going astern the superheat was lowered to 675 deg. F. Throughout the run the temperature of the H.P. turbine rose slowly while the L.P. turbine temperature dropped slowly. At no time during the operation did the temperature of any H.P. turbine exceed 780 deg. (F), or of any L.P. turbine exceed 350 deg. (F)… No bearing or shaft packing boxes ran hot. After running full power astern for one hour full speed ahead was given for the second quick reversal test. The ship was subjected to more vibration at this test than when going full astern from full ahead. All machinery operated very satisfactorily during tests."

Some initial evidence of sea keeping qualities came soon after the first ship of the class went to sea. The commanding officer, Essex, sent a letter to the Bureau of Ships on 21 April 1943 that reported on initial sea keeping observations. Extracts from that letter follow:

"1. During the recent shakedown cruise of the Essex no extremely rough weather was encountered. However, the weather on occasion was sufficiently bad to get some indication of what may be expected under more severe weather conditions . . .

a. In a moderate sea with steady wind s of some 30 to 35 knots the ship rolled easily and comfortably with the sea on the quarter.

b. With the sea ahead the ship pounded rather heavily and the shape of the bow caused heavy spray to be thrown up into the overhang of the flight deck on each side forward at speeds of from 18 to 20 knots. This resulted in carrying away the catwalk under the flight deck on either side of the forecastle and also resulted in carrying away three life raft racks under the gallery walkway. These items should be strengthened.

c. With the sea on the port bow the ship pounded heavily due to the seas striking the hangar deck catapult sponson which projects from the port side of the hangar deck forward. The effect of this pounding was quite severe, shaking the whole ship rather violently. This sponson is now being removed from the Essex inasmuch as no hangar deck catapult is to be provided. It is believed that in heavy weather this sponson would be severely damaged and in the process other parts of the ship would suffer also from the resultant vibration.

2. The effect of lightness of construction is quite evident when the ship pounds in a seaway. A severe pounding causes the entire flight deck and island structure to rock back and forth for an appreciable interval of time after each shock. The expansion joints in the flight deck can be observed working with the hogging and sagging of the ship. The amount of this working at the flight deck level has been observed to be as much as one inch at each joint. No misalignment of elevators or essential installations was noted. Cracks, however, in the shell plating at the lower ends of the expansion joints have developed.

3. The lack of rigidity of the flight deck and island structure appears to be quite marked in comparison with both the Yorktown and Lexington class carriers. Remarks made by BuShips personnel on this letter provide some clarification of one issue. The cracks reported in "shell plating" were understood to have occurred in the light, 5 lb. per sq. ft. curtain plating in way of the expansion joints. One comment noted the need for a long taper on the entry to the sponsons on the hull sides of the new CVB-41 class ships then being designed.

Following up on the Essex letter, a team of people traveled to Norfolk, NY to visit Essex to evaluate these potential problems. Mr. J. P. Comstock, a Newport News naval architect, accompanied by a Mr. Cresko of the Newport News Hull Technical Department and a Mr. Furguson of the SupShip Newport News office visited Essex on 15 April 1943. No major damage was found. All four expansion joints at the corners of the island (midship) section of the flight deck were cracked. At the starboard after joint one crack extended approximately 30 inches forward, and included the stiffener on the forward side of the joint. In no case was the sheer strake cracked.

One curious detail was noted as follows: "The "plume" of water thrown up by the bow is phosphorescent under suitable conditions and was reported by an accompanying vessel to be the only visible feature of the vessel to a surface vessel under darken ship conditions. This is considered a source of danger."

Typhoons proved the undoing of some ship structure in Essex class vessels. The following assessment is provided by Mr. Arthur S. Bussey (BuShips Code 633) in a classic 1951 paper delivered to the Chesapeake Section of the Society of Naval Architects and Marine Engineers (SNAME):

"In earlier vessels of the CV9 class the flight deck is cantilevered out 23 feet forward of the first transverse bent at Frame 1, the flight deck extending six feet forward of the foremost part of the forecastle deck. In later vessels of the class a clipper bow is fitted and the forward end of the flight deck is cut back. In the later vessels, the flight deck is cantilevered out twelve feet forward of the first transverse bent at Frame 1, the forward part of the flight deck being located twenty feet aft of the foremost part of the forecastle deck.

Major structural failures of the flight deck overhang forward of the first transverse bent were sustained by three vessels of the class, the Hornet (CV 12), the Wasp (CV18), and the Bennington (CV20), as a result of green water coming aboard in typhoon weather. All of these vessels have the original bow and flight deck arrangement…

As a result of these failures, the strength of the forward overhang of the flight deck in vessels of the class with the original bow arrangement was increased by the installation of doublers on the top and bottom flanges of the longitudinal girders supporting the flight deck and the installation of additional longitudinal and vertical stiffeners on the webs of these girders. In vessels with the modified bow, stanchions were installed under the flight deck at its forward end, in addition to the above stiffening."

Auxiliary Machinery.

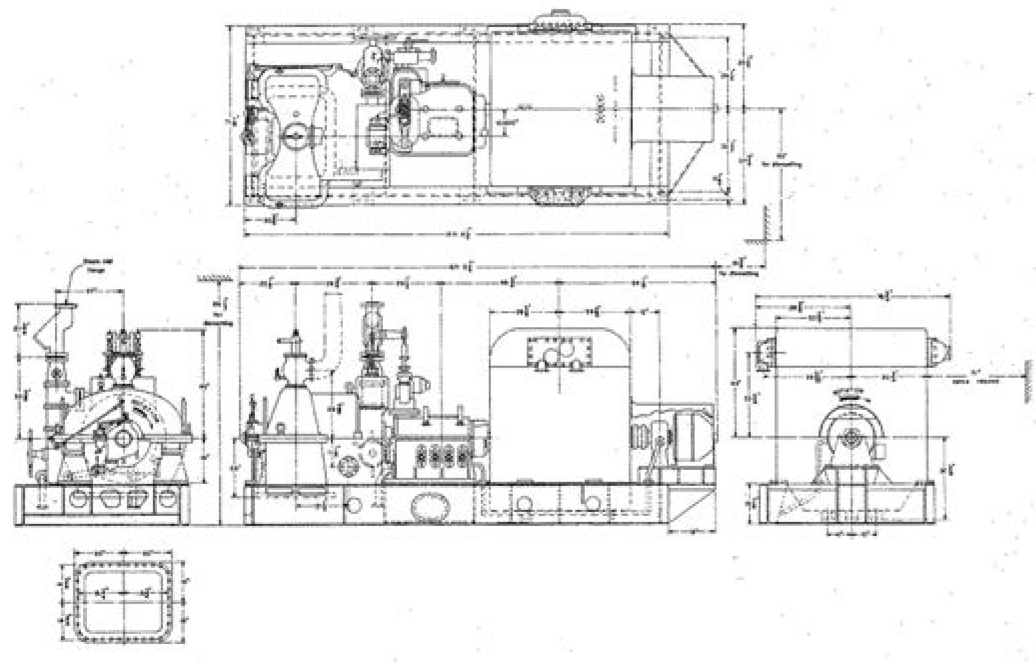

Figure 1.7 Outline Dimensions of Turbine-generator set.

Essex-class carriers had four General Electric impulse type turbo-generators. The turbine elements were designed to operate on steam at a throttle pressure of 525 psi gauge with 825 degrees total temperature or 575 psi gauge with saturated steam and an exhaust pressure of 1 psi absolute. The normal operating speed of the turbine was 7,938 RPM. The turbines were of straight impulse type. Steam entered through a strainer and in sequence passed through the throttle valve, the controlling valve, and the first-stage nozzles. The steam expanded in ten successive stages from main pressure to final, or condenser, pressure.

The turbines could be operated either on main or 600psi auxiliary steam. The piping was arranged so that each generator took its steam from a separate fireroom during battle conditions. The turbo-generators were intended to be operated on superheated steam, but also could be operated on saturated steam in the event of damage or repairs to piping. Typically, three were operated while underway and two while in port.

The associated General Electric ATB-2 type electrical A.C. generators had D.C. exciters. Rated at 1250 KW output, 80% power factor, the generators were three-phase, 60 Hz cycle, 450 Volt AC, 1563 KVA units. The original design concept called for 1,000 KW units, but an increased output was approved during detail design in July 1940.

There were two diesel generators, one forward and one aft. These units had Cooper-Bessemer Corp. 6-cyl., 900 RPM diesels. The generators were General Electric AT 1 type A.C. units with D.C. exciters, 450 Volt, 60 Hz cycle, 3-phase, 312 KVA. They were rated at 250 KW output. Fleet units soon complained about the constraints of the emergency electrical power generating system. In a memorandum dated 22 July 1943, Yorktown's commanding officer stated "It can readily be seen that the estimated minimum battle load is equal to the rating of the generators both forward and aft.

Yorktown calculated minimum emergency battle load as follows:

Estimated Connected Load (amps)

Drainage Pumps	160
Fire Room and Engine Room Ventilation	200
Main Condensate	140
Main Feed Booster	99
Auxiliary Machinery Cooling Water	73
Main Lube Oil	254
Fire Pumps	912
H.P. Air Compressors	123
Lighting Above 3rd Deck	200

From this it is evident that the equivalent of a total of five 250 KW diesel generators are required as a minimum for this ship in order to supply sufficient emergency power for battle."

In fact, Yorktown's commanding officer was applying a far more demanding task to the emergency power system - supporting the main propulsion plant-than the designers had anticipated. In the General Board hearing of 18 Jan. 1940 on CV-9 class design, Capt. J. M. Irish of the Bureau of Engineering recommended that the formal statement of design characteristics be revised to add "emergency diesel generator capacity sufficient to supply the anti-aircraft battery.

The fuel oil transfer main consisted of two parallel systems, one starboard and one port, extending almost the length of the ship. The main was divided into sections by valves, and the two parallel sides were connected together in four places by athwartships double cross-connections. In general, the system was designed so that fuel oil could be taken from any tank and discharged into any other tank, provided that the tanks were not in the same group.

There were eight fuel oil filling risers to the main deck, four port and four starboard. The fuel oil service system delivered fuel to the boilers. There were two fuel oil service pumps in each fireroom driven by 600 psi auxiliary steam. There was no cross connection between fuel oil service pumps in different firerooms.

The auxiliary machinery also included two Westinghouse 125 KW ship's service motor generators, one in the forward auxiliary machinery space and a second in No. 4 machinery room. These supported the internal degaussing installation. The original design included two General Electric 36-in. searchlights, two G.E. 24-in. searchlights, and two G.E. 12-in. searchlights.

Steaming Endurance. The rated endurance at time of delivery was 17,250 miles at 15 knots cruising speed. The Ship’s Characteristics Card for Bunker Hill, dated 20 July 1946, listed 4,650 miles at maximum sustained sea speed (32.5 knots) 10,300 miles at 75% power; and 16,000 miles at economical speed (14 knots).

Class steaming "performance curves" are published with this article. These data reflect standardization and fuel economy trials undertaken by Philippine Sea (CV-47) during 24 to 28 June 1947. Data were taken for two ship load conditions during the trial, 34,600 tons and 36,460 tons.

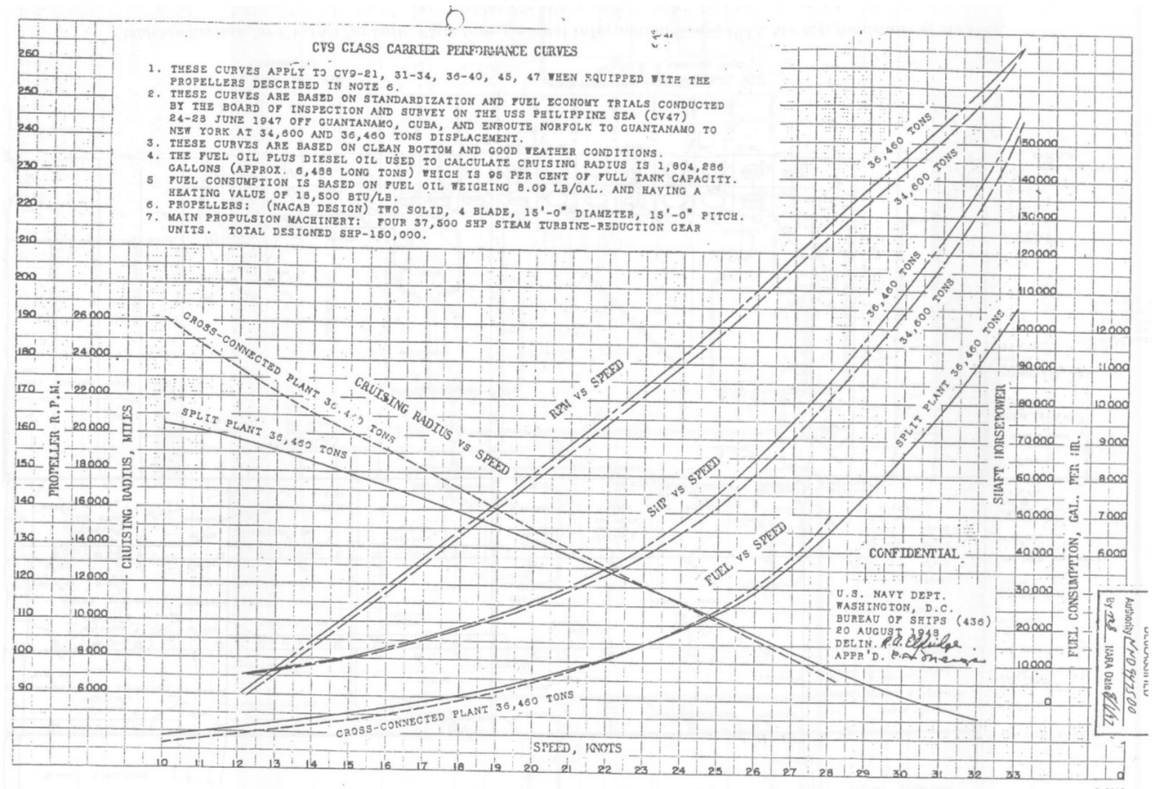

Figure 1.8 Essex class "Performance Curves" showing fuel consumption. Bureau of Ships compilation dated 20 August 1948 reflecting class performance with solid, four blade, 15-ft diameter propellers, clean bottom, and good weather conditions. Fuel assumed to be about 6,448 tons (95% of full tank capacity).

Part of the discrepancy between actual sea trials and model predictions was attributed to the ship's greater displacement (600 tons) and 10 inches trim by the stern on the ship.

A late-war evaluation praised Essex class maneuverability:

"These classes (CV-6 & CV-9) have excellent maneuverability, although not quite as good as some of the newer BBs. They readily maneuver on a 1000-yard tactical diameter. The limiting factor for turning radius of these classes is usually the angle of heel induced by the rudder angle. Normally a list of more than 8 degrees is most undesirable, due to the large amount of gear on deck not permanently secured… The CV9 class vessels have good acceleration and deceleration characteristics, but are usually the limiting type when operating in groups composed of the newer types of BBs, CAs, etc. . . ."

Tactical Diameter. The ship's tactical diameter was taken as 2.74 ship lengths (750 yards) at 28.6 knots. Initial sea trials data for the class was obtained from trials conducted with Intrepid (CV-11). Interestingly, the ship proved rather handier than an earlier model used in Taylor Model Basin predictions.

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USS YORKTOWN
MAINTENANCE PLAN

The extreme size of this vessel mandates that a Maintenance Plan be established to assist the vessel's caretakers in the long term planning and care of this historic vessel. The idea of establishing a Maintenance Plan has a long precedent and allows the caretakers the tools needed to properly plan for the different cycles that will be required through the long anticipated life of this ship as a Museum. .

This document is general in nature, and provides information common to many vessels of the same age and condition as the USS Yorktown; as such, it may be useful in the development and execution of a meaningful ongoing maintenance program.

1. Project Planning

Every sound historic vessel preservation project should begin with a plan; a well thought out, detailed, written plan for preservation treatment that addresses and takes into account the following:

- The historical significance of the vessel, and degree of historic integrity it possesses

- The availability of information that might be required for preservation treatment, such as original construction, changes made during the life of the vessel, etc.

- The physical condition of the vessel, as determined by a competent surveyor

- The environment in which the vessel is to be preserved, and the projected effect of that environment on the vessel

- The intended use of the vessel, and the projected effect of that use on the historic integrity of the vessel

- The work required to implement the proposed treatment, and the sequence in which the work will be performed

- The availability of suitable materials, equipment, and technology to successfully carry out the project

- The availability of competent personnel with the requisite skills and expertise to perform the work

- The availability of a suitable site for carrying out the proposed treatment

- The cost of the proposed treatment, and the source and availability of funding to complete the work.

- Developing, whenever possible, plans for the preservation, maintenance, and compatible use of the vessel.

- Determining through the services of a competent professional marine surveyor experienced with the type of vessel under consideration, the existing condition of the vessel, the extent of work required to implement the proposed treatment plan, the feasibility of the project, and the projected cost.

- Ensuring that adequate funds are available, or can be obtained, to achieve the proposed treatment objective and to maintain the vessel thereafter.
- Ensuring the availability of competent staff with the requisite skills to manage and carry out the project.

Implementation of such a plan is time-consuming and expensive. But it is a vital element in any responsible, long term project.[1]

Documentation

Documentation is the most easily overlooked aspect of a historic vessel preservation project, yet it is arguably the most important.

Timely, complete documentation is vital for three reasons. First, there is always a possibility of partial or total loss of the vessel through fire, collision, mismanagement, neglect, vandalism, etc. If loss should occur, the information collected in the documentation process may be the only surviving record of what once existed.

Second, even if the vessel is successfully preserved, it will never be exactly the same as when built, or when acquired for preservation. Thorough documentation of changes made to the vessel will help to create a better understanding of the vessel as it is in the present and as it evolves in the future.

Finally, documentation of work performed during preservation treatment, including maintenance, material renewals, etc., is useful in the planning and carrying out of later work.

Documentation should begin with the earliest stages of project planning, and should continue throughout the process. All available information about the vessel's history, construction, and significance should be researched and recorded, and records should be kept of all preservation and maintenance work performed. Before any preservation treatment is undertaken, however, the vessel should be regarded as primary physical evidence to be recorded in detail. Duplicate copies of the collected body of records, suitably organized, should be carefully protected and stored in separate locations.[2]
It is recommended that the Museum obtain all of the publications and ship construction drawings while they still exist. They are stored at various U.S. Navy and non-profit museums and are easily obtained.

Stabilization

In every vessel, the process of decay begins even before construction is complete. Wood rots. Steel, bronze, and aluminum oxidize and corrode. Deterioration is continuous, exacerbated by exposure, the rigors of use, and the harsh marine environment. By the time preservation is considered, much or all of a historic vessel's fabric is likely to have been affected--sometimes severely--by deterioration.

After the physical form, configuration, and condition of a historic vessel at the time of acquisition have been thoroughly documented, measures should be undertaken to stabilize the vessel. Measures include steps to arrest rot and corrosion, to stop leaks, to reinforce or repair structural members, to ventilate and dry out interior spaces,

[1] The Secretary of the Interior's *'Standards for Historic Vessel Preservation Projects'*. Department of the Interior, National Park Service.
[2] Ibid.

etc.-in short, to halt the deterioration process to the greatest possible degree. This work should be undertaken before the ultimate preservation treatment planned for the vessel is begun.

Stabilization, accompanied and followed by comprehensive maintenance, "buys time" for completion of the preservation process. Too often, stabilization measures at the beginning of a preservation project are either inadequate or non-existent. This almost inevitably results in expensive and time-consuming preservation work having to be redone later. It could even result in loss of the vessel.

Preservation, Restoration, and Rehabilitation

Only after a solid preservation plan has been developed, based on sound knowledge of the vessel's condition, extensive research, thorough consideration and assessment of available technical, material, and economic resources, etc.; only after the vessel has been extensively documented as acquired; and only after stabilization measures have been implemented--only then should work begin on the preservation treatment selected for the vessel.

Whether the chosen treatment is preservation of the vessel as acquired, rehabilitation for a new use, or restoration, good historic preservation practice demands that the preservationist adhere to one basic precept in all work undertaken: to retain and preserve to the greatest extent possible the historic form and fabric of the vessel.

Preservation is the ultimate treatment in any historic vessel preservation project, and it is the most straightforward in theory and in practice.

Restoration should be undertaken only if there is sufficient detailed historical information about the vessel on which to base the restoration work. Selection of the time or period in a vessel's career to be represented by the restoration should be done only after careful consideration of the effects of the restoration on historic fabric from other, possibly more significant, periods in the life of the vessel.

Rehabilitation because it normally requires more extensive changes to historic fabric and departures from historic methods of construction than other treatments, should be undertaken only after preservation and restoration have been considered as alternatives. Whenever possible, historic fabric should be retained; changes or additions required by the rehabilitation should be reversible, and should be made with the least possible disruption of historic form or fabric.

A vessel might be preserved exactly as found or acquired, or it might be preserved as it has evolved through restoration or rehabilitation.

Developing, whenever possible, plans for the preservation, maintenance, and compatible use of the vessel. Determining through the services of a competent professional marine surveyor experienced with the type of vessel under consideration, the existing condition of the vessel, the extent of work required to implement the proposed treatment plan, the feasibility of the project, and the projected cost.

Ensuring that adequate funds are available, or can be obtained, to achieve the proposed treatment objective and to maintain the vessel thereafter.

Ensuring the availability of competent staff with the requisite skills to manage and carry out the project. Obtaining, in cases where adequate funds for purchase are not on hand, legal option to purchase title to the vessel for a period sufficient to secure required funding and/or to develop a preservation plan.

Preservation Maintenance

Preservation is an unending process and is the single most demanding task of all Museum ship maintenance teams. After the treatment goal selected for a vessel is achieved, every effort must be made to maintain the vessel in its preserved state. This involves regular, thorough inspections of the vessel; "housekeeping" measures such as cleaning; routine maintenance such as tightening, adjusting, lubricating, paint touchup, etc.; cyclic maintenance such as refinishing, material renewal and repair, etc.; and ongoing stabilization and emergency work as required.[3] Developing, whenever possible, plans for the preservation, maintenance, and compatible use of the vessel.

Determining through the services of a competent professional marine surveyor experienced with the type of vessel under consideration, the existing condition of the vessel, the extent of work required to implement the proposed treatment plan, the feasibility of the project, and the projected cost.

Ensuring that adequate funds are available, or can be obtained, to achieve the proposed treatment objective and to maintain the vessel thereafter.

Ensuring the availability of competent staff with the requisite skills to manage and carry out the project.

Maintenance Team

To ensure the proper long term longevity of the vessel and to ensure that ongoing repairs are completed in a timely and safe manner, a dedicated, full-time maintenance team will be required for this ship. Given the experience of other historic ships, typically aircraft carrier (MIDWAY, INTREPID) museums have one (1) full-time Engineer/Shipboard manager and ten (10) full time maintenance personnel (highly skilled and trained in their particular fields) as the minimum number of personnel required to carry out the Plan*.

*NOTE: Existing staff personnel at Patriots Point are extremely talented in many different fields aboard YORKTOWN. The job descriptions are only provided as a guide for HR purposes.

It is suggested that the following skill sets and their qualifications be as follows:

One Ship Engineer*
Two Journeyman Electricians,
One Journeyman Plumber,
Two Journeyman Carpenters,
Three Painters
One Welder
One Hull Technician (ship fitter)

Ship's Engineer

Job Description

[3] Ibid.

This position requires a Bachelor's degree in the appropriate naval architecture (NA) or engineering discipline from an ABET accredited school of engineering, and 5 or more years of specialized engineering experience, including 2 or more years at the Engineer II level. A candidate must be able to apply a thorough understanding of engineering/design specifications, and engineering principles and methods, to perform engineering analysis and resolve engineering problems of significant complexity. A comprehensive knowledge of engineering analysis and design applications programs as well as developed analytical, problem-solving, conceptual, and general project management and communications skills is required. May require the ability to physically access a wide variety of work sites aboard ship under various stages of construction or overhaul, including the use of vertical and inclined ladders, and may involve limited kneeling, stooping, standing, etc. Assignments generally involve complex engineering tasks and issues, and may often involve new product design, systems integration, process reengineering, etc., and requiring developed expertise in both engineering and business processes. Incumbent performs the following:

Designs systems, components, structures, and processes. Capture and analyzes technical and management requirements, and defines detailed design requirements, with understanding of available technologies, impact on business processes, engineering standards, and the efficiencies and attributes of quality engineering processes and products. Evaluates performance and life-cycle operational requirements, and develops engineering design to meet the Museum's requirements. Prepares layouts and specifications; reviews design proposals and drawings; and assures that specifications meet performance requirements. Develops technical specifications, requisition and bid documents, inspection and testing requirements. Analyzes and resolves design and productivity issues.

Evaluates and prepares testing and training program policies and procedures to effectively test and control ship systems and components; ensuring successful integration of the test program with production activities. Plans and prepares test procedures, which contain testing instructions, requirements, and sequences, ensuring compliance with contract specifications, military specifications, system diagrams, equipment drawings, etc. Writes or revises test policies and procedures to control testing and system operations. Directs shipboard testing performed by hourly or salaried Museum staff. Monitors the performance of tests and identifies and resolves system operational issues. Analyzes test data and determines operational conditions and design appropriateness. Works collaboratively with outside design engineers to resolve design issues.

Provides on-site resolution of engineering problems encountered during conversion of ship to Museum's needs. Investigates problems incurred during testing and operations, resolves problems, and directs re-tests to ensure the satisfactory performance of the system.

Proposes budgetary priorities to Museum management with detailed performance and cost analysis. Must be able to properly supervise and oversee all of the Museum's permanent staff and tasking.

Understands and utilizes the Secretary of the Interior's 'Standards for Historic Vessel Preservation Projects' guidelines.

Other Job Duties (Duties listed are not intended to be all inclusive or to limit duties that might be assigned):
Performs related work as required or assigned by the Shipboard Engineer/Project Manager or designee.
Knowledge's, Abilities and Skills: (These are pre-employment knowledge's, abilities and skills that apply to Essential Job Functions):
Ability to:

- Understand and communicate with both verbal and written skills.
- Climb shipboard ladders.

- Work in constricted spaces.

Required Qualifications: (Note: Any acceptable combination of education, training, and experience that provides the above knowledge's, abilities, and skills may be substituted:

- Requires initiative and ingenuity to analyze a situation and to make frequent technical decisions based on specifications and electrical codes.
- Ability to sustain considerable physical effort at frequent intervals.
- Must have a valid South Carolina Driver's License.

Training and/or Education: U.S. Navy Shipyard training a plus.
Experience: Experience as Shipyard Project Manager/Engineer preferred.
Licenses or Certificates: Valid South Carolina Driver's License and Bachelor's degree in the appropriate naval architecture (NA) or engineering discipline from an ABET accredited school of engineering, and 5 or more years of specialized engineering experience, including 2 or more years at the Engineer II level..
Physical Demands: Work requires heavy physical effort.
Unusual Demands: Subject to "call back" in emergencies.
Terms of Employment: Twelve-month year salary as established.

Electricians

Two (2) electricians with previous experience in U.S. Navy type ships incorporating 440V AC, three phase power systems.

Job Description

Installs and repairs wiring, fixtures, and equipment for all electrical services aboard ship and in shipyard facilities, following blueprints and wiring diagrams: Installs conduit to bulkheads with brackets and screws, using hand tools, and threads wires through conduit to terminals, such as connection boxes, circuit breakers, voltage regulators, and switch panels. Strips insulation from wire ends and solders ends to terminals, using stripping pliers and soldering iron. Connects/disconnects power-supply circuits to radio, radar, sonar, fire control, and other electronic equipment. Tests electrical characteristics, such as voltage, resistance, and phase angle, in circuits, using voltmeters, ohmmeters, and phase rotation indicators. May construct instrument panels, using hand tools, rulers, dividers, and power drills, following specifications.

Performs work required for the repair, maintenance, installation, and modernization of electrical systems for ship, building, equipment and grounds. Performs work of a skilled variety demanding a high degree of manual and technical competency. Repairs malfunctions by such methods as replacing burned out elements, fuses, and replacing defective wiring, cleaning and repairing motors. Tests electrical equipment, such as, motors, heaters, and controls for safety and efficiency, using standard test equipment and by observing functions. Installs fixtures, wiring conduits, motors, and other electrical equipment. Inspects circuits for specified shielding and grounding. Knowledge of security and fire alarm systems.

Performs other duties as may be required.

Understands and utilizes the Secretary of the Interior's 'Standards for Historic Vessel Preservation Projects' guidelines.
Other Job Duties (Duties listed are not intended to be all inclusive nor to limit duties that might be assigned): Performs related work as required or assigned by the Shipboard Engineer/Project Manager or designee.

Knowledge, Abilities and Skills: (These are pre-employment knowledge, abilities and skills that apply to Essential Job Functions):
Ability to:

- Understand and communicate with both verbal and written skills.
- Climb shipboard ladders.
- Work in constricted spaces.

Required Qualifications: (Note: Any acceptable combination of education, training, and experience that provides the above knowledge's, abilities, and skills may be substituted.)

- High school diploma or equivalent.
- Thorough knowledge of the electrical trade.
- Journeyman Electrician's License.
- Requires initiative and ingenuity to analyze a situation and to make frequent technical decisions based on specifications and electrical codes.
- Ability to sustain considerable physical effort at frequent intervals.
- Must have a valid South Carolina Driver's License.

Training and/or Education: Graduation from high school or possession of a GED certificate preferably including or supplemented by courses in electrical trade. U.S. Navy training a plus.
Experience: Experience as electrician preferred.
Licenses or Certificates: Valid South Carolina Driver's License and Journeyman Electrician's License.
Physical Demands: Work requires heavy physical effort.
Unusual Demands: Subject to "call back" in emergencies.
Terms of Employment: Twelve-month year salary as established.
Plumbers

Job Description

Supervises and coordinates activities of workers engaged in assembly, installation, and repair of pipes, fittings, and fixtures of heating, water supply, and waste disposal systems for buildings: Trains new workers. Inspects work in progress and completed work to determine conformance to specifications. Performs duties as required by the vessel's Engineer. Supervising workers or Contractors who specialize in maintenance and repair of heating, water, and drainage systems in industrial or commercial establishments, is designated Plumber Supervisor, Maintenance (construction).

Installs bath plumbing systems in manufactured buildings, according to blueprints: Reads blueprints to determine type of plumbing system required. Writes cutting list that specifies sizes and quantity of copper pipe to be cut. Marks locations and bores holes in floor joists for pipes, using tape measure, template, and power auger. Selects and inserts precut pieces of copper tubing and fittings in holes. Connects tubing and fittings, using solder paste or solder and torch, to form sewer, drain, and water lines. Selects plumbing fixtures, such as toilets, sinks, and tubs, from storage. Squares tubing projecting through floor to ensure snug fit of fixtures, using square, wedges, and hammer, and solders fixtures to tubing. Squares fixtures with level. May direct workers engaged in pre-assembly and installation of wall systems, such as risers, air chambers, and shower assemblies.
Other Job Duties (Duties listed are not intended to be all inclusive nor to limit duties that might be assigned): Performs related work as required or assigned by the Shipboard Engineer/Project Manager or designee.
Knowledge, Abilities and Skills: (These are pre-employment knowledge, abilities and skills that apply to Essential Job Functions):
Ability to:

- Understand and communicate with both verbal and written skills.

- Climb shipboard ladders.
- Work in constricted spaces.

Required Qualifications: (Note: Any acceptable combination of education, training, and experience that provides the above knowledge, abilities, and skills may be substituted.)

- High school diploma or equivalent.
- Thorough knowledge of the plumbing trade.
- Journeyman Plumber's License.
- Requires initiative and ingenuity to analyze a situation and to make frequent technical decisions based on specifications and electrical codes.
- Ability to sustain considerable physical effort at frequent intervals.
- Must have a valid South Carolina Driver's License.

Training and/or Education: Graduation from high school or possession of a GED certificate preferably including or supplemented by courses in electrical trade. U.S. Navy training a plus.
Experience: Experience as plumber preferred.
Licenses or Certificates: Valid South Carolina Driver's License and Journeyman Plumber's License.
Physical Demands: Work requires heavy physical effort.
Unusual Demands: Subject to "call back" in emergencies.
Terms of Employment: Twelve-month year salary as established.

Carpenters

Job Description

Reads blueprints to determine dimensions of furnishings in ships or boats. Shapes and laminates wood to form parts of ship, using steam chambers, clamps, glue, and jigs. Repairs structural woodwork and replaces defective parts and equipment, using hand tools and power tools. Shapes irregular parts and trims excess material from bulkhead and furnishings to ensure fit meets specifications. Must be able to understand and supervise restoration and repair of vessel’s teak decking system.

Constructs floors, doors, and partitions, using woodworking machines, hand tools, and power tools. Cuts wood or glass to specified dimensions, using hand tools and power tools. Assembles and installs hardware, gaskets, floors, furnishings, or insulation, using adhesive, hand tools, and power tools. Transfers dimensions or measurements of wood parts or bulkhead on plywood, using measuring instruments and marking devices. Greases gears and other moving parts of machines on ship.

Sets up and operates machines, including power saws, jointers, mortises, tenoners, molders, and shapers, to cut and shape woodstock. Marks dimensions of parts on paper or lumber stock, following blueprints, and matches lumber for color, grain, and texture. Studies blueprints, drawings, and written specifications of articles to be constructed or repaired and plans sequence of performing such operations. Installs hardware, such as hinges, catches, and drawer pulls, using hand tools.

Dips, brushes, or sprays assembled articles with protective or decorative materials, such as stain, varnish, or lacquer. Sands and scrapes surfaces and joints of articles to prepare articles for finishing. Bores holes for insertion of screws or dowel by hand or using boring machine. Trims component parts of joints to ensure snug fit, using hand tools, such as planes, chisels, or wood files. Glues, fits, and clamps parts and sub-assemblies together to form complete unit. Drives nails or other fasteners to joints of articles to prepare articles for finishing.

Understands and utilizes the Secretary of the Interior's 'Standards for Historic Vessel Preservation Projects' guidelines.
Other Job Duties (Duties listed are not intended to be all inclusive nor to limit duties that might be assigned):
Performs related work as required or assigned by the Shipboard Engineer/Project Manager or designee.
Knowledge, Abilities and Skills: (These are pre-employment knowledge, abilities and skills that apply to Essential Job Functions):
Ability to:

- Understand and communicate with both verbal and written skills.
- Climb shipboard ladders.
- Work in constricted spaces.

Required Qualifications: (Note: Any acceptable combination of education, training, and experience that provides the above knowledge's, abilities, and skills may be substituted.)

- High school diploma or equivalent.
- Thorough knowledge of the carpenter trade.
- Journeyman Carpenter's License or equivalent.
- Requires initiative and ingenuity to analyze a situation and to make frequent technical decisions based on specifications and electrical codes.
- Ability to sustain considerable physical effort at frequent intervals.
- Must have a valid South Carolina Driver's License.

Training and/or Education: Graduation from high school or possession of a GED certificate preferably including or supplemented by courses in electrical trade. U.S. Navy training a plus.
Experience: Experience as carpenter preferred.
Licenses or Certificates: Valid South Carolina Driver's License and Journeyman Carpenter's License.
Physical Demands: Work requires heavy physical effort.
Unusual Demands: Subject to "call back" in emergencies.
Terms of Employment: Twelve-month year salary as established.

Painters

Job Description

Takes direction from the Ship's Engineer or Curator. Renders drawings, illustrations, and sketches exhibit space of ship and Museum, manufactured products, or models, working from sketches, blueprints, memory, or reference materials. Studies style, techniques, colors, textures, and materials used by previous shipboard practices to maintain consistency in reconstruction or retouching procedures. Performs tests to determine factors, such as age, structure, pigment stability, and probable reaction to various cleaning agents and solvents. Confers with professional personnel or client to discuss objectives of exhibits and displays, develop illustration ideas, and themes to be portrayed.

Brushes or sprays protective or decorative finish on completed background panels, informational legends, exhibit accessories, or finished painting. Integrates and develops visual elements, such as line, space, mass, color, and perspective to produce desired effect.

Painter should have the ability to perform quality control (QC) on outside painting contractors brought aboard for major painting projects. Must have a detailed understanding of interior and exterior shipboard painting systems to enable the Museum to benefit from reduced painting maintenance cycles. Understands and utilizes the Secretary of the Interior's 'Standards for Historic Vessel Preservation Projects' guidelines.
Other Job Duties (Duties listed are not intended to be all inclusive nor to limit duties that might be assigned):

Performs related work as required or assigned by the Shipboard Engineer/Project Manager or designee.
Knowledge, Abilities and Skills: (These are pre-employment knowledge, abilities and skills that apply to Essential Job Functions):
Ability to:

- Understand and communicate with both verbal and written skills.
- Climb shipboard ladders.
- Work in constricted spaces.

Required Qualifications: (Note: Any acceptable combination of education, training, and experience that provides the above knowledge, abilities, and skills may be substituted.)

- High school diploma or equivalent.
- Thorough knowledge of the carpenter trade.
- Journeyman Carpenter's License or equivalent.
- Requires initiative and ingenuity to analyze a situation and to make frequent technical decisions based on specifications and electrical codes.
- Ability to sustain considerable physical effort at frequent intervals.
- Must have a valid South Carolina Driver's License.

Training and/or Education: Graduation from high school or possession of a GED certificate preferably including or supplemented by courses in electrical trade. U.S. Navy training a plus.
Experience: Experience as carpenter preferred.
Licenses or Certificates: Valid Hawaii Driver's License and Journeyman Carpenter's License.
Physical Demands: Work requires heavy physical effort.
Unusual Demands: Subject to "call back" in emergencies.
Terms of Employment: Twelve-month year salary as established.

Welder

Job Description

Takes direction from Engineer or Project manager. Must be familiar with U.S. Navy shipboard construction and fabrication practices. Prospective employee must become familiar with all types of shipboard steel and armor, welding and riveting practices. Lays out, positions, and secures parts and assemblies according to specifications, using straightedge, combination square, calipers, and ruler. Tack-welds or welds components and assemblies, using electric, gas, arc, or other welding equipment. Cuts work piece, using powered saws, hand shears, or chipping knife. Melts lead bar, wire, or scrap to add lead to joint or to extrude melted scrap into reusable form. Installs or repairs equipment, such as lead pipes, valves, floors, and tank linings. Observes tests on welded surfaces, such as hydrostatic, x-ray, and dimension tolerance to evaluate weld quality and conformance to specifications. Inspects grooves, angles, or gap allowances, using micrometer, caliper, and precision measuring instruments. Removes rough spots from work piece, using portable grinder, hand file, or scraper. Welds components in flat, vertical, or overhead positions.
Prospective welder must be capable of utilizing the onboard machine and metal fabrication shop. Heats, forms, and dresses metal parts, using hand tools, torch, or arc welding equipment. Ignites torch and adjusts valves, amperage, or voltage to obtain desired flame or arc. Analyzes engineering drawings and specifications to plan layout, assembly, and welding operations. Develops templates and other work aids to hold and align parts. Determines required equipment and welding method, applying knowledge of metallurgy, geometry, and welding techniques.

Other Job Duties (Duties listed are not intended to be all inclusive nor to limit duties that might be assigned):
Performs related work as required or assigned by the Shipboard Engineer/Project Manager or designee.

Knowledge, Abilities and Skills: (These are pre-employment knowledge, abilities and skills that apply to Essential Job Functions):
Ability to:

- Understand and communicate with both verbal and written skills.
- Climb shipboard ladders.
- Work in constricted spaces.

Required Qualifications: (Note: Any acceptable combination of education, training, and experience that provides the above knowledge, abilities, and skills may be substituted.)

- High school diploma or equivalent.
- Thorough knowledge of the welding/fabrication trade.
- Journeyman Welder's License or equivalent.
- Requires initiative and ingenuity to analyze a situation and to make frequent technical decisions based on specifications and electrical codes.
- Ability to sustain considerable physical effort at frequent intervals.
- Must have a valid South Carolina Driver's License.

Training and/or Education: Graduation from high school or possession of a GED certificate preferably including or supplemented by courses in electrical trade. U.S. Navy training a plus.
Experience: Experience as carpenter preferred.
Licenses or Certificates: Valid South Carolina Driver's License and Journeyman Welder's License (or equivalent).
Physical Demands: Work requires heavy physical effort.
Unusual Demands: Subject to "call back" in emergencies.
Terms of Employment: Twelve-month year salary as established.

Hull Technician

Job Description

The applicant must be intimately familiar with all U.S. Navy shipboard construction practices/details and be able to take direction from the Engineer and/or Project Manager. The duties include: installing, maintaining and repairing valves, piping, plumbing system fittings and fixtures, and marine sanitation systems. Repairing decks, structures and hulls by welding, brazing, riveting and caulking; examining, testing welds and various shipboard structures; using radiological, ultrasonic and magnetic particle testing equipment. fabricating with light and heavy gauge metal such as aluminum, stainless steel, sheet copper and brass, steel, sheet and corrugated iron; heat treating, hot and cold forming of metals; pipe cutting, threading and assembly; repairing installed ventilation ducting; repairing metal, wood and fiberglass boats; installing and repairing insulation and lagging; operating marine sanitation systems.

Other Job Duties (Duties listed are not intended to be all inclusive nor to limit duties that might be assigned): Performs related work as required or assigned by the Shipboard Engineer/Project Manager or designee.
Knowledge, Abilities and Skills: (These are pre-employment knowledge, abilities and skills that apply to Essential Job Functions):
Ability to:

- Understand and communicate with both verbal and written skills.
- Climb shipboard ladders.
- Work in constricted spaces.

Required Qualifications: (Note: Any acceptable combination of education, training, and experience that provides the above knowledge, abilities, and skills may be substituted.)

- High school diploma or equivalent.

- Thorough knowledge of the shipboard welding/fabrication trade.
- Journeyman Welder's License or equivalent.
- Requires initiative and ingenuity to analyze a situation and to make frequent technical decisions based on specifications and electrical codes.
- Ability to sustain considerable physical effort at frequent intervals.
- Must have a valid South Carolina Driver's License.

Training and/or Education: Graduation from high school or possession of a GED certificate preferably including or supplemented by courses in electrical trade. U.S. Navy training a plus.
Experience: Experience as commercial or U.S. Navy ship fitter preferred.
Licenses or Certificates: Valid South Carolina Driver's License and Journeyman Welder's License (or equivalent).
Physical Demands: Work requires heavy physical effort.
Unusual Demands: Subject to "call back" in emergencies.
Terms of Employment: Twelve-month year salary as established.

Daily/Weekly Ship Maintenance Schedule

The following items will be performed on a daily/weekly basis:

1.) Preparation and painting of exterior topside areas by ship's maintenance team.

2.) Daily cleaning of topside spaces by ship's maintenance team.

3.) Preparation and painting of interior spaces by ship's maintenance team.

4.) Cleaning of interior spaces by ship's maintenance team.

5.) Ensure watertight integrity of vessel.

6.) Repair/maintenance of vessel's plumbing system.

7.) Repair/maintenance of vessel's ventilation (heating & cooling) system.

8.) Repair/maintenance of vessel's impressed cathodic system.

9.) Repair/maintenance of vessel's lifelines and other safety systems (high bilge alarms, fire alarms, fire extinguishers, etc.

10.) Repair/maintenance of vessel's security systems.

11.) Repair/maintenance of vessels mooring lines and pier head facilities.

12.) Repair/maintenance of Museum's grounds and building.

13.) Prepare/maintain vessel's exhibits.

14.) Prepare daily work plan and budgets needed to implement Maintenance Plan.

15.) Prepare ongoing annual, five year, 10 year, and 20 year maintenance data into a central planning database.

Annual/Intermediate Ship Maintenance Schedule

The following items will be performed on an annual/intermediate basis:

1.) Preparation and painting of exterior topside areas by ship's maintenance team.

2.) Daily cleaning of topside spaces by ship's maintenance team.

3.) Preparation and painting of interior spaces by ship's maintenance team.

4.) Cleaning of interior spaces by ship's maintenance team.

5.) Ensure watertight integrity of vessel.

6.) Repair/maintenance of vessel's plumbing system.

7.) Repair/maintenance of vessel's ventilation (heating & cooling) system.

8.) Repair/maintenance of vessel's impressed cathodic system.

9.) Repair/maintenance of vessel's lifelines and other safety systems (high bilge alarms, fire alarms, pumps, etc.)

10.) Repair/maintenance of vessel's security systems.

11.) Repair/maintenance of vessel's mooring lines and pier head facilities.

12.) Repair/maintenance of Museum's grounds and building.

13.) Prepare/maintain vessel's exhibits.

14.) Prepare/maintain new spaces within the ship opened to public visitation.

15.) Prepare/maintain new spaces within the ship opened to public visitation.

16.) Prepare daily work plan and budgets needed to implement Maintenance Plan.

17.) Prepare ongoing long term, five year, 10 year, and 20 year maintenance data into a central planning effort.

Long Term Ship Maintenance Schedule

The following items will be performed on a long term basis:

1.) Preparation and painting of exterior topside areas by ship's maintenance team.

2.) Daily cleaning of topside spaces by ship's maintenance team.

3.) Preparation and painting of interior spaces by ship's maintenance team.

4.) Cleaning of interior spaces by ship's maintenance team.

5.) Ensure watertight integrity of vessel.

6.) Repair/maintenance of vessel's plumbing system.

7.) Repair/maintenance of vessel's ventilation (heating & cooling) system.

8.) Repair/maintenance of vessel's impressed cathodic system.

9.) Repair/maintenance of vessel's lifelines and other safety systems (high bilge alarms, fire alarms, fire extinguishers, etc.).

10.) Repair/maintenance of vessel's security systems.

11.) Repair/maintenance of vessels mooring lines and pier head facilities.

12.) Repair/maintenance of Museum's grounds and building.

13.) Prepare/maintain vessel's exhibits.

14.) Have divers survey vessel's underwater shell plating and appendages twice yearly.

15.) Prepare/maintain new spaces within the ship opened to public visitation.

16.) Prepare daily work plan and budgets needed to implement Maintenance Plan.

17.) Prepare and implement vessel dry-docking/repair planning and financial efforts.

18.) Prepare ongoing 10 year, and 20 year maintenance data into a central planning effort.

Maintenance Plan Implementation

Discussion

It has been felt by the Board and Management that it is necessary to break down, into segmented sections, the individual tasking of the short term, intermediate term and long term planning and task assignments for the Ship's Engineer and his maintenance staff. This is to formalize and simplify the tasking and management needed to properly maintain and preserve the icon that is aircraft carrier U.S.S. YORKTOWN.

A proper mind set is needed to realize the complexity of these ships; they are NOT your everyday fleet unit and to treat this ship as just a demobilized ship is to really miss the point. Taking care of this ship as it would be cared for under INACTSHIPS auspices is to condemn the vessel for very expensive repairs and increase the need for additional dry-docking evolutions downstream.

Aircraft Carrier and Battleship memorials that are of World War II vintage have already shown the ravages of time due to poor maintenance or no maintenance. U.S.S. ALABAMA leaked copious amounts of oil from her exterior shell tanks into Mobile Bay several years ago; the ship was repaired utilizing Federal grants by coffer damming the entire hull, cleaning up the oil within her tanks and installing doubler plates at her wind/waterline.

Coffer dam around battleship U.S.S. ALABAMA after holed shell plating leaked oil into Mobile Bay. Notice installation of wind/waterline shell plate doublers.

The battleship U.S.S. NORTH CAROLINA is six years older than the IOWA class battleships; yet she was sunk on purpose in Wilmington, NC due to the propensity of hurricanes that frequent the Cape Fear River area. Her fuel oil and/or ballast tankage and her voids were filled with water many years ago. An outboard armor belt is bolted on and is leaking into her interior shell plating/fuel/ballast tanks. Also, the sun rises and sets underwater in the extreme ends of the ship due to wasted shell plating. When will she commence leaking oil?

Where is YORKTOWN in this scenario?

Holed shell plating repaired with small doubler patches (a Band-Aid), subsequent to inspection/survey by the undersigned, above the waterline on battleship U.S.S. NORTH CAROLINA. Much additional work is desperately needed.

Leaking shell plating below the waterline, Frame 34, starboard side, battleship U.S.S. NORTH CAROLINA. Her shell plating forward matches exactly the same plating fitted aboard U.S.S. MISSOURI.

There is no discussion possible on any other alternative methodologies that shortcuts the long term needs of the ship.

The battleship U.S.S. MASSACHUSETTS was drydocked in late 1998 for hull inspection. Her hull is protected by an impressed cathodic system, but severe galvanic action had occurred as a result of a large ground short on the nearby U.S.S. JOSEPH P. KENNEDY at Battleship Cove. Her wind/waterline forward on both sides back to the main stack required the installation of doubler plating; I believe this installation to be a mistake as the doubler plating has separated on occasion from the side shell. Her bottom rivets were leaking oil at time of dry-docking as a result of water and sand blasting. Several thousand rivets and plating seams were ring/seam welded to arrest the leaking oil/water. Many more thousand rivets were coated with an epoxy putty over the rivet heads and then painted with anti-fouling. The impressed cathodic system, lying on the river bed, was repaired and adjusted while the ship was in dry-dock, stray currents were searched out and arrested.

U.S.S. MASSACHUSETTS drydocked at Dry-dock #3, S. Boston in 1998/9. Notice installation of shell doubler plating at the wind/waterline. Also, note the epoxy sheathing weldments and riveting on underwater plating.

U.S.S. MASSACHUSETTS showing the outboard propellers removed and protective steel sheathing installed.

Understanding the vessel by studying her drawings and textual data is a must before initiating any complex evolution; the Chief Engineer and his staff must KNOW how the ship is constructed, what kind of plating is utilized for her exterior shell and interior scantlings; her plumbing and ventilation systems, electrical harness from the shore power cables to the individual service panels throughout the ship, what kind of rivets (and their rivet patterns) and what welding patterns the builders utilized to construct this ship. He must UNDERSTAND the forces of nature working against his ship; be it sun, tropical precipitation, paint system breakdown, galvanic corrosion and the inevitable dirt/standing water issues of drainage.

U.S.S. MISSOURI at a 1 ½ degree starboard list, December 2007. Her list caused by leaking rivet(s) in her fuel/ballast tank. This took over two months to correct with resulting drainage issues caused by poor understanding of tank ventilation systems.

U.S.S. MISSOURI has now drydocked and repaired the sea water ingress through her shafting and largely solved the 'leaking rivet' syndrome elsewhere on her hull. The photo below illustrates the standing water and waterline within this void that had been recently pumped during the inspection of December 2007. This void is adjacent to the starboard shaft alley and was indicative of migrating water within the ship. Dry-docking alleviated this condition. The regular pump-off overboard of standing water from these spaces may incur a liability for the Museum under the Clean Water Act and Oil Pollution Act of 1990.

Obtaining the previous shipyard availability packages, original as-built construction plans, BUSHIPS design book, and engineering manuals are a must; utilizing them after obtaining them is also paramount as previous information onboard was locked up in curatorial spaces or was right in front of maintenance staff and was never consulted before certain evolutions.

The Ship's Engineer must also be up to speed on the condition of every area of the ship, from truck to keel. He must stay abreast on new technologies that will diminish the amount of work his crew must per-form on a regular basis and that will improve the long term upkeep of the ship. This knowledge must inevitably decrease budgetary stresses in the day-to-day operation of the ship. In this way he can manage his meager staff to prioritize his attacks on the larger issues.

One must think of the long term and act accordingly. SAVE THE ICON! That is the goal.

THREAD TASK ITEMS COMMON TO THE THREE MAINTENANCE CYCLES

I. Preparation and painting of exterior topside by Ship's Maintenance Team.

The Maintenance crew has historically renewed the vessel's topside paint system with the use of semi-gloss silicon alkyd enamels. The turn-around on renewing coatings depends upon UV damage and chemical breakdown of the coating depending upon which side of the ship is viewed. Coatings generally last awhile longer to port with the starboard side of the ship suffering from sun and rain damage. This is not the way to best utilize limited maintenance crews.

It behooves the Ship's Engineer to closely study new technologies with regard to new paint systems and their application methodology; many of them incorporating a one part primer/finish coat with one application over prepared steel surfaces. Polysiloxane (INTERNATIONAL PAINT) come to mind being utilized at tank farms, oil rig platforms and remote high tension electric poles; it also is benign in that it can be brushed, rolled or sprayed. INTERNATIONAL 300V makes an excellent primer and can be utilized on both interior and exterior surfaces; this coating is also compatible with impressed cathodic systems presently installed surrounding YORKTOWN.

The maintenance crew needs to be properly trained in the art of surface steel preparation, priming and final coating applications. Many paint companies send their paint specialists into the field and are eager to educate the team on proper paint application and all of the variables with regards to mil thickness; application with humidity/temperature variables, drying times, etc.

II. Daily cleaning of topside spaces by Ship's Maintenance Team.

The Ship's Engineer is responsible for maintaining a properly cleaned topside environment for the visiting public and the well keeping of the vessel by ensuring the vessel's Maintenance Team carries out the daily cleaning of the following:

a.) Ensure all drainage conduits and waterways are clear of dirt and debris,
b.) Ensure all downpipes are free and not blocked with debris,
c.) Ensure all downpipes have proper screens over their drains,
d.) Eliminate all concrete waterways and replace wasted steel; prime/paint as needed,
e.) Start from top to bottom of citadel and topside hamper on a monthly basis with fresh water fire hoses and clean drains, superstructure and appendages,
f.) Hose down teak decks with salt water; hose down waterways outboard with fresh water and clean all overboard discharge opening,
g.) Renew wasted rubber drain water fairleads as needed,

III. Preparation and painting of interior spaces by Ship's Maintenance Team

The following tasking is the responsibility of the Ship's Engineer:

The Maintenance crew has historically renewed the vessel's interior paint system with the use of egg-shell silicon alkyd enamels. The turn-around on renewing coatings depends upon the space use, either for Museum staff or public access. Coatings generally are in good repair and last for a good period of time. Cleanliness is the issue.

It behooves the Ship's Engineer to closely study new technologies with regard to new paint systems and their application methodology; many of them incorporating a one part primer/finish coat with one application over prepared steel surfaces.

The maintenance crew needs to be properly trained in the art of surface steel preparation, priming and final coating applications. Many paint companies send their paint specialists into the field and are eager to educate the team on proper paint application and all of the variables with regards to mil thickness; application with humidity/temperature variables,

IV. Cleaning of interior spaces by Ship's Maintenance Team

The following tasking is the responsibility of the Ship's Engineer:

This tasking has been poorly performed in the past with waxed over decks and generally poor habitability over shadowed by standing dirt/debris an many areas of the public access areas. Generally, Museum office spaces and passageways aboard are kept very clean.

The food service mess line, mess decks and wardroom were in need of an upgrade with regard to general cleanliness; this has lately improved, but there is a need for further improvement. These spaces require daily sweeping, daily dusting and wipe-down of all surfaces, mopping of decks and cleaning of food service lines and display cases.

All interior decks and overheads should be swept and cleaned on a daily basis. The decks should be mopped with clean water and appropriate detergent on a daily basis. Waxing of decks (linoleum) can be done on a weekly basis or as needed due to traffic flow. Do not wax over dirt.

All Plexiglas door shields, windows and display cases should be wiped down and cleaned daily.

V. Ensure watertight integrity of vessel.

The following tasking is the responsibility of the Ship's Engineer:

The Ship's Engineer shall establish a tank sounding log with appropriate labels for locations of tank sounding tubes for all fuel/ballast tanks and voids and shall task a dedicated person to sound these tanks on a weekly basis. These inspections shall be logged both in a paper book and on computer. These computer results shall be presented to the Chief Operating Officer on a quarterly basis or as needed to verify current status of tankage.

The Ship's Engineer shall establish a daily round of bilge inspections throughout the ship and that these inspections shall be logged both in a paper book and on computer. Discrepancies shall be reported immediately to the Chief Operating Officer whenever a slight change occurs.

The Ship's Engineer shall ensure that the vessel's high water bilge alarm system is functional and shall test this system weekly; this shall be logged.

The Ship's Engineer shall ensure that the vessel's high water bilge alarm system is tested by the manufacturer or competent Contractor on a twice yearly basis (or as required) and shall be reported in writing to the Chief Operating Officer.

The Ship's Engineer shall ensure that all unnecessary hatches, watertight doors and scuttles are closed below the waterline of the vessel.

The Ship's Engineer shall report immediately any water intrusion below the waterline to the Chief Operating Officer. No pump-out of water overboard is approved until sampling has been completed and the results analyzed for hazmats. If there is the accidental discharge of water, immediate action is required by contacting the U. S. COAST GUARD SPILL RESPONSE HOTLINE or U. S. COAST GUARD MSO District Charleston.

The Ship's Engineer shall ensure that there is a pollution standby contractor and that this team is familiar with all shipboard areas of concern.

VI. Repair & Maintenance of Shipboard Plumbing Systems

The following tasking is the responsibility of the Ship's Engineer:

The Ship's Engineer shall determine areas aboard ship where potable water can be shut down to staterooms, heads and showers, with drainage and supply piping broken at the flanges and drained. This is an endemic condition in the Officer's Country and crew berthing facilities not utilized by the overnight program.

The Ship's Engineer shall design, or have designed, a proper drain discharge piping system for the mess decks soft drink machines.

The Ship's Engineer shall monitor and repair as needed the vessel's CHT sewerage discharge system, holding tanks and heads with associated discharge piping to the pier head. He shall develop a detailed drawing of existing sewerage discharge piping to AUTOCAD specifications.

The Ship's Engineer shall monitor and repair as needed the vessel's potable water intake piping from the pier and its distribution system throughout the ship. He shall develop a detailed drawing of existing potable water supply and discharge piping to AUTOCAD specifications.

VII. Repair/Maintenance of the Vessel's Ventilation and Cooling Systems

The following tasking is the responsibility of the Ship's Engineer:

The Ship's Engineer shall monitor and repair as needed the vessel's HVAC ventilation system throughout the ship where the Museum staff and visiting public are present. This includes the monitoring and performance of maintenance of the vessel's cooling towers/systems. Develop a schedule with the manufacturer with regard to a maintenance schedule and inspection.

The Ship's Engineer shall monitor and repair as needed the vessel's vents, vent duct fans sys-tems and hanger system throughout the vessel where the Museum staff and visiting public are present. He shall develop a detailed drawing of existing ventilation/AC system to AUTOCAD specifications.

VIII. Repair/Maintenance of the Vessel's Impressed Cathodic System

The following tasking is the responsibility of the Ship's Engineer:

The Ship's Engineer shall monitor and log on a weekly basis the readings of galvanic potential gathered by taking potential readings on 30' centers along the sides of the ship (both port & starboard, high and low readings) with a MILLER silver/silver chloride probe attached to a fluke meter and grounded to the vessel. Readings should be between .75 and 1.00 volts DC. The Ship's Engineer shall record these readings into a paper log and then transposed to a computer data base. The results shall be presented to the Chief Operating Officer on a quarterly basis or when any changes are noticed that puts the potential outside the established boundaries as noted above.

The Ship's Engineer shall ensure that all rectifiers and sensors are in proper operating condition.

The Ship's Engineer shall ensure that all underwater ceramic arrays and sensors are cleaned by industrial dive team on at least a quarterly basis.

Cathodic Protection

The purpose of the Cathodic protection System is to eliminate the rusting or corrosion to the ship's hull which occurs when the ship's hull is immersed in water. When properly installed the system will eliminate the corrosion on the hull, rudders and propellers. Corrosion protection of hull openings and recesses such as sea chests and intake and discharge ports, are only provided for in a limited degree. Zincs are often used in these areas to act as sacrificial anodes for the appropriate protection.

IX. Repair/Maintenance of Vessel's Lifelines, Brows, ADA Elevator, & Fire Alarms/Extinguishers

The following tasking is the responsibility of the Ship's Engineer:

The Ship's Engineer shall ensure that all lifelines aboard the ship are properly secured with adequate net fencing well secured and in good repair. He shall ensure that all stanchions are properly preserved and well connected to the deck. He shall ensure that all lady fingers are intact and that all turnbuckles for lifelines are properly adjusted for good tension. He shall ensure that all bronze lifelines are wire brushed quarterly or as needed to eliminate any broken strands.

The Ship's Engineer shall ensure that the boarding brows are well sited, properly adjusted to the position of the ship and well preserved.

The Ship's Engineer shall ensure that the starboard aft elevator receives structural attention with regard to structure on the elevator and supporting ships' structure inboard.

The Ship's Engineer shall ensure that the vessel's fire extinguishers are inspected and tagged annually with each bottle carrying a proper tag; these should be well mounted. Their location shall be entered on a drawing developed by the Ship's Engineer as to location and type of extinguisher.

X. Repair/Maintenance of Vessel's Security Systems

The following tasking is the responsibility of the Ship's Engineer:

The Ship's Engineer, working with the Head of Security, shall develop a security plan for clo-sure of all 2nd and 3rd Deck spaces not open to the public for tours or to Museum personnel.
A lock plan should be drafted and drawings developed on AUTOCAD showing locations of locked doors, hatches and scuttles.

The Ship's Engineer, working with the head of Security, should test on a weekly/quarterly basis all security systems in the park and onboard the vessel. These results should be presented to the Chief Operating Officer immediately.

The Ship's Engineer, working with the Head of Security, shall develop a security plan based on threat patterns that could impact the ship, the public and Museum personnel. These should be re-viewed by upper management, the Board and Base Security.

XI. Repair/Maintenance of Vessel's Pierhead Facilities

The following tasking is the responsibility of the Ship's Engineer:

The Ship's Engineer shall ensure that the vessel's utility piping and wiring are periodically inspected for chafe and UV damage and replaced as needed.

The Ship's Engineer shall ensure that the vessel's pier head emergency generators are functional and tested periodically. Some thought should be given to moving this system aboard ship.

XII. Repair/Maintenance of Museum's Grounds and Temporary Pier Buildings

The following tasking is the responsibility of the Ship's Engineer:

The Ship's Engineer shall ensure the safe operation on the pier of all vehicular traffic, movement of supply/contractor's vehicles and movement/storage of all museum supplies.

The Ship's Engineer shall ensure that all office temporary structures are safely illuminated, have adequate security and adequate air conditioning.

The Ship's Engineer shall ensure the cleanliness of the parking lot, pier head, bathrooms, shops and structures.

The Ship's Engineer shall ensure the orderly and timely disposal of all waste and recyclable material.

XIII. Maintenance of Vessel's Exhibits

The following tasking is the responsibility of the Ship's Engineer:

To the extent required, provide assistance to the Museum's curatorial staff for the care of all exhibits and objects. This may require proper provisions for security for shipyard period or weather event of all office equipment and files, curatorial storerooms and movement of Museum displays to areas of safe keeping.

With assistance from the vessel's Curator, develop a logistical plan for movement and safe storage of valuable artifacts and office files for an 'off ship' location in the event of natural disaster.

XIV. Dive Team Survey of Vessel's Underwater Shell Plating and Appendages

The following tasking is the responsibility of the Ship's Engineer:

The Ship's Engineer shall engage a qualified industrial dive team to conduct an under-water inspection of the vessel's shell plating, impressed cathodic ceramic arrays/ sensors and appendages twice yearly.

The underwater report should be recorded to DVD with digital still photos as appropriate.

The impressed cathodic ceramic arrays and sensors should be cleaned twice yearly.

XV. Prepare/maintain new Spaces within the Ship opened to Public Visitation.

The following tasking is the responsibility of the Ship's Engineer:

Working with the vessel's management, education, and curatorial staff, the Ship's Engineer shall develop plans for the routing and utilization of additional passageways and spaces aboard for Museum staff and public visitation.

The Engineer shall plan his work to the Secretary of the Interior's Standards for Historic Vessel Preservation and shall follow the directives of the Regional Environmental Protection Agency and State of South Carolina/local authorities.

The Ship's Engineer shall have performed environmental sampling of the affected space (s) for air quality, lead, asbestos and PCBs with the results tabulated and a proposed remediation plan developed for submitted to EPA for their comment and remediation.

NOTES: This section shall remain unchanged as it is a good reference for many of the tasks that require completion aboard YORKTOWN. That several of these textual sections are 'official' Navy procedures for the various evolutions does not in any way diminish their importance to the current maintenance crew. Indeed, this is the time tested methodology for repairing and periodic maintenance for these items.

Anchors, Chains & Chain Lockers

Preservation procedures for anchors, chains, and chain lockers include:

a. Anchors shall be touched up.
b. Chains shall be scraped to remove loose rust and scale, and stowed in the chain locker under dehumidification.
c. Chain lockers and sump shall be cleaned and preserved while the chains are removed, then placed under dynamic dehumidification.

Cathodic Protection System

The vessel currently has five (5) integral CAPAC impressed cathodic system rectifiers aboard that are operational. Readings taken at time of structural survey by Miller silver-silver chloride probe showed that the hull is protected even though some of the paint system at the wind/waterline has deteriorated. The hull is freely eroding at the waterline (although minimally) where the paint system has been breached. An underwater inspection will determine the ultimate condition of the vessel's bottom paint system. Periodic dive inspections (which are a requirement of the Donation Contract) will allow the cleaning of these sensors and anodes.

COATINGS FOR HISTORIC SHIPS

1. **1. Coating Manufacturers, Representatives**

Ameron has purchased Devoe. Both very high quality manufacturers. Other manufacturers have also combined.
1.1. Importance of local sales/technical representative

a. Local rep is your first line of defense relative to technical questions, application conditions, dealing with factory leading to WARRANTY
b. Local rep needs intestinal fortitude
    1. Is your project and its successful completion the priority
    2. Is the yard/applicator's repeat business the priority
    3. Complexity of project and/or success product application if applicator is inexperienced, may require assigning a factory representative
    4. Your evaluation of the local rep, friend or not, may, or may not, be the selection criterion for the successful supplier, but certainly is a valid reason for deciding which supplier you do not select

1.2. Beware the manufacturer that by-passes the local rep

a. Manufacturer that is willing to cut-out the local rep, does not have your interests at heart either

2. **2. Coatings and Surface Preparation**

2.1. Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultrahigh-Pressure Water Jetting Prior to Recoating, SSPC-SP 12.

a. Replacing sand blasting in many cases
b. 35-40,000 psi working pressure
c. Small water volumes (relatively), no major volumes of sand to collect/dispose of.
d. Minimal dusting
e. Removes chloride contamination
f. The National Shipbuilding Research Program, Surface Preparation & Coating Handbook, Carderock Division, Naval Surface Warfare Center, states that High Pressure Water Jetting (10-25 ksi) has far lower productivity rates (20-30 ft2/hr.) than abrasive blasting. However all things change, and new pumps and nozzles achieve blast pressures of 35-40 ksi in the field have production rates of 80-100 ft2/hr., with abrasive blasting at 90-120 ft2/hr.
g. High pressure water jetting does not put a new surface profile on a surface. On an older, wasted surface, such as 30-40 years out of dry-dock, a new profile is needed and this will require an abrasive blast. Your friend, the Manufacturer's Rep is there to advise you.

2.2. Coatings Removal By Laser

a. Relatively new technology
b. Vaporizes coating by heating surface to about 250F
c. Vapors collected by vacuum enclosure, similar to vacu-blast
d. Skid or truck mounted for portability.
e. Units for sale only at this time: $200,000 to $3,000,000 each-too expensive for HNSA ships
f. Used mainly on high value operating aircraft. Eventually might be useful in ordnance or electronics antenna preservation, when and if available for specific task rental.

2.3. Surface Preparation
Still no free lunch, but some newer "snake oils" work much better than the "snake oils" of old.

a. Phosphoric acid, molybdates acted to convert rust to a moderately tightly adhering base coating that could be over coated
b. Newer epoxy mastics, also polyurethane mastics used to "wet" surface, combine, and tightly adhere with minimal surface preparation (hand, and/or power tool cleaning.) These act as primers

c. Surface tolerant aluminum-filled epoxy mastics are now used to overcoat and encapsulate lead based paint. The trick is the two systems have to adhere to the surface, or the lead paint has to come off.
    1. Still no free lunch. Encapsulating lead delays the inevitable lead based coating removal, with all the attendant problems of removal, personnel protection, and disposal.
    2. Disturbing an encapsulated surface will always trigger 29 CFR 1926.62.

2.4. Application Conditions

a. Epoxy coatings normally applied at SOF temperature, or higher, with the surface temperature at least SF above the dew point.
b. Some newer coatings will go as low as 20F, and perhaps as low as OF.
c. These low temperatures are achieved by altering the catalysts and the resulting chemical reactions. If low temperature coatings are required, be very careful this is a normal product for the manufacturer, that he knows what the long term effects are on coating durability, and that he is willing to guarantee coating performance.
d. *Kennedy* used a low temperature cure International (Courtalds) epoxy primer in 1986-7. Except for local ice damage, it seems to be holding up well in 1996.
e. Epoxy and polyurethane (both catalyzed two component coatings) continue to cure and get harder as they age. This results in an over coating "time window" in which another coating can be applied and stick/bond to the undercoat. If the "window" is exceeded, the undercoat will have to be roughened so the new coat will adhere. There is no fudging on this one. The window varies from product to product and is affected by the ambient temperatures between coats.
f. Some coatings claim a greater resistance to water penetration, etc. by the addition of aluminum, stainless steel, glass, ceramic, or micaceous iron oxide flakes/platelets depending on the service or use intended.
    1. They work.

2.5 Coatings

a. Labor for surface preparation, coating application, and clean-up is the most expensive part of painting whether you hire an outside contractor or use your own staff, which you already have on pay-roll.
b. Current costs and cash flow often dictate the paint that is purchased.
    1. Buying Mil-Spec paint should be good enough. It is cheap and I can get a good deal from the supplier. It often isn't. Navy coatings are good, but usually not the high end in performance. Often a manufacturer has a higher performance version of the same type coating that will help maximize the impact of your labor dollar.
c. What are representative costs of some high performance coatings. Cost ranges are first given per gallon in small orders (less than 500 gallons), and then per gallon in 500 gallon orders.

o-20-30% Silicone Alkyd	$34.00	$20-22
o-30% Silicone Alkyd	$40.00	$25-30
o-Epoxy Mastics	$35-40	$20-25

d. An ideal topside system would include extensive surface preparation, epoxy mastic primer/encapsulant, and acrylic polyurethane topcoat. Systems similar to this are in use with an expected service life of about 15 years.
    1. Problems: Polyurethane is a two part catalyzed system, requiring mixing and, perhaps losing, large amounts of product for even relatively small touch-ups. (It comes packaged that way) The polyurethane system is very hard and will require relatively extensive surface preparation to overcoat, i.e., blast cleaning.
e. A more user-friendly system starts off with surface preparation, an epoxy mastic primer/ encapsulant, and then a high quality 30% Silicone Alkyd. This system should have an expected service life of 10-12 years.

1. The Silicone Alkyd is a single component coating that does not require extensive surface preparation to overcoat. It is more familiar to a user. A container can be opened, a portion used, and the container sealed until the next use.
2. *Massachusetts* used the older Silicone Alkyd system in 1986 on the superstructure, and did not require a full overcoat, now in progress, until 1995. Spot touch-up had been on-going for several years.
3. The Navy Surface Preparation & Coating Handbook says: "A workhorse coating, haze gray silicone alkyd often is the finish coat for much exposed steel topside."

f. Excessive paint film build-up is always a problem and will eventually fail in adhesion, either to itself, or the substrate. *Massachusetts* has build-ups of 60-100 mils, and is not unusual among HNSA ships. What is unusual, in 1989 *Texas*' exterior was blast cleaned to bare metal from keel to mast head being recoated with an epoxy/silicone alkyd system.

g. Natural oil-based or synthetic resin based (alkyd) were among the original decorative/protective coatings. Both have moderate water vapor transmission rates (good on wood, bad on steel) and require an inhibitive pigment for steel. Drying (film formation) is by reaction with oxygen.

1. Lead was discovered to be a dryer when added to the mixture. Later other metals were also found to be dryers: cobalt, zirconium and manganese.
2. Alkyds tend to absorb water and swell. They lose adhesion when immersed in water but usually recover when the substrate dries out. Repeated wet/dry cycling will cause coating disbondment.
3. The chemical reaction with oxygen continues from application until the coating becomes brittle and deteriorates. In sunlight, eventually the surface will chalk, decomposition products wash off, and the binder become more brittle and decompose.
4. However, many alkyds need the presence of ultraviolet light to preserve the protection qualities. Coatings with high linseed oil content will yellow considerably indoors. Remember mixing blue with white when painting interior compartments?
5. Smelly paints: probably "short oil", with aromatic solvents. They dry faster, have greater gloss, are more brittle, do not wet the surface as well, and do not weather as well as "long oil" alkyds.
6. There are various alkyd resin modifiers: phenolics, epoxies, urethanes, and silicones. The silicone alkyds are of particular interest because of their gloss retention, weathering and ultra-violet resistance.
   a. These coating are hybrids, combining technologies from other chemical categories. Generalizing, the hybrid coating is better than the straight oil-based, but not as good as a coating cured by chemical reaction.
7. Lead and chromates have severe toxicity problems as inhibitive pigments. There are many alternative inhibitors, used singly and in combination, all with specific strengths and weaknesses.
8. Water based alkyds do not in general meet the performance of solvent based alkyds.

h. Vinyls and Chlorinated Rubbers

1. Use of both systems started in the 1940s, chlorinated rubber being more popular in Europe than the U.S.
2. These coatings have very low moisture and oxygen transmission properties.
3. Vinyls and chlorinated rubbers are lacquers and are vulnerable to their solvents. This weakness helps in over coating as the next coat solvent bonds (welds) with the surface of the earlier coat. Chlorinated rubber is attacked by almost all common solvents.
4. Adhesion of vinyls to steel is high over a coat wash coat primer (Navy Formula 117), a vinyl butyral primer.
5. Vinyl bottom paint systems have been used by the Navy since about 1960, usually over a near white metal blast (SSPC-10), and a coat of vinyl butyral wash coat primer. A great system except in fresh water (Philadelphia), because of soluble chromates. *Cassin Young* (DD-796) was

inactivated at Norfolk in 1960 using the vinyl system, and stored in Philadelphia. Dry-docking in Boston in 1981, I can testify the system was still in remarkably good condition.

6. Vinyl film toughness allows it to resist ice damage.
7. Very good coatings in the right place, vinyls and chlorinated rubbers are probably doomed because of the VOCs in their solvents.

i. Coal Tar and Coal Tar Epoxies
    1. Coal tars go back to around 1000 A.D.
    2. Used because of very low water penetration and stand up very well against disintegration in water. Also, relatively inexpensive.
    3. Coal tars do not like sunlight;
    4. Great color selection in black, or almost black.
    5. Because of aromatic compounds, thought to be carcinogenic, use of coal tar epoxies is restricted by some countries. Although my reference notes no legislation to eliminate coal tar epoxies use in the U.S., as of 1996, great precautions are recommended both in application and removal due to flammability, toxicity, and carcinogenicity.
    6. Coal tar epoxies are heavy and usually need at least two coats to assure coverage of discontinuities. However, the overcoat time window is very limited before the coating becomes too hard and too slick for the next coat to adhere.
    7. National Shipbuilding Research Program, Surface Preparation and Coating Handbook, notes coal tar epoxy use restricted for reasons noted above (5) in U.S. Navy shipbuilding projects.

j. Organic and Inorganic Zinc rich Coatings
    1. The difference between the organic and inorganic coatings is the binder, often epoxy for the organic, and a silicate for the inorganic.
    2. Performance differences: In a sea coast marine environment, with commercial blast cleaning, SSPC-SP 6, the service life estimate for an inorganic zinc with high-build epoxy system versus organic zinc with high-build epoxy system is 15 years versus 13.5 years.
    3. However, the inorganic system requires more application expertise than the organic, both in regard to carefully monitoring ambient atmospheric conditions to assure appropriate inorganic zinc curing before top coating, and in applying the proper dry film thicknesses of both the inorganic zinc and the topcoats.
    4. Organic zincs are easier to top coat and are compatible with more coatings due to their denser surface. Based on average surface preparation for both types of zincs, organic zincs may outperform the inorganic product.
    5. Inorganics are highly resistant to abrasion, sunlight, and solvents. On inactive ships, the Navy recommends no over coating, but use the gray and not the reddish color!
    6. The Navy also likes inorganic zinc on the hull and boot top areas (2 feet above to 2 feet below the floatation waterline), suitably over coated.
    7. Zinc coatings are not recommended on the underwater body, particularly old steel. In 1988, both Devoe and Ameron strongly recommended against using zinc silicates (inorganic) on decks, because point loads from walking, loading stores. etc. would cause the coating to shatter, notwithstanding outstanding abrasion resistance.

k. Epoxies
    1. We are talking of two-component catalyzed epoxy resins. These break into the polyamine hardeners and polyamide hardeners.
        a. Polyamine hardeners are resistant to chemicals and solvents and are often used for lining tanks.

   b. Polyamide hardeners are the most popular coatings on structural steel, with superior flexibility and durability. The standard Navy hull coating is polyamide chemistry (MIL-P-24441), the well-known 150 series formulas.
2. Epoxies have poor resistance to sunlight, as evidenced by chalking. Chalking in itself does not affect the initial corrosion performance. As chalking washes off the coating becomes thinner, and then performance is affected.
3. In maintenance areas, high solid, high build epoxies with good surface wetting characteristics have been developed to overcoat aged coatings, such as lead-containing alkyds. These are the "Mastics".
   a. Applied to a marginally adhering base coating, they may well cause delamination.
   b. These mastics are referred to as "surface tolerant", but there are questions as to how much contamination they will tolerate before performance is sacrificed.
   c. Aluminum flake filled mastics are being used to successfully overcoat old alkyd lead containing coatings. The mastics are then themselves over coated. This delays deleading.
4. As noted earlier, epoxies have a definite overcoat time window, not too early and not too late.
5. Also as noted, application temperatures/humidity are critical. 50 F is normally the lower end. Devoe has a regular product, No. 235 that will cure at 0 F, a derivative of No. 230 with more usual curing characteristics. A product of this type allows potential dry-docking and painting in Boston during December into March.
6. Epoxies can be strong skin sensitizers and respiratory irritants and have to be handled very carefully. Thermal decomposition products are also of concern during structural maintenance work.
7. Some epoxies can, and do, cure underwater. My experience has been varied: temperature appears important as are considerations involving the effects of cathodic protection on the area to be plugged/coated. Leaking fuel is also a real problem.

3. Sources:

1. Generic Coating Types, an Introduction to Industrial Maintenance Coating Materials. L. M. Smith Editor Technology Publishing Company, Pittsburgh, PA, 1996
2. Surface Preparation & Coating Handbook, The National Shipbuilding Research Program
U.S. Department of the Navy Carderock Division, Naval Surface Warfare Center
Steel Structures Painting Council, Pittsburgh, PA 1994
3. Advance Change Notice 1/A, Naval Ships' Technical Manual 050, Inactivation and Maintenance of Ships and Craft, Naval Sea Systems Command, U.S. Navy, Arlington, VA 1994

Preparation and Painting of Interior and Exterior Areas by Ship's Maintenance Team.

Surface Preparation

Introduction.

Surface preparation is the single most important factor in determining coating durability. Available data and experience indicate that in most situations, money spent for a clean, well-prepared surface reduces life-cycle costs.

A proper surface preparation:

a) Removes surface contaminants (e.g., salts and chalk) and deteriorated substrate surface layers (e.g., rust and sunlight-degraded wood) which hinder coating adhesion and;

b) Produces a surface profile (texture) that promotes tight adhesion of the primer to the substrate.

Selection Factors.

Factors which should be considered in selecting the general type and degree of surface preparation are:

a) Type of the substrate

b) Condition of the surface to be painted

c) Type of exposure

d) Desired life of the structure, as some procedures are much more expensive than others

e) Coating to be applied

f) Environmental, time, and economical constraints

Specification Procedure.

A performance-based requirement for surface preparation, rather than a prescriptive requirement, is recommended for contract use. That is, it is usually better to describe the characteristics of the cleaned surface (e.g., profile and degree of chalk removal) than to specify the specific materials and procedures to be used. Often the general type of surface preparation (washing, blasting, etc.) is specified, because of job or other constraints, along with requirements for characteristics of the cleaned surface. In this way, the specifier allows the contractor to select the specific equipment, materials and procedures to get the job done and avoids putting contradictory requirements into the job specification.

Section Organization.
This section is organized into: discussions of repair procedures usually done in conjunction with a painting contract and prior to painting; specific recommendations for surface preparation procedures and standards for specific substrates; recommendations for coating removal; and general background information on surface preparation methods.

Surface preparation methods are summarized in Table 6.

Repair of Surfaces.

All surfaces should be in good condition before recoating. If repairs are not made prior to painting, premature failure of the new paint is likely. Rotten wood, broken siding, and other deteriorated substrates must be replaced or repaired prior to maintenance painting. Water associated problems, such as deteriorated roofs and non-functioning drainage systems, must be repaired prior to coating. Interior moist spaces, such as bathrooms and showers must be properly vented. Cracks, holes, and other defects should also be repaired.

Areas in need of repair can sometimes be identified by their association with localized paint failures. For example, localized peeling paint confined to a wall external to a bathroom may be due to inadequate venting of the bathroom.

Joints, Cracks, Holes, or Other Surface Defects.

Caulks and sealants are used to fill joints and cracks in wood, metal and, in some cases, in concrete and masonry. Putty is used to fill holes in wood. Glazing is used to cushion glass in window sashes. Specially formulated Portland cement materials are available for use in cracks and over spalled areas in concrete. Some of these contain organic polymers to improve adhesion and flexibility. Other materials are available to repair large areas of interior plaster (patching plaster), to repair cracks and small holes in wallboard (spackle), to fill joints between wallboards (joint cement), and to repair mortar. Before application of these repair materials, surfaces should be clean, dry, free of loose material, and primed according to the written instructions of the material manufacturer.

Caulking and sealant compounds are resin based viscous materials. These compounds tend to dry on the surface but stay soft and tacky underneath. Sealants have application properties similar to caulking materials but tend to be more flexible and have greater extendibility than caulks. Sealants are often considered to be more durable than caulks and may also be more expensive. Commonly available generic types of caulks and sealants include oil-based, butyl rubber, acrylic latex, silicone, polysulfide, and polyurethane. The oil-based and butyl-rubber types are continually oxidized by exposure to sunlight and become brittle on aging. Thus, their service life is limited. Acrylic-latex and silicone caulks tend to be more stable and have longer service lives. Applications are usually made with a caulking gun. However, some of these materials may also be available as putties or in preformed extruded beads that can be pressed in place. Putty and glazing compounds are supplied in bulk and applied with a putty knife. Putties are not flexible and thus should not be used for joints and crevices. They dry to form a harder surface than caulking compounds. Glazing compounds set firmly, but not hard, and thus retain some flexibility. Rigid paints, such as oil/alkyds, will crack when used over flexible caulking, sealing, and glazing compounds and should not be used.

Acrylic-latex paints, such as TT-P-19, Paint, Latex (Acrylic Emulsion, Exterior Wood and Masonry) are a better choice.

Cementitious Surfaces.

Epoxy resin systems for concrete repair are described in MIL-E-29245, Epoxy Resin Systems for Concrete Repair. This document describes epoxy repair materials for two types of application. They are: bonding hardened concrete to hardened concrete, and using as a binder in mortars and concrete. These types are further divided into classes based on working temperature. Thus, an appropriate material can be specified.

Recommendations by Substrate.

Each different type of construction material may have a preferred surface preparation method. For substrates, grease and oil are usually removed by solvent or steam cleaning and mildew is killed and removed with a hypochlorite (bleach) solution.

Wood. Bare wood should not be exposed to direct sunlight for more than 2 weeks before priming. Sunlight causes Photo degradation of surface wood-cell walls. This results in a cohesively weak layer on the wood surface which, when painted, may fail. If exposed, this layer should be removed prior to painting by sanding. Failure of paint caused by a degraded-wood surface is suspected when wood fibers are detected on the backside of peeling paint chips.

When the existing paint is intact, the surface should be cleaned with water, detergent, and bleach as needed to remove surface contaminants, such as soil, chalk, and mildew. When the existing paint is peeling and when leaded paint is not present, loose paint can be removed by hand scraping. Paint edges should be feathered by sanding. Power sanding may damage the wood if improperly done. Water and abrasive blasting are not recommended for wood, because these techniques can damage the wood. When leaded paint is present, special precautions, such as wet scraping, should be taken.

Table 6
Commonly Used Methods of Surface Preparation for Coatings
(IMPORTANT NOTE: Methods may require modification or special control when leaded paint is present.)

Cleaning Method	Equipment	Comments
Organic solvent	Solvent such as mineral spirits, sprayers, rags, etc.	Removes oil and grease not readily removed by other methods; precautions must be taken to avoid fires and environmental contamination; local VOC regulations may restrict use.
Detergent/ power washing	Pumps, chemicals, sprayers, brushes	At pressures not exceeding 2000 psi, removes soil, chalk, mildew, grease, and oil, depending upon composition; good for smoke, stain, chalk and dirt removal.
Acid	Chemicals, sprayers, and brushes	Removes residual efflorescence and laitance from concrete after dry brushing. Thoroughly rinse afterwards.
Chemical paint strippers	Chemicals, sprayers, scrapers, washing equipment	Removes coatings from most substrates, but slow, messy, and expensive; may degrade surface of wood substrates.
Steam	Heating system pump, lines, and nozzles	Removes heavy oil, grease, and chalk; usually used prior to other methods.
Water blasting	High pressure water pumps, lines, and nozzles	At pressures of 2000 psi and above, removes loose paint from steel, concrete and wood; can damage wood or masonry unless care is taken; inhibitor generally added to water to prevent flash rusting of steel.
Hand tool	Wire brushes, chipping hammers, and scrapers	Removes only loosely adhering contaminants; used mostly for spot repair; slow and not thorough.
Power tool	Wire brushes, grinders, sanders, needle guns, rotary peeners, etc.	Faster and more thorough than hand tools because tightly adhering contaminants can be removed; some tools give a near-white condition on steel but not an angular profile; slower than abrasive blasting; some tools are fitted with vacuum collection devices.
Heat	Electric heat guns	Can be used to soften coatings on wood, masonry, or steel; softened coatings are scraped away, torches SHOULD NOT be used.
Abrasive blasting	Sand, metal shot, and metal or synthetic grit propelled onto metal by pressurized air, with or without water, or centrifugal force	Typically used on metal and, with care on masonry; can use recyclable abrasives; special precautions are needed when removing lead containing paint. Water may be added to control dust and its addition may require use of inhibitors. Vacuum blasting reduces dust but is slower than open. Centrifugal blasting is a closed cycle system in which abrasive is thrown by a spinning vaned wheel.

Paint should be removed from wood when failure is by cross-grain cracking (that is, cracking perpendicular to the wood grain). This failure occurs when the total paint thickness is too thick and/or the paint is too inflexible.

Painting over this condition almost always results in early failure of the maintenance paint layer. Paint removal from wood is difficult and may not always be feasible. Chemical strippers can be used, but the alkaline types may damage (chemically degrade) the surface of the wood and cause a future peeling-paint failure.

Failure caused by a stripper-degraded wood surface is more likely for exterior exposures than for interior exposures. This is because the greater expansion and contraction of wood in exterior exposures requires that the surface wood have a greater mechanical strength.

Concrete/Masonry.

Bare concrete and masonry surfaces, as well as painted surfaces, are usually best cleaned with water and detergent. Use low-pressure washing (less than 2000 psi) or steam cleaning (ASTM D 4258) to remove loose surface contaminants from surfaces. Use high-pressure water blasting (greater than 2000 psi and usually about 5000 psi) (ASTM D 4259, Abrading Concrete) to remove loose old coatings or other more tightly held contaminates or chalk. If existing paints are leaded, special worker safety and environmental controls will be needed.

Abrasive blasting (ASTM D 4259 and D 4261, Surface Cleaning Concrete Unit Masonry for Coating) or acid etching of bare surfaces (ASTM D 4260, Acid Etching Concrete) may also be used to obtain a surface profile as well as clean surfaces for coating. Care must be taken to avoid damaging surfaces with high-pressure water or abrasives. Grease and oil must be removed with detergents or steam before abrasive blasting. Any efflorescence present should first be removed by dry wire brushing or acid washing. Special worker safety and environmental controls may be needed. Concrete surfaces must be completely dry prior to paint application for all types of paints except waterborne. The plastic sheet method (ASTM D 4263, Indicating Moisture in Concrete by the Plastic Sheet Method) can be used to detect the presence of water (i.e., tape a piece of plastic sheet to the surface, wait 24 hours and look for condensed moisture under the sheet - the inside of the sheet should be dry).

Steel.

The first step in preparing steel for coating is solvent cleaning as described in SSPC SP 1. Cleaning methods described in SSPC SP 1 include organic solvents, vapor degreasing, immersion in appropriate solvent, use of emulsion or alkaline cleaners, and steam cleaning with or without detergents.

SSPC SP 1 is specifically included as the first step in the SSPC surface preparation procedures. For large areas of uncoated steel and coated steel with badly deteriorated coatings, the preferred method of removing mill scale, rust and coatings is abrasive blasting (SSPC SP 7, SSPC SP 6, SSPC SP 10, SSPC SP 5). These methods can both clean the surface and produce a surface profile. The specific abrasive method selected depends upon the conditions of the steel, the desired coating life, the environment and the coating to be applied. If leaded paint is present, special precautions must be taken to protect workers and the environment. High-pressure water blasting, with or without injected abrasives, should be considered if dry abrasive blasting cannot be done because of environmental or worker safety restrictions.

Coating	Minimum Surface Preparation
Drying Oil	SSPC SP 2 or SSPC SP 3
Alkyd	SSPC SP 6 or SSPC-SP 11
	SSPC SP 3 for limited localized areas
Asphaltic	SSPC SP 6 or SSPC SP 11
Latex	SSPC SP 6 or SSPC SP 11
Vinyl Lacquer	SSPC SP 10
Chlorinated Rubber	SSPC SP 10
Epoxy	SSPC SP 6 or SSPC SP 10
Polyurethane	SSPC SP 10
Organic Zinc	SSPC SP 6 or SSPC SP 10
Inorganic Zinc	SSPC SP 10 or SSPC SP 5

For small localized areas, other cleaning methods such as hand tool cleaning (SSPC SP 2) or paw.

Specific Surface Preparation Requirements for Coatings for Steel. Different types of coatings may require different levels of cleaning. Commonly agreed upon minimum requirements are listed below. However, manufacturers of some specific coatings may require or recommend a cleaner surface. Conflicts between manufacturer's written instructions (tech data sheets) and contract specifications should be avoided.

For immersion or other severe environments, the higher level of the two options should be used. Higher levels may also be used to ensure the maximum lives from coating systems.

Galvanized and Inorganic-Zinc Primed Steel.

The recommended method of cleaning uncoated galvanized steel varies with the condition of its surface. Simple solvent (organic or detergent-based) cleaning (SSPC SP 1) is usually adequate for new galvanizing. This will remove oil applied to the galvanizing to protect it during exterior storage. If loose zinc corrosion products or coating are present on either galvanized or inorganic-zinc primed steel, they should be removed by bristle or wire brushing (SSPC SP 2 or SSPC SP 3) or water blasting. The method chosen must success-fully remove the contaminants. Uniform corrosion of unpainted galvanizing may expose the brownish iron/ zinc alloy. If this occurs, the surface should be painted as soon as possible. If rusting is present on older galvanized or on inorganic-zinc primed steel, remove the rust by sweep abrasive blasting (SSPC SP 7) or using power tools, such as wire brushing (SSPC SP 2, SSPC SP 3). Abrasive blasting is usually more appropriate when large areas are corroded, while the use of hand or power tools may be more appropriate when rusting is localized.

For either method, the procedure should be done to minimize removal of intact galvanizing or of the inorganic zinc primer. Deteriorated coatings should also be removed using abrasive blasting or hand or power tools. When leaded-coatings are present, special worker safety and environmental precautions must be taken.

Aluminum and Other Soft Metals.

New, clean aluminum and other soft metals may be adequately cleaned for coating by solvent cleaning (SSPC SP 1). The use of detergents may be required for removal of dirt or loose corrosion products. Abrasive blasting with plastic beads or other soft abrasives may be necessary to remove old coatings. Leaded coatings will require special worker safety and environmental precautions.

Standards for Condition of Substrates

Unpainted Steel.

Verbal descriptions and photographic standards have been developed for stating the condition of existing steel substrates. SSPC VIS 1, Abrasive Blast Cleaned Steel (Standard Reference Photographs) illustrates and describes four conditions of uncoated structural steel. They are:

Title	Grade
Adherent mill scale	A
Rusting mill scale	B
Rusted	C
Pitted and rusted	D

Since the condition of the surface to be cleaned affects the appearance of steel after cleaning, these conditions are used in the SSPC VIS 1 cleanliness standards described below.

Non-ferrous Unpainted Substrates.

Standards for Cleanliness of Substrates

Standards for Cleaned Steel Surfaces

SSPC and NACE Definitions and Standards. The SSPC and the NACE Standards are used most frequently for specifying degree of cleanliness of steel surfaces. SSPC has standard definitions and photographs for common methods of cleaning (SSPC VIS 1 and SSPC VIS 3, Power- and Hand-Tool Cleaned Steel). NACE TM0170,

Surfaces of New Steel Air Blast Cleaned With Sand Abrasive; definitions and metal coupons) covers only abrasive blasting. Volume 2 of SSPC Steel Structures Painting Manual contains all the SSPC standards, as well as other useful information. For both types of standards, the definition, rather than the photograph or coupon, is legally binding. The SSPC and NACE surface preparation standards are summarized in Table 7.

To use the SSPC or NACE standards, first determine the condition of steel that is to be blasted (e.g., Grade A, B, C, or D), since different grades of steel blasted to the same level do not look the same. After determining the condition of steel, compare the cleaned steel with the pictorial standards for that condition. The appearance of blasted steel may also depend upon the type of abrasive that is used. NACE metal coupons represent four degrees of cleanliness obtained using one of three types of abrasives - grit, sand, or shot.

Job-Prepared Standard. A job-specific standard can be prepared by blasting or otherwise cleaning a portion of the structure to a level acceptable to both contractor and contracting officer, and covering it with a clear lacquer material to protect it for the duration of the blasting. A 12-inch steel test plate can also be cleaned to an acceptable level and sealed in a water- and grease-proof bag or wrapper conforming to MIL-B-131, Barrier Materials, Water Vapor proof, Greaseproof, Flexible, Heat-Sealable.

Pictorial Standards for Previously Painted Steel. Photographic standards for painted steel are available in the Society for Naval Architects and Engineers Abrasive Blasting Guide for Aged or Coated Steel Surfaces. Pictures representing paint in an original condition and after each degree of blasting are included.

Table 7
SSPC and NACE Standards for Cleaned Steel Surfaces

Method	SSPC No.	NACE No.	Intended Use
Solvent Cleaning	SSPC SP 1		Removal of oil and grease prior to further cleaning by another method
Hand Tool	SSPC SP 2		Removal of loose mill scale, rust, and paint
Power Tool	SSPC SP 3		Faster removal of loose mill scale, rust, and coatings than hand tool cleaning
White Metal Blast	SSPC SP 5	NACE 1	Removal of visible contaminants on steel surfaces; highest level of cleaning for steel
Commercial Blast	SSPC SP 6	NACE 3	Removal of all visible contaminants except that one third of a steel surface may have shadows, streaks, or stains
Brush-Off Blast	SSPC SP 7	NACE 4	Removal of loose mill scale, rust, and paint (loose paint can be removed with dull putty knife)
Pickling	SSPC SP 8		Removal of mill scale and rust from steel
Near-White Blast	SSPC SP 10	NACE 2	Removal of visible contaminants except that 5 percent of steel surfaces may have shadows, streaks, or stains
Power Tool Cleaning	SSPC SP 11		Removal of visible contaminants (surface is comparable to SSPC SP 6, also provides profile)

Standards for Cleaned Nonferrous Metals.

No industry standards describe the degree of cleaning of nonferrous metals, and previously painted non-steel substrates.

Previously Coated Surfaces. When the surface to be painted is an old weathered coating film (that is, surface preparation will not include removal of the old coating), ASTM visual standards should be used for chalk, mildew, and dirt removal. In general, a minimum chalk rating (ASTM D 4214, Evaluating Degree of Chalking of Exterior Paint Films) of 8 should be required for chalk removal, a minimum mildew removal rating (ASTM D 3274, Evaluating Degree of Surface Disfigurement of Paint) of 8 (preferably 10) should be required for mildew removal, and an ASTM D 3274 rating of 10 should be required for dirt removal. Consideration should be given to requiring preparation of a job-specific standard when large jobs are contracted. This standard should cover removal of loose material, chalk, and mildew, as well as feathering of edges, and other requirements of the contract specification.

Recommendations for Paint Removal.

It is often necessary to remove old coatings that are peeling, checking, cracking, or the like. General recommendations for removal of paint from a variety of substrates are made in Table 8.

Table 8
Procedures for Coating Removal
(IMPORTANT NOTE - Presence of Leaded Paint Will Require Environmental and Worker Safety Controls)

Substrate	Methods
Wood	Chemical removers; heat guns or hot plates along with scraping; power sanding (must be done with caution to avoid damaging wood).
Masonry	Careful water blasting to avoid substrate damage; brush-off blasting and power tools, used with caution.
Steel	Abrasive blasting; water blasting.
Miscellaneous metals	Chemicals; brush-off blast; water blast

Methods of Surface Preparation.

Information on surface preparation methods and procedures are presented to help select appropriate general procedures and to inspect surface preparation jobs. It is not intended to be a complete source of information for those doing the work.

Abrasive Blasting. Abrasive blast cleaning is most often associated with cleaning painted and unpainted steel. It may also be used with care to prepare concrete and masonry surfaces and to clean and roughen existing coatings for painting. Abrasive blasting is an impact cleaning method. High-velocity abrasive particles driven by air, water, or centrifugal force impact the surface to remove rust, mill scale, and old paint from the surfaces. Abrasive cleaning does not remove oil or grease.

If the surface to be abrasive blasted is painted with leaded paint, additional controls must be employed to minimize hazards to workers and the surrounding environment. There are four degrees of cleanliness of blast cleaning designated by the SSPC and the NACE for steel substrates. These designations are white metal, near-white metal, commercial, and brush-off.

The degree of cleanliness obtained in abrasive blasting depends on the type of abrasive, the force with which the abrasive particles hits the surface, and the dwell time.

Types of Abrasive Blasting

a) Air (Conventional). In conventional abrasive blasting (Figure 1), dry abrasive is propelled against the surface to be cleaned so that rust, contaminates, and old paint are removed by the impact of the abrasive particles. The surface must be cleaned of blasting residue before painting. This is usually done by blowing clean air across the surfaces. Special care must be taken to ensure that horizontal or other obstructed areas are thoroughly cleaned. Uncontrolled abrasive blasting is restricted in most locations because of environmental regulations. Consult the local industrial hygiene or environmental office for regulations governing local actions.

Procedures for containment of blasting debris are being used for paint removal from industrial and other structures. The SSPC has developed a guide (SSPC Guide 6I) for selecting containment procedures depending upon the degree of containment desired. The amount of debris generated can be reduced by recycling the abrasive. Recycling systems separate the paint waste from the abrasive.

b) Wet. Wet-abrasive blasting is used to control the amount of airborne dust. There are two general types of wet abrasive blasting. In one, water is injected near the nozzle exit into the stream of abrasive (Figure 2). In the other, water is added to the abrasive at the control unit upstream of the nozzle and the mixture of air, water, and sand is propelled through the hose to the nozzle. For both types of wet-blasting, the water may contain a corrosion inhibitor. Inhibitors are generally sodium, potassium, or ammonium nitrites, phosphates or dichromates. Inhibitors must be chosen to be compatible with the primer that will be used. After wet blasting, the surface must be rinsed free of spent abrasive. (The rinse water should also contain a rust inhibitor when the blasting water does.) Rinsing can be a problem if the structure contains a large number of ledges formed by upturned angles or horizontal girders since water, abrasives, and debris tend to collect in these areas. The surface must be completely dry before coating. When leaded paint is present, the water and other debris must be contained and disposed of properly. This waste may be classified as a hazardous waste under Federal and local regulations, and must be handled properly.

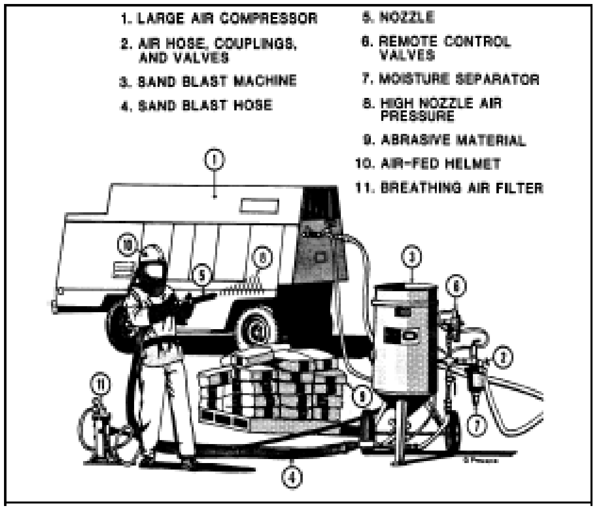

Figure 1
Schematic Drawing Illustrating Components of Conventional Abrasive Blasting Equipment

c) Vacuum. Vacuum blasting systems collect the spent abrasives and removed material, immediately adjacent to the point of impact by means of a vacuum line and shroud surrounding the blasting nozzle. Abrasives are usually recycled. Production is slower than open blasting and may be difficult on irregularly shaped surfaces, although shrouds are available for non-flat surfaces. The amount of debris entering the air and the amount of cleanup is kept to a minimum if the work is done properly (e.g., the shroud is kept against the surface). This procedure is often used in areas where debris from open air blasting or wet blasting cannot be tolerated.

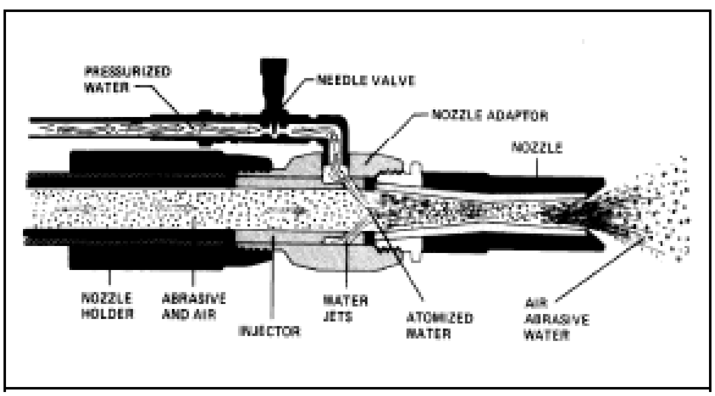

Figure 2
Schematic Drawing of Cross Section of Typical Water-Injected Wet Abrasive Blasting Nozzle

d) Centrifugal. Cleaning by centrifugal blasting is achieved by using machines with motor-driven bladed wheels to hurl abrasives at a high speed against the surface to be cleaned. Advantages over conventional blasting include savings in time, labor, energy, and abrasive; achieving a cleaner, more uniform surface; and better environmental control. Disadvantages of centrifugal blasting include the difficulty of using it in the field, especially over uneven surfaces, although portable systems have been developed for cleaning structures such as ship hulls and storage tanks. Robots may be used to guide the equipment. In many cases, the abrasive used is reclaimed and used again.

Conventional Abrasive Blasting Equipment. Components of dry abrasive blasting equipment are air supply, air hose and couplings, abrasive blast machines, abrasive blast hose and couplings, nozzles, operator equipment, and oil and moisture separators. A brief description of each component follows:

a) Air Supply. The continuous and constant supply of an airstream of high pressure and volume is one of the most critical parts of efficient blasting operations. Thus, the air supply (compressor) must be of sufficient capacity. Insufficient air supply results in excessive abrasive use and slower cleaning rates. The compressor works by taking in, filtering, and compressing a large volume of air by rotary or piston action and then releasing it via the air hose into the blasting machine.

The capacity of a compressor is expressed in volume of air moved per unit time (e.g., cubic feet per minute (cfm)) and is directly related to its horsepower. The capacity required depends upon the size of the nozzle orifice and the air pressure at the nozzle. For example, a flow of 170 to 250 cfm at a nozzle pressure of 90 to 100 psi is necessary when using a nozzle with a 3/8 to 7/16 inch orifice. This typically can be achieved with a 45 to 60 horsepower engine.

b) Air-Supply Hose. The air-supply hose delivers air from the compressor to the blasting machine. Usually the internal diameter should be three to four times the size of the nozzle orifice. The length of the hose should be as short as practical because airflow through a hose creates friction and causes a pressure drop. For this reason, lines over 100 feet long generally have internal diameters four times that of the nozzle orifice.

c) Blasting Machine. Blasting machines or "sand pots" are the containers which hold the abrasives. The capacity of blasting machines varies from 50 pounds to several tons of abrasive material. The blasting machine should be sized to maintain an adequate volume of abrasive for the nozzles.

d) Abrasive Blasting Hose. The abrasive blasting hose carries the air and abrasive from the pot to the nozzle. It must be sturdy, flexible, and constructed or treated to prevent electrical shock. It should also be three to four times the size of the nozzle orifice, except near the nozzle end where a smaller diameter hose is attached.

e) Nozzles. Nozzles are available in a great variety of shapes, sizes, and designs. The choice is made on the basis of the surface to be cleaned and the size of the compressor. The Venturi design (that is, large throat converging to the orifice and then diverging to the outlet, Figure 3) provides increased speed of abrasive particles through the nozzle as compared with a straight bore nozzle. Thus, the rate of cleaning is also increased. Nozzles are available with a variety of lengths, orifice sizes, and lining materials. The life of a nozzle depends on factors such as the lining material and the abrasives and varies from 2 to 1500 hours. Nozzles should be inspected regularly for orifice size and wear. Worn nozzles result in poor cleaning patterns and efficiency.

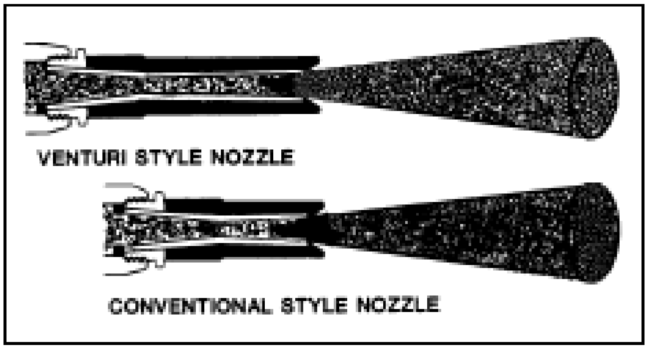

Figure 3
Cross-Sectional Drawing of Nozzles

f) Oil/Moisture Separators. Oils used in the compressor could contaminate the air supply to the nozzles. To combat this, oil/moisture separators are installed at the blast machine. The separators require periodic draining and routine replacement of filters. Contamination of the air supply can be detected by a simple blotter test. In this test, a plain, white blotter is held 24 inches in front of the nozzle with only the air flowing (i.e., the abrasive flow is turned off) for 1 to 2 minutes. If stains appear on the blotter, the air supply is contaminated and corrective action is required. ASTM D 4285, Indicating Oil or Water in Compressed Air describes the testing procedure in more detail.

g) Operators Equipment. The operators equipment includes a protective helmet and suit. The helmet must be air-fed when blasting is done in confined or congested areas. To be effective it must furnish respirable air to the operator at a low noise level, protect the operator from rebounding abrasive particles, provide clear vision to the operator, and be comfortable and not restrictive. Air-fed helmets must have National Institute of Safety and Hygiene (NIOSH) approval.

h) Wet Blasting. In addition to equipment needed for dry abrasive blasting, metering, delivery, and monitoring devices for water are needed.

i.) Vacuum Blasting. Although there are many designs for vacuum blasting equipment, all systems have a head containing a blast nozzle, surrounded by a shroud connected to a vacuum system, and a collection chamber for debris.

j) Centrifugal Blasting. In centrifugal blasting, abrasive is hurled by wheels instead of being air-driven. This type of blasting is often used in shop work. Portable devices have been developed for use on flat surfaces. Abrasive is contained and usually recycled.
Abrasive Properties.

The SSPC has a specification for mineral and slag abrasive, SSPC AB 1, Mineral and Slag Abrasives.
Abrasives covered by the specification are intended primarily for one-time use without recycling. The specification has requirements for specific gravity, hardness, weight change on ignition, water soluble contaminant, moisture content and oil content. MIL-A-22262, Abrasive Blasting Media, Ship Hull Blast

Cleaning, a Navy Sea Systems specification for abrasives, also limits the heavy metal content of abrasives. These and other properties of abrasives are discussed below:

a) Size. Abrasive size is a dominant factor in determining the rate of cleaning and the profile obtained. A large abrasive particle will cut deeper than a small one of the same shape and composition, however, a greater cleaning rate is generally achieved with smaller-sized particles. Thus, a mix is generally used.

b) Shape. The shape and size of abrasive particles determine the surface profile obtained from blasting (Figure 4). Round particles, such as shot, produce a shallow, wavy profile. Grit, which is angular, produces a jagged finish. Usually a jagged finish is preferred for coating adhesion. Round particles are well suited for removal of brittle contaminants like mill scale and are also used when little or no change in surface configuration is permitted. Sand and slag, which are semi-angular, produce a profile that is somewhere between that of shot and grit. Currently, sand is used much less than other abrasives because of health and breakdown factors.

c) Hardness. Hard abrasives usually cut deeper and faster than soft abrasives. Hence, hard abrasives are best suited for blast cleaning jobs where the objective is to remove surface coatings. Soft abrasives, such as walnut hulls, can remove light contaminants without disturbing a metal substrate or, in some cases, the existing coating system.

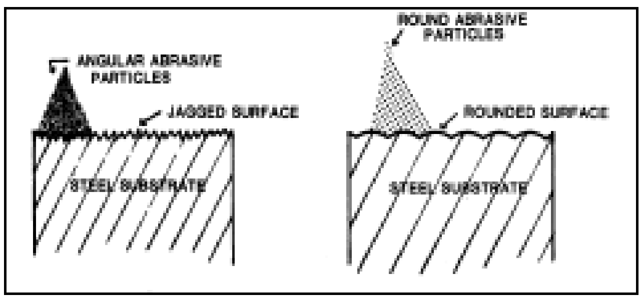

Figure 4
Drawing Illustrating Effect of Shape of Abrasive Particle on Contour of Blast-Cleaned Metallic Substrate

d) Specific Gravity. Generally the more dense a particle, the more effective it is as an abrasive. This is because it takes a certain amount of kinetic energy to remove contaminants from the surface and the kinetic energy of an abrasive particle is directly related to its density (specific gravity).

e) Breakdown Characteristics. Abrasive particles striking the surface at high speeds are themselves damaged. The way in which they fracture (breakdown) and/or in which they change their shape and size is called their breakdown characteristic. An excessive breakdown rate results in a significant increase in dusting, requires extra surface cleaning for removal of breakdown deposits, and limits the number of times the abrasive can be reused.

f) Water-Soluble Contaminants. ASTM D 4940, Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives describes a conductivity test for determining the level of contamination of metallic, oxide, slags, and synthetic abrasives by water-soluble salts. SSPC AB 1 requires that the conductivity of the test solution be below 100 microsiemens.

Abrasive Types.

Abrasives fall into seven general categories: metallic, natural oxides, synthetic, slags, cellulose (such as walnut hulls), dry ice pellets (carbon dioxide), sodium bicarbonate, and sponge. A summary of typical properties of some of these abrasives is found in Table 9.

Table 9
Typical Physical Characteristics of Abrasives (1)

	Hardness	Shape	Specific Gravity	Bulk Density (pounds per cubic foot)	Color	Free Silica Wt Percent	Degree of Dusting
Naturally Occurring Abrasives							
	(Mohs Scale)						
Sands: Silica	5	Rounded	2 to 3	100	White	90 +	High
Mineral	5 to 7	Rounded	3 to 4	125	Variable	< 5	Medium
Flint	6.7 to 7	Angular	2 to 3	80	Lt. Grey	90 +	Medium
Garnet	7 to 8	Angular	4	145	Pink	Nil	Medium
Zircon	7.5	Cubic	4.5	185	White	Nil	Low
Novaculite	4	Angular	2.5	100	White	90 +	Low
By-Product Abrasives							
	(Mohs Scale)						
Slags: Boiler	7	Angular	2.8	85	Black	Nil	High
Copper	8	Angular	3.3	110	Black	Nil	Low
Nickel	8	Angular	2.7	85	Green	Nil	High
Walnut Shells	3	Cubic	1.3	45	Brown	Nil	Low
Corn Cobs	4.5	Angular	1.3	30	Tan	Nil	Low
Manufactured Abrasives							
	(Mohs Scale)						
Silicon Carbide	9	Angular	3.2	105	Black	Nil	Low
Aluminum Oxide	8	Blocky	4.0	120	Brown	Nil	Low
Glass Beads	5.5	Spherical	2.5	100	Clear	67	Low
Metallic Abrasives							
	(Rockwell C)						
Cast Steel (2) Shot & Grit	as spec. or range 35-65 RC	Spherical or Angular	3 to 10		Grey	Nil	
Malleable Iron Shot or Grit	range: 28-40 RC	Spherical or Angular	3 to 10		Grey	Nil	
Chilled Cast Iron Shot or Grit	range: 57-65 RC	Spherical or Angular	3 to 10		Grey	Nil	

NOTES: (1) Taken from SSPC SP COM, Steel Structures Painting Manual, Systems and Specifications, Vol. 2, p. 17, and Vol. 1 of Good Painting Practice, p. 34.
(2) Represents 85 percent of the metallic abrasives used.

a) Metallic. Steel shot and grit are the most commonly used metallic abrasives. Metallic abrasives are used to remove mill scale, rust, and old paint and provide a suitable anchor pattern. The advantages of metallic abrasives include longer useful life (can be recycled many times), greater impact energy for given particle size, reduced dust formation during blasting, and minimal embedment of abrasive particles. The disadvantages include blast cleaning equipment must be capable of recycling, abrasives must be kept dry to prevent corrosion, and impact of steel shot on metal surfaces may cause formation of hackles on the surface. These hackles are relatively long slivers of metal and must be removed mechanically by sanding or grinding before coating to prevent pinpoint corrosion through the paint film.

b) Natural Oxides. Silica is the most widely used natural oxide because it is readily available, low in cost, and effective. Sand particles range from sharply angular to almost spherical, depending on the source. OSHA and EPA regulations have restricted the use of sand in many areas. Non-silica sands generally termed "heavy mineral" sands) are also being used for blast cleaning. However, they are generally of finer particle size than silica sand and are usually more effectively used for cleaning new steel than for maintenance applications.

c) Synthetics. Aluminum oxide and silicon carbide are nonmetallic abrasives with cleaning properties similar to the metallics and without the problem of rusting. They are very hard, fast-cutting and low-dusting, but they are costly and must recycled for economical use. They are often used to clean hard, high tensile strength metals.

d) Slags. The most commonly used slags for abrasives by-products from metal smelting (metal slags) and electric power generation (boiler slags). Slags are generally hard, glassy, homogeneous mixtures of various oxides. They usually have an angular shape, a high breakdown rate, and are not suitable for recycling.

e) Cellulose Type. Cellulose type abrasives, such as walnut shells and corncobs, are soft, low density materials used cleaning of complex shaped parts and removing dirt, loose paint, or other deposits on paint films. Cellulose type abrasives will not produce a profile on a metal surface.

f) Dry Ice. Special equipment is used to convert liquid carbon dioxide into small pellets which are propelled against the surface. Since the dry ice sublimes, the abrasive leaves no residue. The method can be used to remove paint from some substrates, but not mill scale and will not produce a profile. Paint removal is slow (and very difficult from wood) and the equipment needed to carry out the blasting is expensive.

g) Sponge. Specially manufactured sponge particles, with or without impregnated hard abrasive, are propelled against the surface. Less dust is created when sponge abrasive is used as compared to expendable or recyclable abrasives. The sponge is typically recycled several times. If sponge particles with impregnated hard abrasive are used, a profile on a metal can be produced. Sponge blasting is typically slower than with conventional mineral or steel abrasives.

h) Sodium Bicarbonate. Sodium bicarbonate particles are propelled against the surface, often in conjunction with high-pressure water. This method provides a way to reduce waste if the paint chips can be separated from the water after cleaning since sodium bicarbonate is soluble in water. These particles can be used to remove paint, but not mill scale or heavy corrosion

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Selection.

Selection of the proper abrasive is a critical part of achieving the desired surface preparation. Factors that influence the selection include: desired degree of cleanliness; desired profile; degree of rusting; deep pits; and kind and amount of coating present. Since obtaining the desired degree of cleanliness and profile are the main reasons for impact cleaning, they must be given priority over all other factors except environ-mental ones in abrasive selection.

Inspection.

Abrasives must be dry and clean. It is most important that they are free of inorganic salts, oils, and other contaminants. There are only limited standard procedures for inspecting abrasives. The following general procedure is suggested:

a) Visually inspect the abrasive to ensure that it is dry,

b) Test for presence of water soluble salts by following ASTM D 4940 in which equal volumes of water and abrasive are mixed and allowed to stand for several minutes and the conductivity of the supernatant is measured using a conductivity cell and bridge,

c) Examine the supernatant of the ASTM D 4940 test for presence of an oil film.

Procedures/General Information.

Good blasting procedures result in efficient and proper surface preparation. Adequate pressure at the nozzle is required for effective blasting. Other factors, such as flow of abrasive, nozzle wear, position of the nozzle with respect to the surface, and comfort of operator are also important. A well trained operator is essential to obtaining an acceptable job.

a) Handling the Nozzle. The angle between the nozzle and the surface and the distance between the nozzle and surface are important factors in determining the degree and rate of cleaning (Figure 5). The working angle will vary from 45 to 90 degrees depending upon the job. To remove rust and mill scale, the nozzle is usually held at an angle of between 80 and 90 degrees to the surface. This is also the preferred configuration for cleaning pitted surfaces. A slight downward angle will direct the dust away from the operator and ensure better visibility. A larger angle between nozzle and surface allows the operator to peel away heavy coats of old paint and layers of rust by forcing the blast under them. Other surface contaminants may be better removed with a cleaning angle of from 60 to 70 degrees.

By varying the distance between the nozzle and the surface, the type and rate of cleaning can also be varied. The closer the nozzle is to the surface, the smaller the blast pattern and the more abrasive strikes it. Thus, a greater amount of energy impacts the surface per unit area than if the nozzle were held further away. A close distance may be required when removing tight scale, for example. However, a greater distance may more effectively remove old paint. Once an effective angle and distance have been deter-mined, each pass of the nozzle should occur in a straight line to keep the angle and distance between the nozzle and the surface the same (Figure 6). Arcing or varying the distance from the surface will result in a non-uniform surface.

b) Rates. The rate of cleaning depends on all of the factors discussed above. Abrasive blasting of steel to a commercial degree of cleanliness (SSPC SP 6 or better) is much slower than painting. No more steel surface area should be blast cleaned at one time than can be primed the same day, since significant rusting can occur overnight. If rusting does occur, the surface must be re-blasted before painting.

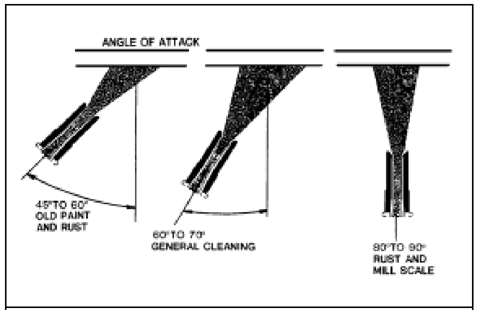

Figure 5
Schematic Illustrating Typical Cleaning Angles
for Various Surface Conditions

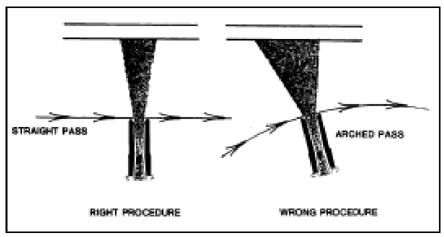

Figure 6
Illustration of Proper Stroke Pattern for Blast Cleaning

Acid Cleaning.

Acid cleaning is used for cleaning efflorescence and laitance from concrete.

APPLICATION OF PAINT

Introduction.

This section provides general information on paint application and on activities associated with application such as paint storage and mixing. Application procedures discussed include brushing, rolling, and spraying (conventional air, airless, air-assisted airless, high-volume low-pressure, electrostatic, plural component, thermal, and powder).

Paint Storage Prior to Application.

The installation industrial hygienist should be consulted about local regulations for paint storage, since storage of paint may be subject to hazardous product regulations. To prevent premature failure of paint material and to minimize fire hazard, paints must be stored in warm, dry, well ventilated areas. They should not be stored outdoors, exposed to the weather. The storage room or building should be isolated from other work areas. The best temper-ature range for storage is 50 to 85 degrees F. High temperatures may cause loss of organic solvent or premature spoilage of water-based paints. Low temperature storage causes solvent-borne coatings to increase in viscosity, and freezing can damage latex paints and may cause containers to bulge or burst. (When paint is cold, a 24-hour conditioning at higher temperatures is recommended prior to use.) Poor ventilation of the storage area may cause excessive accumulation of toxic and/or combustible vapors. Excessive dampness in the storage area can cause labels to deteriorate and cans to corrode. Can labels should be kept intact before use and free of paint after opening so that the contents can readily be identified. The paint should never be allowed to exceed its shelf life (normally 1 year from manufacture) before use. The stock should be arranged, so that the first paint received is the first paint used. Paint that has been stored for a long period of time should be checked for quality and dry time before use.

Preparing Paint for Application

Mixing.

During storage, heavy pigments tend to settle to the bottom of a paint can. Prior to application, the paint must be thoroughly mixed to obtain a uniform composition. Pigment lumps or caked pigment must be broken up and completely re-dispersed in the vehicle. Incomplete mixing results in a change of the formulation that may cause incomplete curing and inferior film properties. However, caution must be used not to over-mix waterborne paints since excessive foam can be created. Constant mixing may be required during application for paints with heavy pigments, such as inorganic zincs. Mixing can be done either manually or mechanically.

Two types of mechanical mixers are commonly used: ones which vibrate and ones which stir with a propeller. Since manual mixing is usually less efficient than mechanical mixing, paints should only be manually mixed when little mixing is needed because there is limited pigment settling or when mechanical mixing is not possible. Vibrator-type mixers should not be used with partly full cans of paint. This can cause air to become entrained in the paint which, if applied, may lead to pinholes in the dry film.

When pigments form a rather hard layer on the bottom of the can, the upper portion of the settled paint can be poured into a clean container (Figure 7), so that the settled pigment can more easily be broken up and re-dispersed to form a smooth uniform thin paste. When mixing manually, lumps may be broken up by pressing them against the wall of the can. It is essential that settled pigments be lifted from the bottom of the can and re-dispersed into the liquid. Once the material is uniform, the thin upper portion of the container is slowly poured into the uniform paste while the paint is stirred. Stirring is continued until the entire contents is uniform in appearance. No more paint should be mixed than can be applied in the same day. Paint should not be allowed to remain in open containers overnight.

Mixing Two-Component Coatings.

Epoxies and polyurethanes are commonly used two-component coatings. The base component, A, contains the pigment, if any. The B component contains the curing agent. The two components must be mixed in the ratio specified by the coating manufacturer on the technical data sheet, unless the coating is being applied using a plural component gun. Usually the materials are supplied so that the contents of one can of component A is mixed with the contents of one can of component B. Failure to mix the components in the proper ratio will likely result in poor film formation. Binder molecules are cross-linked in a chemical reaction upon mixing of the two components. Unless the two components are mixed together, there will be no chemical reaction and no curing of the paint.

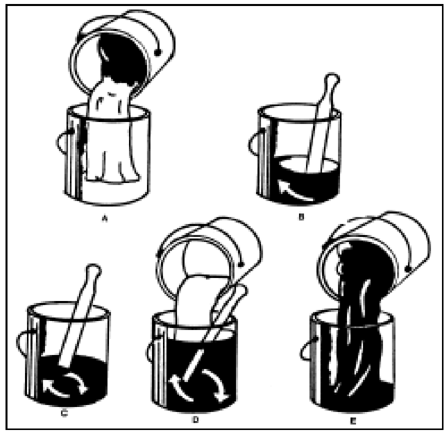

Figure 7
Illustration of Mixing and "Boxing" One-Component Paint: A - Pouring Off Pigment-Poor Vehicle, B and C - Mixing Pigment to Form Smooth Paste, D - Pouring in Vehicle and Mixing, E - Boxing Paint

a) Mixing. Two-component coatings are preferably mixed with a mechanical stirrer as follows:

(1)The base component is mixed to disperse settled pigment. If necessary, some of the thin, upper portion may be poured off before stirring to make it easier to disperse the pigment. When the upper portion is poured off, it must be mixed back with the bottom portion before the two components are mixed together.

(2) While continuing to stir, the two components are slowly mixed together. No more than a few gallons should be mixed at a time, or no more than that specified by the coating manufacturer, since heat is usually generated upon mixing because of the chemical cross-linking reaction. Excessive heat may lead to premature curing of the coating, reducing the pot life.

(3) The two combined parts are agitated until they are of smooth consistency and of uniform color. (Often the color of the two components is different.)

b) Induction. Some two-component paints must stand for approximately 30 minutes after mixing before application. This time is called the induction time. During induction, the chemical reaction proceeds to such an extent that the paint can be successfully applied. However, some formulations of two component paints do not require any induction time and can be applied immediately after mixing the two components. Material specifications and manufacturer's recommendations must be followed carefully. Induction time will depend on temperature of
the paint.

c) Pot Life. Pot life is the time interval after mixing in which a two-component paint can be satisfactorily applied. Paints low in VOC content often have a reduced pot life. The chemical reaction that occurs when two component paints are mixed accelerates with increasing temperature. Thus, paint’s pot life decreases as the temperature increases. Above 90 degrees F, the pot life can be very short. (Curing time of the applied coating is also faster at higher temperatures.) Pot life is also affected by the size of the batch mixed, because the chemical reaction produces heat. The larger the batch, the more the heat produced and the faster the curing reaction proceeds. Thus, the shorter the pot life. Paint must be applied within the pot life. The coating manufacturer's recommendations must be followed carefully. Mixed two-component paint remaining at the end of a shift cannot be reused and must be discarded. Lines, spray pots, and spray guns must be cleaned during the pot life of the paint.

Thinning.

Usually thinning to change the viscosity of liquid paint should not be necessary. A manufacturer formulates paint to have the proper viscosity for application. If thinning is necessary, it must be done using a thinner recommended by the coating manufacturer. Also, the amount used should not exceed that recommended by the coating manufacturer. Prior to adding the thinner, the temperature of the coating and the thinner should be about the same. The thinner must be thoroughly mixed into the paint to form a homogeneous material. Some "false bodied" or "thixotropic" paints are formulated to reach the proper application viscosity after stirring or during brush or roller application. Undisturbed in the can, they appear gel like, but upon stirring or under the high shear of brush or roller application, these materials flow readily to form smooth films. Upon standing, the coating in the can will again become gel-like. Because of this property, thixotropic coatings may require constant agitation during spray application.

Tinting.

Tinting should be avoided as a general practice. If materials are tinted, the appropriate tint base (e.g., light and deep tones) must be used. Addition of excessive tinting material may cause a mottled appearance or degrade the film properties (e.g., adhesion). Also, tinting should only be done with colorants (tints) known to be compatible with the base paint. No more than 4 ounces of tint should be added per gallon of paint.

Straining.

Usually, paint in freshly opened containers should not require straining. However, mixed paint having large particles or lumps must be strained to prevent the film from having an unacceptable appearance or clogging spray equipment. Straining is especially important for inorganic zinc coatings. Straining is done after mixing, thinning, and tinting is completed by putting the paint through a fine sieve (80 mesh) or a commercial paint strainer.

Weather Conditions Affecting Application of Paints.

Paint application is a critical part of a complete paint system. Many of the newer paints are more sensitive to poor application procedures and environmental conditions than oil paints. Four main weather conditions must be taken into account before applying coatings: temperature, humidity, wind, and rain or moisture. The paint manufacturer's technical data sheets should be consulted to determine the limits for these conditions as well as other constraints on application of the paint. Applying paints outside the limits is likely to lead to premature coating failure.

Temperature.

Most paints should be applied when the ambient and surface temperature is between 45 degrees F and 90 degrees F. Lacquer coatings such as vinyls and chlorinated rubbers, can be applied at temperatures as low as 35 degrees F.

There are other special coatings that can be applied at temperatures below 32 degrees F but only in strict compliance with manufacturer's instructions. Application of paints in hot weather may also cause unacceptable films. For example, vinyls may have excessive dry spray and latex paints may dry before proper coalescence, resulting in mud-cracking. In all cases painting must be done within the manufacturer's acceptable range. Also, the temperature of the paint material should be at least as high as the surface being painted. Paint should not be applied when the temperature is expected to drop below 40 degrees F before the paint has dried (except when allowed in the manufacturer's instructions).

Humidity.

Ensuring the proper relative humidity during application and cure can be essential for good film performance. However, different types of coatings require different relative humidity. The coating manufacturer's technical data sheet should be consulted. Some coatings cure by reacting with moisture from the air (e.g., moisture-curing polyurethanes, silicones, and inorganic zincs). These coatings require a minimum humidity to cure. However, too high a humidity may cause moisture-curing coatings to cure too quickly resulting in a poorer film. In addition, too high a humidity may cause blushing (whitish cast on surface of dry film) of some solvent-borne coatings. Blushing is caused when the surface of a coating film is cooled by evaporation of a solvent to such an extent that water condenses on the still wet film. Excessive humidity may also cause poor coalescence of latex coatings since the coalescing agent may evaporate before enough water evaporates to cause coalescence of the film.

Wind.

Wind can cause a number of problems during spray application. These include uncontrollable and undesirable overspray and dry spray caused by too fast evaporation of the solvents. The wind velocity at which these undesirable effects occur depends upon the material being applied and the application parameters. Wind can also blow dust and dirt onto a wet surface which could lead to future paint breakdown.

Moisture.

Paint should not be applied in rain, wind, snow, fog, or mist, or when the surface temperature is less than 5 degrees F above the dew point. Water on the surface being painted will prevent good adhesion.

Methods of Application.

The most common methods of application are brush, roller, and spray. They are discussed in detail below. Paint mitts are recommended only for hard to reach or odd-shaped objects such as pipes and railings when spraying is not feasible. This is because it is not possible to obtain a uniform film that is free of thin spots with mitt application.

Foam applicators are useful for touch-up or trim work. Dip and flow coat methods are beyond the scope of this handbook. Of the three primary methods, brushing is the slowest, rolling is faster, and spraying is usually the fastest of all. A comparison of approximate rates of application by one painter of the same paint to flat areas is listed in Table 10.

Table 10
Approximate Rates of Paint Application
(From SSPC Good Painting Practice)

Method	Square Feet Applied in 8 Hour Day
Brush	800 - 1400
Roller	2000 - 4000
Air Spray	4000 - 8000
Airless Spray	8000 - 12,000

Selection of Application Method.

The choice of an application method depends on the type of coating, the type of surface, environmental factors, and cleanup. Alkyd coatings can easily be applied by brush, but fast drying coatings, such as vinyls, are difficult to apply by brush or roller. Brushing is the preferred method for small areas and uneven or porous surfaces, while rolling is practical on large flat areas. Also, brushing of primers over rusted steel and dusty concrete is preferred over spraying. (Note that applying paint over these substrates should be avoided, if possible.) Spraying is usually preferred on large areas and is not limited to flat surfaces. Spraying may not be feasible is some locations and in some environments because of the accumulation of toxic and flammable fumes or overspray.

Brush Application.

Brushing is an effective method of paint application for small areas, edges, corners, and for applying primers. Brush application of primers works the paint into pores and surface irregularities, providing good penetration and coverage. Because brushing is slow, usually it is used only for small areas or where overspray may be a serious problem. Brush application of paint may leave brush marks with paints that do not level well, thus creating areas of low film thickness.

Even a second coat of paint may leave the total coating system with thin and uneven areas that may lead to premature failure. Brushes are made with either natural or synthetic bristles. A drawing of a typical paint brush is shown in Figure 8. Chinese hog bristles represent the finest of the natural bristles because of their durability and resiliency. Hog bristles are also naturally "flagged" or split at the ends. This permits more paint to be carried on the brush and leaves finer brush marks on the applied coating. Horsehair bristles are used in cheaper brushes but are an unsatisfactory substitute for hog hair. Nylon and polyester are used in synthetic bristles or filaments. The ends are flagged by splitting the filament tips. Synthetic bristles absorb less water than natural bristles and are preferred for applying latex paints. However, synthetic bristles may be softened by strong solvents in some paints. Thus, natural bristles are preferred for application of paints with strong solvents.

Brushes are available in many types, sizes, and qualities to meet the needs for different substrates. These types include wall, sash and trim (may be chisel or slash shaped), and enamel (bristles are shorter). It is important to use high quality brushes and keep them clean. Brushes with horsehair or with filaments that are not flagged should be avoided. The brush should be tapered from side to center (see Figure 8).

Procedure for Brush Application

a) Shake loose any unattached brush bristles by spinning the brush between the palms of the hand and remove the loose bristles.

b) Dip the brush to cover one-half of the bristle length with paint. Remove excess paint on the brush by gently tapping it against the side of the can.

c) Hold the brush at an angle of about 75 degrees to the surface. Make several light strokes to transfer the paint to the surface. Spread the paint evenly and uniformly. Do not press down hard but use a light touch to minimize brush marks. If there is time before the paint sets up, cross-brush lightly to eliminate excessive brush marks.

d) Confine painting to one area so that a "wet edge" is always maintained. Apply paint to a surface adjacent to the freshly painted surface sweeping the brush into the wet edge of the painted surface. This helps to eliminate lap marks and provides a more even coating film.

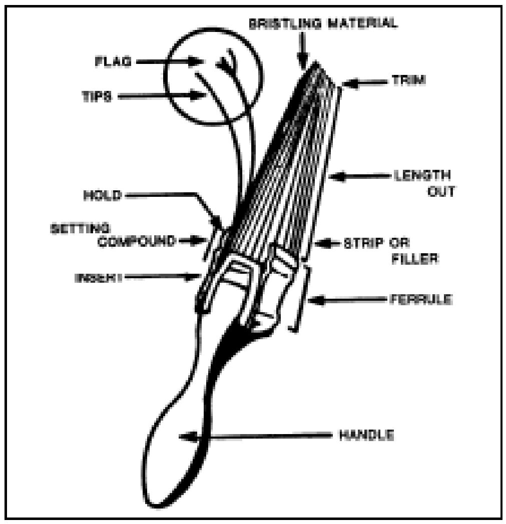

Figure 8
Illustration of Parts of Paint Brush

Roller Application.

Roller application is an efficient method for flat areas where the stippled appearance of the dry film is acceptable. However, paint penetration and wetting of difficult surfaces is better accomplished by brush than roller application. Thus, brush application of primers is preferred over roller application.

A paint roller consists of a cylindrical sleeve or cover which slips onto a rotatable cage to which a handle is attached. The covers vary in length from 1 to 18 inches and the diameter from 1.5 to 2.25 inches. A 9-inch length, 1.5-inch diameter roller, is common. The covers are usually made of lamb's wool, mohair, or synthetic fibers. The nap (length of fiber) can vary from 0.25 to 1.25 inches. Longer fibers hold more paint but do not give as smooth a finish. Thus, they are used on rougher surfaces and chain link fence, while the shorter fibers are used on smooth surfaces. Use of extension handles makes the application of paint to higher surfaces easier. However, use of a long extension handle usually results in a less uniform film. Use a natural fiber roller (for example, wool/mohair) for solvent base paints and a synthetic fiber roller for latex paints.

Procedures for Roller Application.

Rollers are used with a tray which holds the coating or a grid placed in a 5- gallon can (Figure 9).
Application procedure is described below.

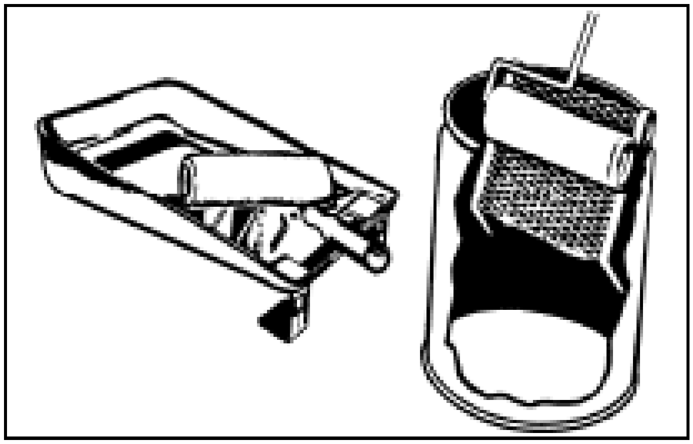

Figure 9
Equipment Used in Applying Paint by Roller

a) If a tray is being used, fill it half full with premixed paint. If a grid or screen is being used, place it at an angle in the can containing premixed paint.

b) Immerse the roller completely in the paint and remove the excess by moving the roller back on the tray or grid. Skidding or tracking may occur if the roller is loaded with too much paint.

c) Apply the paint to the surface by placing the roller against the surface forming a "V" or "W" of a size that will define the boundaries of the area that can be covered with the paint on a loaded roller. Then roll out the paint to fill in the square area. Roll with a light touch and medium speed. Avoid letting the roller spin at the end of a stroke. Always work from a dry adjacent surface to a wet surface. The wet edge should be prevented from drying to minimize lap marks.

d) Use a brush or foam applicator to apply paint in corners, edges, and moldings before rolling paint on the adjacent areas.

Spray Application.

Spray application is the fastest technique for applying paint to large areas. Spray application also results in a smoother, more uniform surface than brushing or rolling. There are several types of equipment: conventional air, airless, air-assisted airless, high-volume, low-pressure (HVLP), electrostatic, multi-component, thermal, and powder. Conventional air and airless were most commonly used. However, with changing VOC requirements the other methods are being used more. Air or air-assisted methods of spraying, including HVLP, rely on air for paint atomization. Jets of compressed air are introduced into the stream of paint at the nozzle. The air jets break the paint stream into tiny particles that are carried to the surface on a current of air. The delivery of the paint to the nozzle may be assisted using hydraulic pressure. In airless spray, paint is forced through a very small nozzle opening at very high pressure to break the exiting paint into tiny droplets.

A general comparison of properties of conventional air and airless spray are given in Table 11. Note that specific application rates, the amount of overspray, and other properties depend to a great extent upon the type of paint, and may vary from those listed in the table. Air methods other than conventional have been developed to overcome some of the environmental and other concerns of air and airless spray. These differences are discussed separately for each method below.

Conventional or Air Spray Equipment.

The conventional method of spray application is based on air atomization of the paint. The basic equipment (air compressor, paint tank, hoses for air and paint, spray gun) is shown in Figure 10. The coating material is placed in a closed tank (sometimes called a pot) connected to the nozzle by a hose and put under regulated

Table 11
Comparison of Conventional Air and Airless Spray

Property	Conventional Air	Airless
Coverage, sq ft/day	4-8000	6-10,000
Overspray	Considerable	Some
Transfer efficiency	Poor (about 30	Fair (35-50)
"Bounce back"	percent)	Minor
Hoses	Significant	1 (fluid)
Penetration of corners,	2 (air and fluid)	
crevices and cracks		Moderate
Film build per coat	Fair	Good
Versatility	Fair	Fair
Paint clogging problems	Good	More
Operator control	Few	Poor
Safety during painting	Good	Poor
Safety during cleanup	Fair	Poor
	Fair	

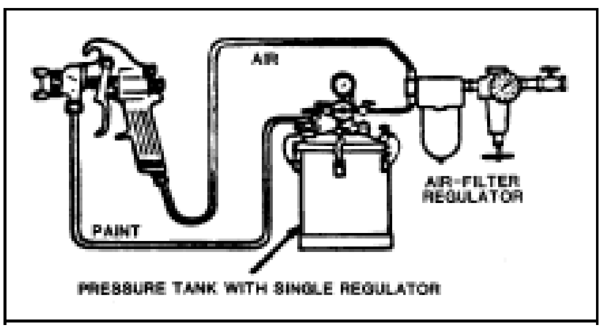

Figure 10
Schematic Drawing Illustrating Basic Parts of Conventional Air Spray Application Equipment

Table 14
Spray Painting Errors

Error	Result
Improper spraying technique (e.g., arcing, tilting gun)	Spray pattern varied from narrow to wide Variation of sheen from overspray Uneven film thickness
Improper fan width	Inadequate or excessive film build on complex substrate shapes, such as "I" or "H" beams
Spray gun too close to surface	Excessive film build Runs, curtains, sags Poor paint adhesion from improper curing Wrinkling during and after surface curing Excessive paint used Orange peel pattern or blow holes
Spray gun too far from surface	Film build too thin Non-uniform film thickness Dry spray Uneven angular sheen from overspray earlier work

Additional guidance on coating systems is provided below:

TOPSIDE/BOTTOM PAINT SYSTEM REFERENCES
&
PRODUCT RECOMMENDATIONS

ANCHOR: The anchor shall be coated with any of the paint systems listed in the Exterior section.

ANCHOR CHAIN: The anchor chain links that must be colored shall be coated with any of the paint systems listed in the Exterior section. The anchor chain links that do not require colors shall be painted with 3 mils/(75 microns) DFT of the inorganic zinc coat only. The section of chain in the first shot that runs from the anchor and along the deck to the spurling tube shall be painted black.

CHAIN LOCKER: Where this space can be properly prepared, it shall be coated with any of the inorganic zinc paints listed in the Exterior section at 3 mils/(75 microns) DFT. Where it is not possible to prepare the steel surface properly for an inorganic zinc coating, then any of the systems listed in the Cofferdams/Voids (Compromised Surfaces) section shall be used.

HIGH TURBULENCE AREAS (SEACHESTS, RUDDERS, KORT NOZZLES,ETC.)

Manufacturer	**Product**	**DFT** mils/(microns)	**Color**
AMERON			
1st Coat	Amerlock 400 Glassflake	6-7/(150-175)	Black
2nd Coat	Amerlock 400 Glassflake	6-7/(150-175)	Terracotta
AMERON			
1st Coat	Amercoat 238	6-7/(150-175)	Black
2nd Coat	Amercoat 238	6-7/(150-175)	Terracotta
HEMPEL			
1st Coat	Hempadur MultiStrength 35530	6-7/(150-175)	Black
2nd Coat	Hempadur MultiStrength 35530	6-7/(150-175)	Terracotta
INTERNATIONAL			
1st Coat	Interzone 1000	6-7/(150-175)	Black
2nd Coat	Interzone 1000	6-7/(150-175)	Terracotta
INTERNATIONAL			
1st Coat	Intershield 803	6-7/(150-175)	Black

2nd Coat	Intershield 803	6-7/(150-175)	Terracotta
INTERNATIONAL			
1st Coat	Intershield 163	6-7/(150-175)	Black
2nd Coat	Intershield 163	6-7/(150-175)	Terracotta
JOTUN			
1st Coat	Marathon 4042/4044	6-7/(150-175)	Black
2nd Coat	Marathon 4046/4044	6-7/(150-175)	Terracotta
SHERWIN-WILLIAMS.			
1st Coat	Phenicon HS Flake Filled	6-7/(150-175)	Black
2nd Coat	Phenicon HS Flake Filled	6-7/(150-175)	Terracotta

UNDERWATER HULL, ABLATIVE (REVERSE COLORS FOR BOOTTOPPING)

Manufacturer	**Product**	**DFT** mils/(microns)	**Color**
AMERON			
1st Coat	Amercoat 385	5-6/(125-150)	Black
2nd Coat	Amercoat 385	5-6/(125-150)	Terracotta
3rd Coat	ABC-4	5-6/(125-150)	Black
4th Coat	ABC-4	5-6/(125-150)	Terracotta
AMERON			
1st Coat	Amercoat 235	5-6/(125-150)	Black
2nd Coat	Amercoat 235	5-6/(125-150)	Terracotta
3rd Coat	ABC-3	5-6/(125-150)	Black
4th Coat	ABC-3	5-6/(125-150)	Terracotta
HEMPEL			
1st Coat	Hempadur 45150	5-6/(125-150)	Black
2nd Coat	Hempadur 45150	5-6/(125-150)	Terracotta
3rd Coat	Olympic HI-7660o	5-6/(125-150)	Black
4th Coat	Olympic HI-7660o	5-6/(125-150)	Terracotta
HEMPEL			
1st Coat	Hempadur 45150	5-6/(125-150)	Black
2nd Coat	Hempadur 45150	5-6/(125-150)	Terracotta
3rd Coat	Globic SP-ECO 81952	5-6/(125-150)	Black
4th Coat	Globic SP-ECO 81952	5-6/(125-150)	Terracotta
INTERNATIONAL			
1st Coat	Intergard 264 (FP Series) or Intertuf 262 (KH Series)	5-6/(125-150)	Black
2nd Coat	Intergard 264 (FP Series) or Intertuf 262 (KH Series)	5-6/(125-150)	Terracotta

3rd Coat	Interclene BRA 570	5-6/(125-150)	Black
4th Coat	Interclene BRA 570	5-6/(125-150)	Terracotta
JOTUN			
1st Coat	Primastic Universal AV	5-6/(125-150)	Black
2nd Coat	Safeguard Universal AV	5-6/(125-150)	Terracotta
3rd Coat	Hydroclean 60A2003	5-6/(125-150)	Black
4th Coat	Hydroclean 60A2000	5-6/(125-150)	Terracotta
SHERWIN-WILLIAMS			
1st Coat	Underwater Hull Epoxy	5-6/(125-150)	Black
2nd Coat	Underwater Hull Epoxy	5-6/(125-150)	Terracotta
3rd Coat	SeaGuard Ablative	5-6/(125-150)	Black
4th Coat	SeaGuard Ablative	5-6/(125-150)	Terracotta

UNDERWATER HULL, CONVENTIONAL (REVERSE COLORS FOR BOOTTOPPING)

Manufacturer	**Product**	**DFT** mils/(microns)	**Color**
AMERON			
1st Coat	Amercoat 385	5-6/(125-150)	Black
2nd Coat	Amercoat 385	5-6/(125-150)	Terracotta
3rd Coat	Amercoat 275E/277E	2-3/(50-75)	Black
4th Coat	Amercoat 275E/277E	2-3/(50-75)	Terracotta
HEMPEL			
1st Coat	Hempadur 45150	5-6/(125-150)	Black
2nd Coat	Hempadur 45150	5-6/(125-150)	Terracotta
3rd Coat			Black
4th Coat			Terracotta
INTERNATIONAL			
1st Coat	Intergard 264 (FP Series) or Intertuf 262 (KH Series)	5-6/(125-150)	Black
2nd Coat	Intergard 264 (FP Series) or Intertuf 262 (KH Series)	5-6/(125-150)	Terracotta
3rd Coat	International AF 4054	2-3/(50-75)	Black
4th Coat	International AF 4050	2-3/(50-75)	Terracotta
JOTUN			
1st Coat	Primastic Universal AV	5-6/(125-150)	Black

2nd Coat	Safeguard Universal AV	5-6/(125-150)	Terracotta
3rd Coat	Sovaklor V59R27	2-3/(50-75)	Black
4th Coat	Sovaklor V59R27	2-3/(50-75)	Terracotta
SHERWIN-WILLIAMS			
1st Coat	MIL-DTL-24441C, Type IV	5-6/(125-150)	Black
2nd Coat	MIL-DTL-24441C, Type IV	5-6/(125-150)	Terracotta
3rd Coat	MIL-P-15931 F129A N50B100	2-3/(50-75)	Black
4th Coat	MIL-P-15931 F121A N50R100	2-3/(50-75)	Terracotta

COFFERDAMS/VOIDS: Where these spaces can be properly prepared, they shall be coated with ny of the inorganic zinc paints listed in the Exterior section at 3 mils/(75 m microns) DFT.
COFFERDAMS/VOIDS (Compromised Surfaces): Where it is not possible to prepare the steel surface properly for an inorganic zinc coating, then any of the systems listed below shall be applied onto a "compromised surface" if it has been mechanically cleaned, de-greased, and all loose rust and scale has been removed.

AMERON			
1st Coat	Amerlock 2 or 400 or Amercoat 385	6-7/(150/175)	Terracotta
2nd Coat	Amerlock 2 or 400 or Amercoat 385	6-7/(150/175)	Off White
AMERON			
1st Coat	Amercoat 235	6-7/(150/175)	Terracotta
2nd Coat	Amercoat 235	6-7/(150/175)	Off White
CARBOLINE			
1st Coat	Carbomastic 15	6-7/(150/175)	Terracotta
2nd Coat	Carbomastic 15	6-7/(150/175)	Off White
CHUGOKU			
1st Coat	Umeguard SX	6-7/(150/175)	Terracotta
2nd Coat	Umeguard SX	6-7/(150/175)	Off White
CLEARKIN			
1st Coat	Black Corrosion Master	20/(500)	Black
CLEARKIN			
1st Coat	White Corrosion Master	20/(500)	White
CLEARKIN			
1st Coat	Corrosion Battler (for inaccessible areas like rudders	float coat	Black

	and bilge keels)		
HEMPEL			
1st Coat	Hempadur 45150	6-7/(150/175)	Terracotta
2nd Coat	Hempadur 45150	6-7/(150/175)	
INTERNATIONAL			
1st Coat	Intergard 262 (KH Series)	6-7/(150/175)	Terracotta
2nd Coat	Intergard 262 (KH Series)	6-7/(150/175)	Off White
INTERNATIONAL			
1st Coat	Interbond 998 (KRA Series)	6-7/(150/175)	Terracotta
2nd Coat	Interbond 998 (KRA Series)	6-7/(150/175)	Off White
JOTUN			
1st Coat	Primastic AV	6-7/(150/175)	Terracotta
2nd Coat	Primastic AV	6-7/(150/175)	Off White
SHERWIN-WILLIAMS			
1st Coat	Macropoxy 646	6-7/(150/175)	Terracotta
2nd Coat	Macropoxy 646	6-7/(150/175)	Off White

INACCESSIBLE VOIDS:
Interior surfaces of rudders, stern frames, bilge keels, Kort Nozzles or other inaccessible voids may be "float" coated with any commercially available "float" coatable corrosion preventive compound having the following salient characteristics:

1. Forms a soft or semi-soft film.
2. Is rust penetrating.
3. Is not salt water soluble.
4. Is non-polluting (will not produce a sheen on water) and/or is self-oxidizing.
5. Has a flash point of not less than 100 degrees F (38 degrees C).

DECKS (Without non-skid): The systems listed in the exterior section shall be used for these decks except the polyurethane topcoat shall be replaced with 5 mils/(125 microns) of the epoxy midcoat. The system will consist of 3 mils/(75 microns) DFT of the inorganic zinc, 5 mils/(125 microns) DFT of the epoxy and another 5 mils/(125 microns) DFT of the epoxy. The topcoat of epoxy shall be dark gray, FED STD 595 color 26081. Cargo hold decks which see tracked vehicles like the M1A1 tank shall use the inorganic zinc coat only at 3 mils/(75 microns) DFT.

HELO DECK NON-SKID: All helo, VERTREP, and hangar decks should only be coated with a Type I, Composition G rollable epoxy non-skid approved per QPL MIL-PRF-24667 applied over the manufacturer's designated primer (or Navy formula 150 if no specific primer is designated). For helo, VERTREP, and hangar decks not requiring certification, MIL-SPEC MIL-PRF-24667A (Type I, Composition G) non-skid should be used.

PEDESTRIAN NON-SKID: Unless otherwise noted, apply over steel primed with 3 mils/(75 microns) DFT of inorganic zinc and 5 mils/(125 microns) DFT of epoxy from approved systems in the exterior section.

Manufacturer	**Product**	**DFT** mils/(microns)	**Color**
AMERON			

1st Coat	Amercoat 385AS	25-30/(625-750)	Dark Gray
APPLIED SURFACES			
1st Coat	Durabak	25-30/(625-750)	Dark Gray
HEMPEL			
1st Coat	Hempel's Non-Skid 493US	25-30/(625-750)	Dark Gray
INTERNATIONAL			
1st Coat	Intershield 556	25-30/(625-750)	Dark Gray
INTERNATIONAL			
1st Coat	Intergard Non-Skid Deck Finish EK5040H	25-30/(625-750)	Dark Gray
JOTUN			
1st Coat	Primastic AV/1457	25-30/(625-750)	Dark Gray
SHERWIN-WILLIAMS			
1st Coat	AST MS-375G	25-30/(625-750)	Dark Gray

VEHICULAR NON-SKID: Where non-skid coatings are subject to excessive wear, such as RO/RO ramps or forklift corridors, a helo deck non-skid coating shall be used (Type I, Composition G rollable non-skid approved per QPL MIL-PRF-24667, applied over the manufacturer's designated primer.

FREEBOARD AND TOPSIDE

Manufacturer	**Product**	**DFT** mils/(microns)	**Color**
AMERON			
1st Coat	Dimetcote 21-9 or Dimetcote 9HS	3-4/(75-100)	Green
2nd Coat	Amercoat 385	5-6/(125-150)	Terracotta
3rd Coat	Amershield	3-4/(75-100)	Haze Gray
HEMPEL			
1st Coat	Galvosil 15680	3-4/(75-100)	Green
2nd Coat	Hempadur 45150	5-6/(125-150)	Terracotta
3rd Coat	Hempel's Urethane 5595U	3-4/(75-100)	Haze Gray
INTERNATIONAL			
1st Coat	Interzinc 22 HS	3-4/(75-100)	Reddish Gray
2nd Coat	Intertuf 262 (KH Series)	5-6/(125-150)	Terracotta
3rd Coat	Interthane 990HS	3-4/(75-100)	Haze Gray
JOTUN			
1st Coat	MZ-7	3-4/(75-100)	Green
2nd Coat	Primastic AV	5-6/(125-150)	Terracotta

3rd Coat	Hardtop II	3-4/(75-100)	Haze Gray
SHERWIN-WILLIAMS			
1st Coat	Zinc Clad II HS	3-4/(75-100)	Gray-Green
2nd Coat	Macropoxy 646	5-6/(125-150)	Terracotta
3rd Coat	Acrolon 218HS	3-4/(75-100)	Haze Gray

BILGES AND DECKS IN MACHINERY SPACES: The systems listed in the Cofferdams/Voids (Compromised surfaces) section shall be used for this application except that the topcoat shall be terracotta. Note: Use International's Intertuf FP instead of Intertuf KH.

HOLDS: The systems listed in the Cofferdams/Voids (Compromised surfaces) section shall be used for this application.

LIVING SPACES: Interior paints from the Federal Supply System may be requisitioned using national stock numbers. Gloss alkyds shall be used for interior markings and chlorinated alkyds in compliance with DOD-E-24607A or water-based fire retardant coatings in compliance with DOD-C-24596 shall be used for living and all other normally manned spaces.

MACHINERY SPACES: Except for bilges and decks as noted above, gloss alkyds shall be used for interior markings and fire retardant chlorinated alkyds in compliance with DOD-E-24607A or water-based fire retardant coatings in compliance with DOD-C-24596 shall be used for bulkheads and overheads. These paints may be requisitioned using national stock numbers from the Federal Supply System. See section 631.8.23.5 of the NSTM Chapter 631, (Preservation of Ships in Service - Surface Preparation and Painting) for more guidance on fire retardant paint.

ACID RESISTING: Any commercial brand suitable for marine use shall be used for this application.

COMPROMISED SURFACES: These are surfaces which cannot be prepared very well due to accessibility, time, cost, contamination, etc. For example, tight areas in a bilge may be difficult to prepare except by wire brush and chipping hammer. Because of the condition of the surface after this kind of preparation, the coatings required by this section are highly penetrating with a strong wetting action for steel and iron oxide. They penetrate and wet the metal surface to a greater degree than high-polymer high-performance coatings. The systems listed in the Cofferdams/Voids (Compromised surfaces) section shall be used for these applications.

HEAT RESISTING: Heat resisting paints from the Federal Supply System in compliance with TT-P-28 and DOD-P-24555 may be requisitioned using national stock numbers for this application.

Manufacturer	**Product**	**DFT** mils/(microns)	**Color**
AMERON			
1st Coat	PSX 892HS	2-4/(50-100)	Aluminum, Black, or Haze Gray
AMERON			
1st Coat	Amercoat 3279	2-4/(50-100)	Silver
HEMPEL			

1st Coat	Hempel's Silicone Aluminum 56910	2-4/(50-100)	Silver
INTERNATIONAL			
1st Coat	Intertherm 50	2-4/(50-100)	Silver
JOTUN			
1st Coat	Solvalitt	2-4/(50-100)	Silver

SWEAT RESISTING: See section 631-7.8 of the NSTM Chapter 631, (Preservation of Ships in Service - Surface Preparation and Painting), for guidance on sweat resisting paint. FED Spec TT-C-492 for antisweat paint applies.

BALLAST AND SANITARY

Manufacturer	**Product**	**DFT** mils/(microns)	**Color**
AMERON			
1st Coat	Amercoat 395, 395FD, or 385	5-6/(125-150)	Terracotta
2nd Coat	Amercoat 395, 395FD, or 385	5-6/(125-150)	Off White
AMERON			
1st Coat	Amercoat 233ER, 235, or 236	5-6/(125-150)	Terracotta
2nd Coat	Amercoat 233ER, 235, or 236	5-6/(125-150)	Off White
CHUGOKU			
1st Coat	Epicon T-500 Primer R	5-6/(125-150)	Terracotta
2nd Coat	Epicon T-500 Finish B	5-6/(125-150)	Off White
CHUGOKU			
1st Coat	Epicon T-500 Primer R	4/(100)	Terracotta
2nd Coat	Epicon T-500 Undercoat	4/(100)	Light Gray
3rd Coat	Epicon T-500 Finish A	3/(75)	Off White
CLEARKIN			
1st Coat	Black Corrosion Master	20/(500)	Black
CLEARKIN			
1st Coat	White Corrosion Master	20/(500)	White
CLEARKIN			
1st Coat	Corrosion Battler (for inaccessible areas)	float	Black
HEMPEL			
1st Coat	Hempadur 17630	5-6/(125-150)	Terracotta
2nd Coat	Hempadur 17630	5-6/(125-150)	Off White
INTERNATIONAL			
1st Coat	Intergard 143 Series Primer	5-6/(125-150)	Terracotta

2nd Coat	Intergard 143 Series Finish	5-6/(125-150)	Off White
INTERNATIONAL			
1st Coat	Intergard 403(KB Series)	5-6/(125-150)	Terracotta
2nd Coat	Intergard 403 (KB Series)	5-6/(125-150)	Off White
INTERNATIONAL			
1st Coat	Interline 604 (THA Series)	5-6/(125-150)	Terracotta
2nd Coat	Interline 604 (THA Series)	5-6/(125-150)	Off White
INTERNATIONAL			
1st Coat	Interline 624 Primer (THA Series)	5-6/(125-150)	Terracotta
2nd Coat	Interline 624 Finish (THA Series)	5-6/(125-150)	Off White
INTERNATIONAL			
1st Coat	Intergard 704 (THA 700 Series)	5-6/(125-150)	Terracotta
2nd Coat	Intergard 704 (THA 700 Series)	5-6/(125-150)	Off White
INTERNATIONAL PAINT (for Sanitary Tanks, not Ballast)			
1st Coat	Interline 850	5-6/(125-150)	Buff
2nd Coat	Interline 850	5-6/(125-150)	White
JOTUN			
1st Coat	Sovapon 264R5	5-6/(125-150)	Terracotta
2nd Coat	Sovapon 264W2	5-6/(125-150)	Off White
JOTUN			
1st Coat	Epoxy Tanklining 550 Series	5-6/(125-150)	Terracotta
2nd Coat	Epoxy Tanklining 550 Series	5-6/(125-150)	Off White
JOTUN (for Ballast Tanks, not Sanitary)			
1st Coat	Balloxy HB Light	5-6/(125-150)	Green
2nd Coat	Balloxy HB Light	5-6/(125-150)	Beige
SHERWIN-WILLIAMS	***(formerly SEAGUARD)***		
1st Coat	TankGuard N11-100 Series Epoxy	5-6/(125-150)	Terracotta
2nd Coat	TankGuard N11-100 Series Epoxy	5-6/(125-150)	Off White
SHERWIN-WILLIAMS (for Ballast Tanks, not Sanitary)			
1st Coat	DuraPlate UHS Epoxy Primer	5-6/(125-150)	Terracotta
2nd Coat	DuraPlate UHS Epoxy	5-6/(125-150)	Off White

SHERWIN-WILLIAMS			
1st Coat	NovaPlate UHS Epoxy Primer	5-6/(125-150)	Terracotta
2nd Coat	NovaPlate UHS Epoxy	5-6/(125-150)	Off White

CARGO PETROLEUM

Manufacturer	**Product**	**DFT** mils/(microns)	**Color**
AMERON			
1st Coat	Amercoat 395, or 395FD	5-6/(125-150)	Terracotta
2nd Coat	Amercoat 395, or 395FD	5-6/(125-150)	Off White
AMERON			
1st Coat	Amercoat 351	5-6/(125-150)	Gray
2nd Coat	Amercoat 351	5-6/(125-150)	Off-White
AMERON			
1st Coat	Amercoat 233ER or 236	5-6/(125-150)	Terracotta
2nd Coat	Amercoat 233ER or 236	5-6/(125-150)	Off White
AMERON			
1st Coat	Amercoat 236	5-6/(125-150)	Terracotta
2nd Coat	Amercoat 253	5-6/(125-150)	Off White
CHUGOKU			
1st Coat	Epicon T-500 Primer R	5-6/(125-150)	Terracotta
2nd Coat	Epicon T-500 Finish B	5-6/(125-150)	Off White
CHUGOKU			
1st Coat	Epicon T-500 Primer R	4/(100)	Terracotta
2nd Coat	Epicon T-500 Undercoat	4/(100)	Gray
3rd Coat	Epicon T-500 Finish A	3/(75)	Off White
HEMPEL			
1st Coat	Hempadur 15500	5-6/(125-150)	Terracotta
2nd Coat	Hempadur 15500	5-6/(125-150)	Off White
INTERNATIONAL			
1st Coat	Interline 704 (THA 700 Series)	5-6/(125-150)	Terracotta
2nd Coat	Interline 704 (THA 700 Series)	5-6/(125-150)	Off White
INTERNATIONAL			
1st Coat	Interline 604 (THA Series)	5-6/(125-150)	Terracotta
2nd Coat	Interline 604 (THA Series)	5-6/(125-150)	Off White
JOTUN			
1st Coat	Sovapon 264F2	5-6/(125-150)	Gray

2nd Coat	Sovapon 264W2	5-6/(125-150)	Off White
JOTUN			
1st Coat	Sovachem Tanklining 8 Series	5-6/(125-150)	Gray
2nd Coat	Sovachem Tanklining 8 Series	5-6/(125-150)	Off White
SHERWIN-WILLIAMS	***(formerly SEAGUARD)***		
1st Coat	TankGuard N11-100 Series Epoxy	5-6/(125-150)	Terracotta
2nd Coat	TankGuard N11-100 Series Epoxy	5-6/(125-150)	Off White
SHERWIN-WILLIAMS			
1st Coat	DuraPlate UHS Epoxy Primer	5-6/(125-150)	Terracotta
2nd Coat	DuraPlate UHS Epoxy	5-6/(125-150)	Off White

FEEDWATER/FRESHWATER BALLAST

Manufacturer	**Product**	**DFT** mils/(microns)	**Color**
AMERON			
1st Coat	Amercoat 395	5-6/(125-150)	Terracotta
2nd Coat	Amercoat 395	5-6/(125-150)	Off White
AMERON			
1st Coat	Amercoat 233ER or 235 or 236	5-6/(125-150)	Terracotta
2nd Coat	Amercoat 233ER or 235 or 236	5-6/(125-150)	Off White
CHUGOKU			
1st Coat	Epicon T-500 Primer F	5-6/(125-150)	Terracotta
2nd Coat	Epicon T-500 Finish B	5-6/(125-150)	Off White
CHUGOKU			
1st Coat	Epicon T-500 Primer F	4/(100)	Terracotta
2nd Coat	Epicon T-500 Undercoat	4/(100)	Light Gray
3rd Coat	Epicon T-500 Finish A	3/(75)	Off White
HEMPEL			
1st Coat	Hempadur 85671	5-6/(125-150)	Terracotta
2nd Coat	Hempadur 85671	5-6/(125-150)	Off White
INTERNATIONAL			
1st Coat	Intergard 143 Series Primer	5-6/(125-150)	Terracotta
2nd Coat	Intergard 143 Series Finish	5-6/(125-150)	Off White
INTERNATIONAL			
1st Coat	Intergard 264 (FP Series)	5-6/(125-150)	Terracotta

2nd Coat	Intergard 264 (FP Series)	5-6/(125-150)	Off White
INTERNATIONAL			
1st Coat	Intergard 403(KB Series)	5-6/(125-150)	Terracotta
2nd Coat	Intergard 403(KB Series)	5-6/(125-150)	Off White
JOTUN			
1st Coat	Sovapon 264	5-6/(125-150)	Terracotta
2nd Coat	Sovapon 264	5-6/(125-150)	Off White
JOTUN			
1st Coat	Epoxy Tanklining 550 Series	5-6/(125-150)	Gray
2nd Coat	Epoxy Tanklining 550 Series	5-6/(125-150)	Off White
JOTUN			
1st Coat	Balloxy HB Light	5-6/(125-150)	Green
2nd Coat	Balloxy HB Light	5-6/(125-150)	Beige
SHERWIN-WILLIAMS	***(formerly SEAGUARD***		
1st Coat	TankGuard N11-100 Series Epoxy	5-6/(125-150)	Terracotta
2nd Coat	TankGuard N11-100 Series Epoxy	5-6/(125-150)	Off White
SHERWIN-WILLIAMS			
1st Coat	DuraPlate UHS Epoxy Primer	5-6/(125-150)	Terracotta
2nd Coat	DuraPlate UHS Epoxy	5-6/(125-150)	Off White

FUEL OIL SERVICE: Fuel oil service tanks do not require coating with the following exceptions. Any ship which spends time in extended reserve status and all new construction ships shall use the paint systems in the Cargo Petroleum category in the Tanks section for this application.

JP 5 SERVICE: The paint systems in the Cargo Petroleum category in the Tanks section shall be used for this application.

LUBE OIL SERVICE: Lube oil tanks do not require coating with the following exceptions. Any ship which spends time in extended reserve status and all new construction ships shall use the paint systems in the Cargo Petroleum category in the Tanks section for this application.

OILY WASTE: The paint systems in the Ballast and Sanitary category in the Tanks section shall be used for this application. Note: Use International's Intertuf FP instead of Intertuf KH.

POTABLE WATER/CARGO WATER: Approved coatings shall have NSF approval for potable water tanks greater than 1000 gallons.

Manufacturer	**Product**	**DFT** mils/(microns)	**Color**
AMERON			

1st Coat	Amercoat 233ER	5-6/(125-150)	Buff
2nd Coat	Amercoat 233ER	5-6/(125-150)	Off-White
HEMPEL			
1st Coat	Hempadur 85671	5-6/(125-150)	Light Red
2nd Coat	Hempadur 85671	5-6/(125-150)	Off White
INTERNATIONA*L PAINT*			
1st Coat	Interline 850	5-6/(125-150)	Buff
2nd Coat	Interline 850	5-6/(125-150)	White
INTERNATIONAL *PAINT*			
1st Coat	Interline 925	5-6/(125-150)	Buff
2nd Coat	Interline 925	5-6/(125-150)	White
JOTUN			
1st Coat	Epoxy Tanklining 550 Series	5-6/(125-150)	Gray
2nd Coat	Epoxy Tanklining 550 Series	5-6/(125-150)	Off White
SHERWIN-WILLIAMS			
1st Coat	TankGuard #1 N11G100/N11V100	5-6/(125-150)	Green
2nd Coat	TankGuard #3 N11L100/N11V101	5-6/(125-150)	Blue

SANITARY (SEE “BALLAST AND SANITARY” SECTION)

WASTE OIL: Waste oil tanks do not require coating with the following exceptions. Any ship which spends time in extended reserve status and all new construction ships shall use the paint systems in the Cargo Petroleum category in the Tanks section for this application.

DECKS AND DECK EQUIPMENT

Wood Decks. The following is general information relative to the preservation of wood decks.

Preservation measures for wood are intended to:

a. Limit ingress of water into structural areas, and underlying wood decks, and facilitate drainage of water from under wood decks.

b. Limit moisture penetration into wood to prevent rot.

c. Treat wood with preservative to slow fungus attack. Drainage may be facilitated by drilling drain holes approximately an inch in diameter in steel bounding bars at the level of deck plating. These holes shall be reamed out annually. In addition, all carriers shall be listed about two degrees and rimmed about one degree to facilitate run-off rainwater. Wood sides above water line and upper works shall be thoroughly cleaned and any bare wood coated by brushing, spraying, or soaking with wood preservative conforming to MIL-W-18142 (NSN 8030-00-282-0971).

All topside fraying surfaces and other locations where water can penetrate and cause decay shall be saturated with wood preservatives and sealed to prevent entry of water. After at least 72 hours drying time, the entire surface shall be coated by spray or brush with one coat of aluminum paint, prepared by mixing 2.0 pounds aluminum paint FED SPEC TT-A-468, type II, class B, to 1 gallon of mixing varnish, MIL-V-1174, followed by two coats of exterior gray paint. Application of paints or preservatives should only be accomplished after a period of relatively dry weather.

Decks Inactivation. Flight decks shall be watertight; repairs will be authorized only on a case basis when the existing deck shows evidence of leaking. Deteriorated nonskid on steel decks shall be removed and a suitable coating applied.

NOTE

Asbestos containing materials have been found to be in nonskid, especially in applications requiring additional fireproofing. Any nonskid to be removed must be tested for the presence of ACMs.

Steel Decks Covered With Non-Skid. Nonskid shall be in good condition and the deck shall be watertight. Nonskid shall be removed and a suitable paint coating applied, only in areas showing signs of deterioration.

MSO and MSC Decks. If decks have been covered with polyurethane, only local patching is required. If ordinary paint has been used, it shall be removed and the polyurethane coating, conforming to MILD-2461 Type II Class 2, shall be applied in accordance with NSTM S9086-VG-STM-010 Chapter 634, DECK COVERINGS.

Masts, Spars, Booms, Cranes, Boat Davits, Rigging, Lifelines, and Stanchions. Steel masts, spars, and booms shall be primed and painted with haze gray epoxy based paint as necessary to ensure preservation. If wood, apply aluminum paint before over coating with haze gray. Boat booms shall be removed and stored in a dehumidified space. For boat and aircraft (B & A) cranes, place boom in stowage cradle and enclose control stand.

Masts, Spars, Booms, Cranes, Boat Davits, Rigging, Lifelines, Steel masts, spars, and booms shall be primed and painted with haze gray epoxy based paint as necessary to ensure preservation.
Wire Rope. Remove all serving from wire rope standing rigging which remains in place. Clean the exterior surface and preserve with three coats of solvent cutback corrosion preventive, MI-C-16173 (“ESGARD PL-2”), Grade 2 S9086-BS-STM-010

Davits. As applicable, cranes (excluding machinery) shall be painted.. The socket steps shall be thoroughly lubricated with the lubricant regularly used. All items (e.g., goosenecks, swivels, ramp, sheaves, blocks, and pins) shall be cleaned, preserved with Grade 2 thin film corrosion preventive compound. Davit keeper bars must be welded to preclude davit movement. Appropriate records should be made in the ships stowage plans, CSMP, and the activation work list. To simplify the procedure, the boat handling system is categorized into four subsystems: electrical, davit arm(s) and sheaves, winch and stowage.

a. Entire System.

1. Perform system inspection, cleaning and test operation of the boat handling system. .
2. Secure power to the system and tag "OUT OF SERVICE."
3. A complete set of mounting bolts and associated hardware required for reinstallation is to be placed into a cloth bag (NSN 8105-00-281-3924) and attached to the removed component. Attach an identification tag to each item to indicate original installed location.
4. Clean and paint all exposed surfaces requiring touchup, except nameplates, in accordance with NSTM S9086-VD-STM-010 Chapter 631, VOLUME 1, PRESERVATION OF SHIPS IN SERVICE – GENERAL, Table 63 1-3 4.
5. Lubricate all grease points in accordance with PMS.

b. Electrical Subsystem

1. Motor Controller: If motor controller is on the weather deck, place a desiccant bag (NSN 6850-00-264-6573) inside the controller box and close the cover. Use E & T Plastics, Inc. shrink wrap (part number ET-SW-312), or equal and shrink the plastic wrap around the controller. If the motor controller is located within a dehumidified space, no additional lay-up maintenance is required.
2. Control/Limit Switches:
(a.) Control Switches (Master Switch, Emergency disconnect Switch and Emergency Run Switch): Attach an identification tag to each item to indicate original installed location. Disassemble and stow in a dehumidified space.
(b.) Limit Switches: Leave in place. Preserve any unpainted surfaces with grade 2 solvent cutback corrosion
preventive compound (MIL-C-16173).
(c.) Electrical Cabling: All electrical cabling that is exposed due to the removal of a component must be sealed or removed.
c. Davit Arm(s) and Sheaves Subsystem.

WARNING

These steps MUST be accomplished in the order that they are listed below or a serious accident could result.

1. Davit Arm(s): Ensure arm(s) are left in stowed position.
(a.) Trackway davits: Tack weld the keeper bar(s) to the frame to ensure the arms(s) remain stowed.

(b.) Pivoted davits: Tack weld the locking pin into the latch mechanism release handle to ensure the davit
arm(s) remain stowed.
2. Shock absorber(s), quick release hook(s), floating block(s), falls tensioning devices(s) and sheaves: Attach an identification tag to each item to indicate original installed location. Ensure all sheaves are match marked. Disassemble and stow in dehumidified space, unless otherwise noted. .
3. Preventer Stays and Span line (as applicable): Clean the exterior surface and preserve with grade 1 solvent outback corrosion preventive compound (MIL-C-16173). If replacement is necessary, replace with aramid fiber (KEVLAR) in accordance with NAVSEA drawing 803-5184124.
4. Wire Rope and Monkey Lines: Remove for disposal.
5. Strong back and subcomponents (internal sheaves, bearings and latching mechanism): If there is sufficient accessible interior dehumidified space available to store the strong back assembly and mounting subcomponent, dismantle and stow entire assembly. If adequate internal ship space is not available, leave strong back assembly in place, preserve all accessible internal parts with grade 2 solvent cutback corrosion preventive compound (MIL-C-16173) and ensure latching mechanism is engaged and locked in place.
d. Winch Subsystem.
1. Winch Drum(s): Remove the winch drum cover(s), clean the winch drum(s) and reassemble. Preserve any unpainted surfaces with grade 2 solvent cutback corrosion preventive compound (MIL-C-16173). Paint all exposed surfaces needing touch up. Do not paint nameplates.
2. Gear Case: Drain the existing oil from the gear case. Blank off any vents or holes, if they exist, then fill the gear case with fresh oil so that the reduction gear will be fully immersed in oil. Preserve any unpainted surfaces with grade 2 solvent cutback corrosion preventive compound (MIL-C-16173). Paint all exposed surfaces needing touch up. Do not paint nameplates.
3. Entire winch subsystem: Provide enclosure over each winch with dehumidification.

DRYDOCKING OR COFFERDAM PLAN

Funding permitting, ship may be docked in order to accomplish necessary inspections, repairs to and preservation of underwater hull and fittings, removal of propellers, outboard blanking of sea connections,
installation of galvanic anodes, setting up of shaft packing glands, and installation of shaft boots as prescribed in this section.

When an the ship is drydocked for periodic preservation, the underwater body shall be inspected to determine if touchup or complete preservation is required. The extent of recoating shall be determined by considering the following factors in relation to the next anticipated docking period:

1.) Condition of coating at current docking, previous time out of dock, time until next docking, whether a cathodic protection system is installed, and the previous performance record of the coating system to be used. If preservation is deemed necessary, the underwater body shall be thoroughly cleaned by abrasive blasting and shall be coated with the coating systems specified herein.

Hull Inspection and Repairs. Hull inspections shall be conducted in accordance with NSTM S9086-7G-STM-010 Chapter 997, DOCKING INSTRUCTIONS AND ROUTINE WORK IN DRY DOCK and NSTM S9086-DA-STM-010 Chapter 100, HULL STRUCTURES, and this paragraph. They are to be conducted, as necessary, to determine the overall material condition of the hull, and to determine the need for repairs in order to ensure security, watertight integrity, and satisfactory material condition.

Inspect the entire underwater hull after it has been sandblasted and coated with wash primer. Inspect all plating seams, rivets, and welds for deterioration, paying particular attention to the afloat waterline area.
The visual inspection shall be followed by such measurements as are necessary to establish the extent and
nature of required repairs. Some thickness measurement techniques, depths gauges, and drill tests may be used as required for this purpose.

Reports. A docking report shall be prepared. After the initial dry-docking, some readings (e.g., shaft data, bearing data, propeller and rudder data) need not be reported unless damage or failure of preservation has occurred since the previous docking .

In addition, the ship's engineer shall contract to have the underwater shell plating measured for thickness, and prepare a supplementary sheet or sheets containing hull deterioration measurements and a narrative description of hull condition upon docking as follows:

a. A statement of general hull condition:

1. Good. The average loss in the original thickness of the shell plating and the maximum depths of pitting do not exceed 10 percent, and the surface is relatively smooth.

2. Fair. Corrosion does not exceed the criteria in NAVSEAINST 9110.13 and NAVSEAINST 9110.57, and the worst areas have no pitting exceeding 25 percent of original plate thickness.

3. Poor. Hull conditions fail to meet the fair criteria.

b. A statement identifying significantly corroded and eroded areas are discovered, such as shell plating, boot topping area, trivets, sea chests, rudders, rope guards, fairwaters, and struts.

c. A brief description of hull repairs completed.

d. Data of previous dry-docking.
\
e. Inactivation location and date.

f. Date cathodic protection installed.

g. Estimate of additional time the ship could have remained out of dock without serious additional deterioration.

h. Methods of inspection (identify instruments used).

i. Condition and type of stern tube and strut bearings preservation; is visibly intact, analyze the preservative solutions for chloride content.

DRYDOCKING

Situations in which dry-docking may be required for the vessel:

1.) OVERHAUL - Scheduled overhauls as established by vessel's managers. Typical extended periods for dry-docking a Museum ship are anywhere between 20 and 50 years for large capital ship.

2.) EMERGENCIES - Serious hull damage following a collision, grounding, or interior degradation of overboard piping systems. Often necessary to prevent the ship from sinking.

3.) REPAIRS TO UNDERWATER FITTINGS - Any underwater work beyond the capacity of divers.

4.) REMOVE FOULING OF THE HULL - Marine growth resulting in loss of paint system and subsequent shell plate loss.

12 MONTHS PRIOR TO DOCKING

1.) Inspect all overboard valves at the skin of the ship. Chain and lock.

2.) Order any replacements for skin valves.

3.) Inspect hull bottom for areas of shoaling that would prevent movement of ship from berth.

4.) Initiate detailed planning for next dry-dock progression.

6 MONTHS PRIOR TO DOCKING

1.) Conduct inspection of interior of the ship to determine condition of all spaces. Notate any spaces with standing water and investigate causes.

2.) Conduct ship survey and develop 'Trip & Tow' list of items requiring completion prior to rigging tow.

3.) Ensure that all ship's drawings (including the Docking Plan), Ship's Information Books, Damage Control Books and Tank Tables are available.

4.) Ensure that periodic readings of vessel's tanks are up to date.

5.) Determine what spaces/tanks are utilized for ballasting and make preparations for adding ballast (to allow ship to rest evenly on the keel blocks when the dry-dock is pumped out) and de-ballasting ship when in dry-dock.

6.) Prepare Shipyard Specification Package and offer same to yards for bidding on a line-by-line basis.

2 MONTHS PRIOR TO DRYDOCKING

1.) Obtain bids for towing, line handlers, pilotage for movement of the vessel.

1 MONTH PRIOR TO DOCKING

1.) Conduct Docking Planning Conference

DOCKING ARRANGEMENTS

All details are worked out in advance by the Docking Master, towing contractors and vessel's representative. The following details are considered primary issues when considerations for docking are made:

1. Time and date of docking
2. Tugs and pilot to be used
3. Whether bow or stern enter the dock first
4. Proper conditions of list and trim
5. Handling of lines
6. Record of tank soundings before the ship is drydocked
7. Gangways to be used
8. Utilities to be furnished to the ship, such as electric power, steam, and water
9. Sanitary services to be provided
10. Garbage and refuse disposal facilities needed
11. Drydock safety precautions
12. Pumping plans or other instructions or operating directives for ballasting/de-ballasting drydock with or without ship in basin.
13. Fleeting of vessel.

DOCKING INFORMATION

The vessel's representative shall furnish the Docking Master with the following information:

1. Place and date of last docking
2. Last docking position
3. Date and file number of last docking report
4. Number of days underway since last docking
5. General itinerary of ship movements
6. Paint history for last complete painting
7. History of touch-up painting
8. Ship weight distribution (including tank sounding report)
9. Offload supplies and hazardous stores
10. Lock screws in drydock position

11. Have 0° list and no excessive trim.

PRIOR TO DOCKING

1. Ensure drydock movement planned completed.
   a. Provide last plan to Docking Officer
   b. Ship has no List
   c. Ship has less than 1% Trim
   d. Retract all moveable hull appendages
   e. Minimize Free Surface Effect - all tanks full or empty
   f. Deliver list of all hull fittings below the waterline to the Docking Officer.

2. Project manager & drydock management meets prior to both docking and undocking
   a. Shipyard & vessel's representative
   b. Review Docking plan, Hull History, and Hull Penetrations Drawings

DOCKING

1. Responsibility for the ship shifts from the vessel's Pilot to the Docking Officer when the first part of the ship crosses the plane of the drydock sill.

2. Once the ship is positioned in drydock, dewatering of the dock begins. As the ship just touches down on the blocks, pumping is stopped. Divers will verify that the ship is properly resting on the blocks, and that the blocks are in the correct location. Upon verification, dewatering will continue.

3. When the dock is pumped dry, members of the hull board conduct an inspection with the Docking Officer.
   a. Ensure ship is positioned properly in the dock
   b. Ensure all shores in place
   c. Note condition of propellers, rudders, overboards, intakes, and other projections
   d. Note condition of zincs/cathodic protection anodes
   e. Note details of any known or observed damage

4. Docking Master to ensure adequate shoring and side blocking is installed to resist earthquake or hurricane forces.

WHILE IN DRYDOCK

1. Vessel's representative will maintain Dry Weight Log, a log of all weight shifts, additions, and removals in excess of 500 lbs.

2. Ensure all removed skin valves are replaced with blank flanges and that no liquids are discharged to the dock without consent of the Docking Officer.

UNDOCKING

1. Prior to undocking, the Hull Board will:
    a. Inspect compartments and tanks below the waterline to verify tightness.
    b. Ensure all valves below the waterline are secured.
    c. Thoroughly inspect hull and projections.
    d. Inspect drydock for chemicals or debris which might pollute the environment, clog intakes, or cause other damage as the ship is refloated.

2. The following spaces are continuously checked for flooding as the ship is refloated:
    a. Spaces in contact with the keel and side blocks
    b. Tanks and voids
    c. Any space with external hull fittings

STABILITY CONSIDERATIONS

When a ship is drydocked or aground, there is a profound effect on stability. As the water level decreases, the keel will rest on the blocks or sea floor. A percentage of the ship's displacement is now supported by these objects. Stability is affected as if removing weight from that point of contact. When weight is removed from the keel, there is a virtual rise in the ship's center of gravity.

Simply utilizing a Draft Diagram in the CV-10 Ship Information Book will get the same result without complication.

ELECTRICAL MAINTENANCE

Protection of Personnel. Grab rods and guardrails should always be in position around switchboards and other power distribution equipment when the equipment is energized (unless emergency repairs are necessary). Grab rods and guardrails should be carefully maintained to ensure that they are secure and will not be accidentally dislodged. Insulating mattings covering the deck in the front and the rear of the switchboards should always be in place. In addition, the following precautions should be taken.

a. When maintenance work is performed on a circuit, ensure that the circuit remains dead and is not energized by the closing of a remote circuit breaker. All circuit breakers or switches that could energize the circuit if closed shall be tagged with a red danger tag. The tag is not to be removed until work is complete (see **NSTM Chapter 300**). Although an option, it is recommended that a handle-locking device be attached (see **NSTM Chapter 300**), if available, to switches and circuit breakers that have been tagged.

b. Even though all circuit breakers to and from a switchboard are open, voltage can be present in the switchboard through control circuits. Examine switchboard and ship system drawings to determine if control voltages could be present. Add a note to DE energize control power to standard procedures for maintaining or troubleshooting such switchboards.

c. If removable covers (plates or grilles) are provided on switchgear units, use great care in removing them when equipment is energized. A cover may tip in after removing some fastenings or while it is being lifted off. This could result in contact with a live part that could cause a short circuit, an arc, or injury to personnel.

d. For protection of personnel, ground all enclosures and equipment frames to the ship. Particular attention should be paid to the stored capacitance potential present in the 4160V aircraft carrier switchboards

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Moisture in Switchboards. Under some conditions, moisture may condense within switchboards, particularly those having barriers between units. Condensation can form when switchboard parts cool down (such as when a switchboard is secured); lower than normal temperatures exist within a compartment when the compartment is secured; or steam escapes from open drain lines when lighting off cold equipment. Switchboards should be inspected and corrective measures taken when moisture is found or conditions favorable to moisture condensation exist. The corrective measures should follow the applicable Planned Maintenance System's Maintenance

Electric Plant Operating Rules. A few basic operating rules should be observed on all installations.

a. Watch switchboard instruments. They indicate the operating condition of the system, revealing overcurrent or overloads, improper division of kilowatt load or reactive current between generators operating in parallel, and other abnormal operating conditions.

b. Keep the frequency (on ac systems) and voltage at their correct values. Departure from either affects, to some extent, the operation of all equipment supplied with electric power. The operation of vital electronic, interior communication, and weapons control equipment may be seriously affected. This sensitive equipment requires careful adjustment of voltage regulators and prime mover governors to obtain satisfactory performance.

c. Use judgment when closing circuit breakers after they have tripped automatically. If a circuit breaker trips immediately upon the first closure, investigate before closing it again. The circuit breaker may, however, be closed a second time without investigation if the immediate restoration of power to the circuit is important and the interrupting disturbance when the circuit breaker was tripped was not excessive. Repeated closing and tripping could damage the circuit breaker and increase the repair or replacement work needed to get the circuit operating again. Some ships have preventive logic (fault circuit protection to prevent automatic circuit breaker reclosing after they were tripped due to a fault).

d. Use the hold-in device (not available on new ships) on circuit breakers with judgment and only when necessary. The hold-in device enables an operator to hold a trip-free circuit breaker closed when the current is in excess of the tripping value. The circuit breaker opens automatically as soon as the hold-in device is released if the current is more than the tripping current. In an emergency, it may be vitally important to obtain power even at the risk of burning out equipment. The hold-in device makes it possible to do this. When holding a circuit breaker closed, however, keep in mind that the circuit is not protected against damage by excessive current. The longer the circuit breaker is held closed, the greater the chance of permanently damaging circuits or equipment. A circuit breaker should never be held closed unless there is an emergency that justifies this risk.

e. Never parallel ship service generators until they have been synchronized (see **NSTM Chapter 310**).

f. Never close bus tie circuit breakers to parallel buses on two energized switchboards until the buses have been synchronized.

g. Never close the bus tie circuit breaker to restore power to a switchboard that has lost it because of failure of a local generator. The breaker may be closed if the generator circuit breaker has first been tripped by hand or if it has been definitely established that the generator circuit breaker is in the open position. Do not rely on the reverse power relay to trip the generator circuit breaker.

Never parallel ship service generators with shore power except for the short interval required to transfer the load from one source of power to the other.

1.) Never parallel ship service generators with shore power of a different frequency (such as 50 Hz).

2.) Never parallel with shore power for transferring a load without using a synchroscope or synchronizing lights. On ships not provided with a synchroscope for synchronizing between shore power and the bus, generator breakers shall be opened first. Then, the shore power breaker shall be closed. On some ships, shore power may be connected to the bus tie with bus tie breakers open. Synchronizing can then be accomplished across bus tie breakers.

3.) When the shore power and ship service generators are placed in parallel, the normal synchronizing process is reversed. The incoming shore power is the controlling source. Several precautions should be taken when paralleling with shore power, in addition to the usual ones when paralleling two ship service generators. The shore power connection phase rotation must be the same as the ship phase rotation. This is easily determined with a phase-sequence indicator. If more than one shore power connection is to be paralleled, actual phases of the shore power must be in the same rotation and also be connected to match ship phases. This prevents a short circuit through the ship system. If shore power phases 1, 2, and 3 are connected respectively to ship phases A, B, and C at shore power connection no. 1, then the connection at shore power connection no. 2 must also be connected 1, 2, and 3 to A, B, and C, respectively. When paralleling with shore power to transfer the load, bring the ship voltage up to, or as close as possible to, the shore power voltage.

4 In some cases, the shore power voltage will be about 480V. Increase the ship's generator voltage to match shore power voltage. Bring the ship frequency to that of the shore power. Turn on the synchroscope, synchronize the ship power with the shore power, and close the shore power breakers. Quickly transfer load to shore power. Trip the ship service generator breakers.

i. Always check phase sequence before connecting to a shore power supply. Be sure that connections are made so that the phase sequence on the ship will be A, B, and C. If the shore power is connected so that the wrong phase sequence results on the ship, motors (such as those on ventilation exhaust fans) will run in the wrong direction.

j. Never parallel an emergency generator with any other generator because loss of the other generator may cause the emergency generator to become over loaded and trip off line. An emergency generator (standby set), however, may be temporarily paralleled with a main generator to 1) provide a smoother transfer of power at cold ship start for sensitive loads or 2) when cold ship start loads are only accessible through main switchboards.

k. Always observe electrical safety precautions (see **NSTM Chapter 300**).

l. Never adjust a ventilation opening, for personal comfort of watch standers, to a position that allows spray or solid water entering the ventilation system through weather openings to be discharged onto switchboards, distribution panels, bus bars, or other electrical equipment

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m. Always operate switchboards and distribution system equipment as if no automatic protective devices are installed. Sooner or later, problems will result from careless operating practices that assume that automatic protective devices will either prevent incorrect operation or prevent damage from incorrect operation. Automatic protective devices used with the distribution system are intended to protect against damage as a consequence of equipment failure, not operator failure. The operator must read and follow instructions on warning plates and indicator lights and know the system and how to operate it correctly. The operator must never depend on automatic devices to eliminate mistakes or a mistake's consequences.

n. Only operate bus disconnects (disconnect links) when they are not energized. Exception may be taken under emergency conditions and in those instances where a normal means of DE energizing the bus disconnect is not provided, such as in a submarine battery power distribution system. Bus disconnects shall never be opened or closed under load. Not energized is defined as that condition in which no source of voltage is available on either side of the disconnect. Under load is defined as that condition in which current will be interrupted when opening or current will flow immediately after closing the bus disconnect.

o. To secure an ace generator operating in parallel with another generator or other generators

Turn the governor motor control switch of the generator being secured in the DECREASE speed direction Turn the governor motor control switch (or switches) of the other generator(s) in the INCREASE speed direction until all the load is shifted from the generator being secured.

Trip the circuit breaker of the generator being secured.

Return the automatic voltage regulator control to the manual position and the manual voltage control rheostat to the decrease voltage position.

SHORE POWER.

Shore Power Overvoltage Precautions. To minimize the dangers of over voltages on AC shore power to ships, the following precautions should be taken:
a. **New construction and conversion** . The contractor or building yard is responsible for ensuring that over voltages do not occur on any ship under construction or conversion.

b. **Other ships** . The yard or base must take every reasonable precaution to ensure against over voltages when supplying any ship or submarine with 60-Hz shore power.

c. **Maximum voltage tolerance** . The voltage, as measured at the ship's main switchboard, should not be allowed to exceed the maximum steady-state voltage of 462V. This voltage may be exceeded prior to assuming shore power. Once the shore power load is assumed, however, the voltage should drop to the steady-state range as a result of losses in the shore power cables and ship distribution system.

Instructions and Procedures for Shore Power Connection. Shore power arrangements and hardware used on both ship and shore installations are so diversified that no specific installation instructions can be outlined in detail. A shore installation that has one circuit breaker supplying a number of cable sets presents a particular hazard. In this case, phase rotation and phase orientation can be verified only by energizing all shore terminals.

Phase rotation should be checked with only one set of cables installed. The latest designs have a single, three-phase receptacle for ship and shore power terminals. These receptacles are keyed such that phase rotation cannot be altered provided both the ship and shore use these receptacles, and the cables are not spliced. Systems using three-phase receptacles are normally designed so that interlocks on the receptacles automatically trip associated circuit breakers whenever the receptacle cover is open and a shore power cable plug is not in place. Voltage to these receptacles, however, should still be checked to ensure they are reenergized prior to installing the shore cables. The following instructions assume that the shore installation has a separate circuit breaker or disconnect for each set of cables and that three-phase receptacles are used. These basic instructions and procedures shall be followed prior to and when connecting to shore power.

1. To avoid personnel injury and equipment damage, carefully inspect shore power fittings for any defects prior to making shore power connections. Follow installation instructions procedures, and check-off lists cautiously when completing the shore power connection. Also do this when performing any other steps necessary for transfer of the load from ship generators to shore power.

2. Connect and disconnect shore power under the direct supervision of the Electrical Officer, a qualified leading electrician, and the shore activity personnel.

3. Visually inspect shore power cables for any defects (such as cracks, bulges, and indications of overheating).Thoroughly examine spliced cables, in particular, since improperly spliced ones are extremely dangerous because the cable phase continuity may have been altered during splicing. Strip lug-to-lug connection splices of insulation and check the connection itself for cleanliness, tightness, and good surface contact. Repair all defects and reinsulate all lugs before placing cables in service. Check cables for insulation resistance using a 500V megger (megohmeter). Insulation resistance readings shall meet the requirements of **NSTM Chapter 300** . Check resistance between phases and between each phase and ground. For this test, shore ground shall be the enclosure that houses shore power terminals or receptacles. On ships, ground shall be the ship hull or any metal extension of the hull. During the physical inspection and megger tests, check the phase identification of the cables.

4. Ensure shore power cables connected to a ship are the same length to avoid voltage unbalance among cables.

5. Tag with high voltage signs and, if possible, rope off the work area surrounding the ship's shore power terminal box or receptacle. This box or receptacle is exposed to elements, and any moisture can cause a serious problem. With the ship's shore power breaker tagged in the open position, disconnect all equipment (for example, meters and indicator lights) that could be damaged by a megger test or cause a false reading. Test terminals in the ship's shore power terminal box or receptacle with a voltage tester to ensure that they are deenergized. Next, with a 500V megger, test the insulation resistance between terminals and from each terminal to ground.

6. Lay out the cable between the supplying shore power outlet and the ship's shore power terminals box or receptacle. Ensure that the cable is of sufficient length to allow enough slack for the rise and fall of the tide but not of such length as to permit the cable to dip into the water or become wedged between the ship and pier. Do not permit cables to rest on sharp or ragged objects such as gunwales. Avoid sharp bends. Lay cables in wood saddles or wrap in canvas. Raise splices and connectors from the deck or pier to protect against water contamination. Protect excess cable in a manner that will minimize damage from vehicle and pedestrian movements.

7. Connect shore cables to ship's shore power terminals according to phase or polarity in the box and on the cables.

8. Ensure correct phase orientation (phase relationship) by checking color coding or phase identification markings on cables. Reconfirm correct phase identification by meggering between like phases of cables, and using a phase orientation meter. Cables that give a zero indication will have the same phase relationship. After meggering, reconnect any disconnected equipment.

9. With a voltmeter, that has just been checked with a known energized source, check to ensure that shore power terminals are deenergized.

10. Connect shore power cable to terminals.

11. Check for proper phase rotation either by alternately energizing shore power receptacles one at a time and observing the ship phase rotation indicator mounted in the ship service switchboard, or by means of a portable meter connected to an appropriate bus. After checking phase rotation, deenergize each source shore power receptacle prior to energizing the next receptacle for the phase rotation check.

12. Energize all shore power terminals or receptacles and proceed with the transfer of electrical load to shore power in accordance with Engineering Department Operating Instructions. Instructions will vary depending on whether or not the ship is equipped to synchronize with shore power. After cables are carrying the load, inspect all connections to locate any possible overheating resulting from poor connections or reduced copper in the circuit. Inspect cable ends at the connection point for heavy strain or overheating.

Operation from Shore Power. Shore power cables are rated at 400 amperes. Switchboard meters must be checked to ensure that the total load on shore power cables does not exceed the combined rating of the shore power cables. Total shore power load in amperes should be no more than 400 times the number of three phase shore power cables connected.

INDICATOR LIGHT COLOR DESIGNATION. The ability to operate the electrical system properly requires a knowledge of the meaning of indications made by color. Because a limited number of colors can be readily distinguished, only a few colors are used for all designations, and each color is used for a number of designations.

a. Indicator light color designation (except for special applications in dark adapted spaces) is as follows:

1 **RED** - danger or emergency condition requiring immediate attention or corrective action
2 **GREEN** - normal condition
3 **WHITE** - power available or power on
4 **BLUE** - closed, advisory
5 **CLEAR** (not etched) - synchronizing or ground detector lights
6 **YELLOW** - Abnormal, but not requiring immediate attention
Indicators with red lenses and stencil-type marker discs are used in dark spaces requiring visual adaptation by personnel.

PREVENTIVE MAINTENANCE

FUNDAMENTAL RULES. Three fundamental rules for the maintenance of electrical equipment are
a. Keep equipment clean and dry.
b. Keep electrical connections and mechanical fastenings tight.
c. Inspect and test at sufficiently short intervals to make sure that the equipment is in operating condition.

EQUIPMENT CLASSES. Distribution system equipment requiring maintenance can be grouped into two general classes: 1) cables, with their fittings, and 2) switchboards (including distribution panels) with their associated equipment. **NSTM Chapter 300** provides maintenance instructions for both classes of equipment.

PHASE IDENTIFICATION

GENERAL. The terminals on switchboards, distribution panels, and equipment are marked with the letter A, B, or C to identify the phase. The standard arrangement of phases in power and lighting switchboards, distribution panels, feeder distribution boxes, feeder junction boxes, and feeder connection boxes is in the order A, B, C from top to bottom, front to back, or right to left, as viewed from the front of the switchboard, panel, or box (hence, left to right when viewed from the rear).

PHASE SEQUENCE. The phase sequence on United States Navy ships is ABC; that is, for a delta connected system, maximum positive voltages on the three phases are reached in this order, AB, then BC, then CA. Phase sequence determines the rotation direction of three-phase motors.

CASUALTY POWER

The older-style, casualty power portable cable terminates at each end of individual conductors with copper ferrules. Each individual conductor's insulation is exposed to shipboard ambient temperatures oil or oil fumes, and accidental damage. After 5 years or more of exposure, the conductor insulation may have aged and lost elasticity to the extent that it will crack open when bent during rigging of the casualty power system for emergency use. Exposed ends of individual conductor casualty power cables should be inspected at least once a year. The more recently designed casualty power components consist of molded, three-phase plugs or connectors. The cable shall be inspected in the same manner as older-style components. The best method of detecting insulation deterioration is to bend all conductors sharply by hand. If no cracks develop, the insulation is satisfactory If cracking is noted, the following repair must be made.

1. Cut off protruding ends and prepare new terminations as indicated for end preparation of cable for ac systems (see **NSTM Chapter 079, Volume 3**). To avoid baring the conductor when inserting it in bulkhead terminal, do not strip more than one inch of the insulation from the conductor.

2. Make cut ends of the cable insulation watertight by applying one heavy coat of clear, air drying varnish.
COLOR CODING ON THREE-PHASE AC SYSTEMS

Cable Type Phase or Polarity Color Code

4 Conductor A Black
B White
C Red
Neutral Green

3 Conductor A Black
B White
C Red

3. Place round copper ferrule on the conductor and secure it by forming it as shown in Figure 320-3-1.

4. Fabricate forming die as shown in Figure 320-3-2 or order through the supply system.

5. For phase identification by touch, use the following method 1 or 2:

a Method 1 - Apply close wrapping of cotton twine of approximately 3/64-inch diameter as follows: black wire (A phase), one wrapping; white wire (B-phase), two wrappings; and red wire (C phase), three wrappings.

b Method 2 - As an alternative to cotton twine, install O-rings for phase markings. Slip shrink tubing of required color over O-rings as follows: black wire (A phase), one O-ring, black tubing; white wire (B phase), two O-rings, white tubing; and red wire (C phase), three O-rings, red tubing. Apply heat in accordance with manufacturer's instructions to shrink the tubing to hold the O-rings securely in place on the conductor. If colored tubing is unavailable, use transparent tubing.

6. For watertight effectiveness, extend heat shrinkable tubing approximately 1/8 inch over the copper ferrule.

7. For end preparation of cables for dc system, see Figure 320-3-3.

8. Seize ends of bare conductors with 0.025-inch-diameter copper wire; solder in place. Care should be taken to preserve the flexibility of the remaining bared conductor.

9. Seal cut ends of cable insulation by applying a heavy coat of clean air-drying varnish.

10. Terminate casualty power cables using one of the following two acceptable methods:

a Heat shrink tubing - Apply heat shrink tubing to the cable, extend it 1/8-inch over the ferrule, and apply varnish to provide water tightness.

b No heat shrink tubing - Strip the cable insulation back 1/8 inch over the ferrule and apply varnish to provide water-tightness.

Securing Copper Ferrule to Conductor (Typical)

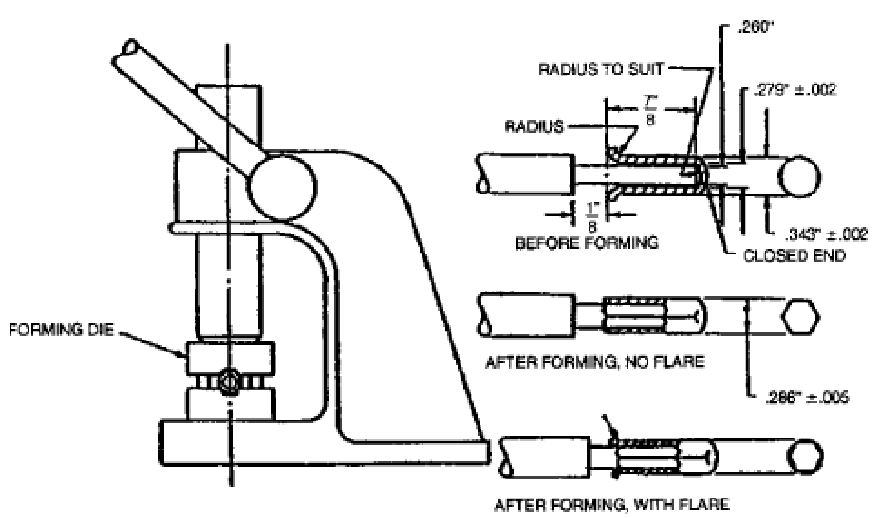

Figure 320-3-1 Securing Copper Ferrule to Conductor (Typical)

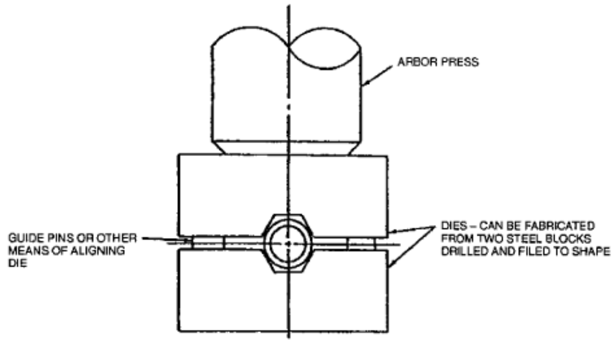

Figure 320-3-2 Forming Die

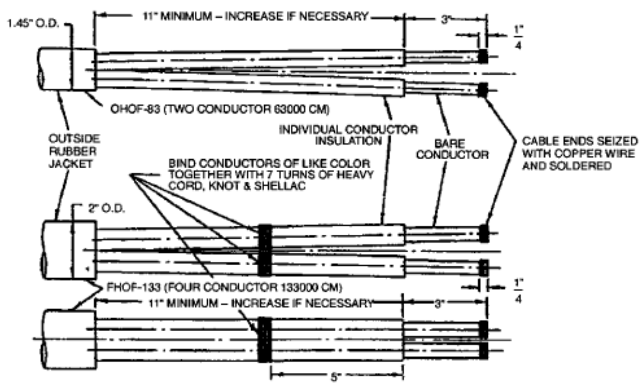

Figure 320-3-3 Portable Casualty Power Cable Ends (DC Systems Only)

FLOODING MARKERS

The ships name, bow numbers, and draft marks shall be painted in accordance with instructions in NSTM S9086-VD-STM-010 Chapter 631, VOLUME 1, PRESERVATION OF SHIPS IN SERVICE – GENERAL. In addition, flooding markers shall be applied to identify the inactive ships water line
and to provide a distant observer a base line to visually detect a change in draft. The marker shall be 6-inch by 3-foot horizontal international orange stripes painted on the hull forward, aft, and amidships at the water edge to allow visual inspection.

LIFELINES

Lifelines. . Portable lifeline stanchions and lifelines should be removed from place and stowed under dehumidification when their removal will not create a safety hazard. The exterior surfaces of stanchions remaining in place shall be painted with the same paint used on the rest of the ship. The interior surfaces, bases, sockets, and other inaccessible areas shall be treated with metal conditioning compound, cleaned of rust to the maximum possible extent, and preserved with grade 1 compound.

MOORING INSPECTION

INSPECTION METHODS.

Local Conditions.

Mooring Hardware Fittings. Each piece of mooring hardware should be visually inspected for anomalies. Conditions that are commonly found include cracks, abrasion (due to wire rope), corrosion and displacement. Cracks are usually the result of impact loading or overloading the hardware under extreme conditions. Abrasion normally occurs when mooring lines are pulled around the hardware causing friction and corrosion of the casting under the barrel or horn. If this condition is severe, it will weaken the casting through loss of cross sectional area. Documentation of the depth of erosion, location, and area are required to establish loss of strength. The condition of the coating should be noted. Coatings that have mechanical damage, i.e., cracks, peeling, or abrasion, should be described. Coating systems that have failed or are worn out should also be described, as well as any resulting corrosion. Levels of corrosion can be described as rust stains, light scale, and heavy scale. The surface roughness of the steel should also be described. Corrosion of the casting should be assessed to determine the loss of section at critical points on the casting. Heavy corrosion will also affect the surface roughness of the hardware increasing the chafing and wearing of mooring lines. Observations of the mooring hardware plumb and level are made to determine prior overloading and failure of the surrounding soil or fasteners.

Fasteners. Fasteners consisting of steel bolts are used to anchor the mooring hardware to the supporting structure. In some cases mooring hardware is embedded directly in the supporting structure. Where fasteners are used, their function within the mooring system is critical and is almost always the critical structural element. Fasteners are generally inaccessible as a result of typical mooring hardware details calling for protection usually in the form of lead fill, bituminous fill or grout being placed in the bolt pockets. If the fasteners are not visible, then a Level 1 or 2 inspection will result in minimal fastener data.

A Level 3 inspection is required to determine the condition of the fasteners. For newer structures, the fasteners may pass through blocking and terminate with nuts and washers bearing on heavy plates. This part of the structure is accessible and should be inspected for loss of section due to corrosion. If fasteners are embedded in the structure and the bolt pockets are filled, the only inspection technique available to the inspector is to remove the casting and observe the fastener for corrosion and loss of cross sectional area. Load testing of the fasteners can be conducted without removal of the casting and will result in the determination of an allowable load. See Appendix B for load testing criteria.

Supporting Structure.

Concrete. The majority of heavy load mooring hardware is attached to concrete decks. Concrete acts well to resist the forces applied by mooring hardware. The compressive strength of concrete resists the shear forces generated as well as providing excellent distribution of load through the structure. Factors to consider when inspecting concrete that supports mooring hardware include cracking, disintegration and corrosion of reinforcing steel. Cracking occurs in all concrete through many processes both as a result of natural factors and from outside forces such as impact.

The inspector must be able to determine the differences between the various types of cracks, their causes and the structural implications of those cracks. Cracks of a concerning nature include: shear cracks near the edge of the pier deck (running at 45 degrees through the corner); diagonal cracking on the deck surface running at 45 degrees from the hardware to the edge; and radial cracking around fasteners indicating cone failure. Gaps at the hardware base or crushing of bedding grout indicate movement or overloading and should be noted. General deterioration of the concrete should be observed and noted.

The mooring hardware should be founded on a solid concrete matrix and/or bedded in grout to provide full contact on the bottom and sides. The concrete should be solid and not exhibit any significant disintegration or spalling.

Timber. Timber structures should be inspected for structural failures such as: crushing of the timber under the hardware or the fastener bearing plates, cracking or failed members, and displaced members. Timber also exhibits deterioration in several forms such as: dry rot, marine borers, termites or other insects. These conditions should be noted and assessed based on their impact to the structure and mooring hardware.

Steel. Steel supporting structures exhibit conditions such as corrosion, buckling, and cracking. Steel members are generally fastened with either bolts or welds. Bolts should be inspected for tightness, loss of cross sectional area due to corrosion, and bearing. Welds should be inspected visually for cracking.

Fender System. Visual observation of the fender system should be made in sufficient detail to establish the typical cross-section and to detail the energy absorbing characteristics of the system. Where timber fender systems are employed the general condition of the timber components should be noted in terms of berthing capability. Where other types of fender systems are in place, the overall capacity of the system should be documented. Locations where damage has occurred should be noted. Missing fender units should be noted and identified.

Global Conditions. Global conditions refer to the condition of the supporting pier, wharf or dolphin structure. The inspection of these structures is closely related to the condition of the mooring hardware with respect to the capacity of the mooring system. For example, the sum of the capacities of the mooring hardware may exceed the total capacity of the structure to resist these loads. In this case the mooring hardware cannot be fully developed. Berthing plans are required to factor these limitations into the allowable berthing capacity for the facility. Inspection of pier facilities is addressed in UFC 4-150-07, *Maintenance of Waterfront Facilities*.

Pier Structure. The significant loading imposed on the pier structure by mooring hardware is in the lateral direction (horizontal “x” direction), which in most cases is resisted by batter piles or passive earth pressure. Piers vary in their
construction and the methods employed to transmit these loads to the soil. Open pier structures generally have battered piles (piles at an angle) along with plumb piles (vertical piles,) as well as significant dead loads to resist the lateral and resulting uplift loads. Solid pier structures rely on their massive dead load for stability, as in cellular structures or in the resistance of deadman in the case of tied back sheet pile bulkheads.

Structural Analysis. The inspecting engineer should collect all available data to ascertain the capacity of the pier structure to resist lateral loads. Available information may include:

- Original design drawings and calculations
- Modifications to the structure
- Previous inspection reports

Calculations. When directed, a licensed professional engineer should calculate the lateral capacity of the facility based on available data and according to MIL-HDBK 1026/4, *Handbook for Mooring Design*. The NAVFAC software, *Waterfront Analysis Toolbox for Engineers (WATERS)* provides electronic tools to assist in the analysis. For each ship that uses the facility, the analysis should provide the maximum wind speed for safe mooring. Caution should be exercised in using appropriate factors of safety based on the accuracy and scope of available data.

PHOTOGRAPHY. Photography should be used to document the condition of each piece of hardware. This can be used in future assessments to determine the change in conditions. Photographs should include a general overview of the hardware piece and any significant conditions. The hardware should be identified within the photograph. An overview of each berth showing the fender system should be taken and included within the report.

PEST CONTROL

The appearance of the Museum and ship site will be (and is) and extremely important priority. The Museum's grounds and the ex-MISSOURI will be kept clean by museum staff and sub-contracted venders where needed; this will discourage pest intrusion. A daily garbage clean-up schedule will be incorporated into the maintenance job description and all museum personnel are encouraged to pick up loose debris. In addition, staff will also be responsible for onboard pest detection and inspections. If pest species are discovered in the Museum or ship, management will be informed and a pest control firm will exterminate the problem.

PROPULSION SHAFT OUTBOARD BEARINGS AND STERN TUBE

General.

a. Seal. A leak proof seal must be provided to prevent the ingress of foul and silt-laden water and its various contaminants and will retain the preservative compound in the bearings during the inactive status of the ship.

Either of the two procedures described herein should be followed to provide divers with a standard method of removal. The propulsion bearing seals should be installed after a positive lock has been secured on the shafts to prevent accidental turning of the shaft when the ship is undertow. One method of sealing is to use a two-component, cold bonded polysulfide (Thiokol) paste conforming to MIL-S-23498. This material may be applied to metallic or plastic hulls, and with certain modifications is adaptable to wood.

b. Preservative Compound. Use MIL-C-16173 Grade 2 (ESGARD PL-2). Protect all bearings and point surfaces to prevent chemical and electrical corrosion and displace all seawater to exclude the formation of marine growths and accumulation of abrasive mud or silt during the inactivation period. The preservative compound prevents freeze-up of the bearings, provides initial bearing lubrication, and be capable of being flushed out of the bearings at the time of reactivation of the ship.

Seal and Preservative. To adequately preserve the water lubricated stern tube and strut bearings of inactive ships, a leak proof seal and an effective preservative compound must be employed which will meet the following general requirements:

a. Seal. A leak proof seal must be provided to prevent the ingress of foul and silt-laden water and its various contaminants and will retain the preservative compound in the bearings during the inactive status of the ship

.

Either of the two procedures described herein should be followed to provide divers with a standard method of removal. The propulsion bearing seals should be installed after a positive lock has been secured on the shafts to prevent accidental turning of the shaft when the ship is undertow. One method of sealing is to use a two-component, cold bonded polysulfide (Thiokol) paste conforming to MIL-S-23498. This material may be applied to metallic or plastic hulls.

b. Preservative Compound. The preservative compound employed in this method must be water soluble, of low viscosity, and penetrable to all bearing voids. It must effectively protect all bearing and joint surfaces to prevent chemical and electrical corrosion and displace all seawater to exclude the formation of marine growths and accumulation of abrasive mud or silt during the inactivation period. The preservative compound must prevent freezeups of the bearings, must provide initial bearing lubrication, and be capable of being flushed out of the bearings at the time of reactivation of the ship.

Materials, Equipment and Supplies. The following items are used to preserve the propulsion outboard bearings and stern tube:

a. Sealing Compound, MIL-S-23498 or equivalent, and associated primer. Pending availability of military specification material, Technical Research Company, Seattle, USN Ship Bearing Sealant is available. Other alternates which may perform acceptably are PR-380-MT (primer 1523M) manufactured by Products Research and Chemical Corporation, Gloucester City, NJ, and Sealing Compound Bearing Preservation (formula 117 primer), supplied by Philadelphia Resins Corporation, Montgomeryville, PA.

b. Mixing motor, approximately 350 rpm, 1/2 horsepower minimum, with chuck for item c.

c. Propeller mixer, 3 blade.

WARNING

Trichloroethane is toxic and shall be used only under conditions of adequate ventilation. Inhalation of vapors and prolonged contact with bare skin should be avoided. Whenever trichloroethane is used in closed spaces with limited ventilation, personnel should wear airline masks with forced air ventilation. Eye protection should be worn at all times when working with trichloroethane.

d. Trichloroethane solvent, 10 gallons.

e. Clean rags (grease and oil-free), 1 small bale.

f. 2-inch paintbrush (new), 2 each.

g. Paddles, oak or aluminum.

h. Putty knife.

i. 1/2-inch by 4-inch black iron nipples and caps, two per strut, also drills and taps for installing.

j. 2-inch wide vinyl or paper masking tape, 1 roll.

k. Antifreeze solution, ethylene glycol type, 20 percent by volume, to be used in the event that the ship is to be stored in water which may go below 0°C (32°F).

l. Large funnel for filling struts and stern tubes

m. Solvent-resistant gloves.

n. Can opener, rim-cutting type.

o. Scissors.

p. Shore durometer, type A (Shore Instruments Company, Jamaica, NY).

Bearing Sealing Procedures. The procedure for bearing preservation includes the following:

a. Inspection and cleaning of bearings

b. Preparation and cleaning of surfaces

c. Preparation of bearing seal primer and its application

d. Mixing and catalyzing of bearing sealant followed by its application

e. Curing time

f. Pressurization and testing for leaks

g. Introduction of preservative compound by gravity into bearing voids for complete immersion of the bearings.

NOTE

All materials used in plugs and structural modifications described herein, when not covered by a specification, shall be selected based on electrolytic corrosion compatibility and corrosion resistance to seawater.

Inspection and Cleaning. Remove and check the fairwaters and rope guards and determine that shafts have been inspected and repaired where necessary. Perform necessary cleaning of each bearing by use of air and water. Insert copper tubing between each stave for the entire length of the bearing and eject lodged sediment with a stream of air or water. When excessive clearances are in evidence, renew bearing staves as needed.

Preliminary Steps Before Sealing Procedure.

a. Drill and tap 1/2-inch IPS in tops of rope guards and fairwaters prior to their reinstallation on the ship
.

b. Remove tallow filling plugs from bottom of fairwaters and stern tubes to check for entrapped water. If stern tubes are leaking water at this point, they must be steamed out thoroughly and allowed to dry before soaking can take place. Refill with preservative and replace plugs.

c. Install rope guards and fairwaters and screw in 4-inch-long 1/2-inch IPS black iron filling and venting nipples. After struts will have nipples in fairwater and rope guard, while intermediate struts will have nipples in fore and after fairwaters. Do not install stem-tube fairwaters.

d. Insert items (removable) such as rags, packing, plugs, or rope into all voids through which sand could enter bearings during subsequent sandblasting operation. Water ingress and egress holes in fairwaters and rope guards may be conveniently plugged with tapered wooden plugs.

e. Disconnect water service pipe line to forward end of stern tube. Subsequent testing and filling and venting will be accomplished at this point.

f. Repack all stem tube packing glands with new packing. Tighten packing gland retaining ring firmly in place so that the gland will later withstand a pressure of 2 psi without leakage.

Preparation of Surfaces. The surfaces to receive the primer and sealant shall be dry sandblasted approximately 4 inches from each point of seal, including the rubber shaft covering. Sandblasting shall be down to bare shiny metal except for the rubber shaft covering. Remove dust with a clean, dry paintbrush; brush away from masking materials and surfaces to be sealed; remove rags, rope, or masking tape. All areas must be clean and dry prior to the application of primer. If there is any oil, grease, or waxy contamination on surfaces to receive the primer or sealant, remove it by wiping the contaminated area with a clean rag wetted with trichloroethane.

Cut 2-inch wide vinyl or masking tape into short pieces and stretch the pieces over the water circulating holes and openings, contacting the surfaces not more than 1/4 inch beyond opening. Tape around fairwater sealing between the fairwater and shaft, and between the fairwater and strut barrel. The same applies to the gap between the rope guards and strut barrel or propellers. If any openings exist at time of sealant application, the sealant will permeate into the openings and, as a result, the sealant cannot be removed by peeling when required, and difficulties in locating and cutting out the plugged holes are encountered. It is essential that the tape does not extend more than 1/4 inch beyond any opening. Use caution so that sandblasted areas are not touched by fingers or hands.

Preparation and Application of Bearing Seal Primer. After sandblasting and taping, prepare the primer in accordance with the manufacturer’s instructions and apply with a clean brush to all sandblasted and taped areas, including rubber areas that have been sandblasted. Apply a very thin coating of primer, ensuring complete coverage, which is necessary in obtaining a good bond of the sealant. Allow to dry for the time period recommended by the manufacturer before applying bearing sealant. If sealant application does not follow within the manufacturer's specified time limit, clean primed areas with trichloroethane and reprime.

Mixing and Catalyzing of Ship Bearing Sealant. Mix the sealant components as recommended by the manufacturer. The importance of thorough mixing cannot be over-emphasized, as proper mixing is critical in acquiring a complete cure. This has been a source of difficulty in the past. A propeller-type mixer is recommended attached to a motor of one-half horsepower minimum. To perform the actual mixing, securely attach the mixing motor to an immovable object. The operator then sits in front of the mixer holding the can of base material. Cut the rims out of both the base mix and catalyst cans, and using a putty knife, transfer all the catalyst paste into the base material can. Add fiberglass particles to sealant for strength. The mixing operation may now proceed. Best mixing can be accomplished by folding the material in the can by raising and lowering it while also rotating it. Stop the mixer twice during mixing operation and scrape down the propeller and shaft on order that no unmixed material will remain. Also, ensure that no material on the sides or bottom of the can is left unmixed. If streaks of colored material can still be seen in the material, it is not thoroughly mixed, and must not be used without further mixing. The catalyzed material must be used immediately, as mixed sealants have a limited pot life.

Do not use sealant that has started to set.

Application of The Sealant:

a. Apply thoroughly mixed sealant with either wooden or aluminum paddles or spatulas. The material shall be applied to a thickness of 1/2-inch minimum and 4-6 inches wide in contact with metal or rubber adjacent to each point of seal. If the gap to be jumped exceeds two inches, the thickness of the sealant should be increased to 1 inch or more.

b. Sealant shall be forced into all indentations such as pits and cracks, and then be faired out to as fine a feather edge as possible (1/8 inch maximum thickness at edge) and the entire surface smoothed out to prevent drag when the ship is being towed through the water. Gloves wet with trichloroethane are appropriate for this fairing and smoothing operation. .

c. One or two days at 75° to 80°F (and longer times at lower temperatures) will be required to fully cure the material. The cure may be hastened with the application of external heat in accordance with the manufacturer's recommendations. Care should be taken, however, that the material is cured throughout, and not just on the surface, before pressure testing takes place. Live steam should not be used in such a way as to cause cavitation of the sealant. If drydock temperature is below 70°F and undocking of the ship is less than 24 hours away, cure to a durometer a hardness of 60 with infrared lamps.

Pressurization and Testing for Leakage.

a. Air test all strut bearings and stern tubes at 2 psi gauge pressure to a no-pressure-drop test for 30 minutes. All seals and entire strut should be checked with a soap solution, including those portions not covered by sealant. The no-pressure-drop test alone is not sufficient evidence of a perfect seal (the pressure may change with temperature). Soap solution must be used on all sealed areas and packing glands. At this point, the necessity of ensuring that the packing gland at the forward end of the stern tube is not leaking cannot be overemphasized. Do not go by a no-pressure-drop test, only by the soap bubble test.

b. In the event of a leak either through the sealant or immediately adjacent to it, mark a circle around the leak with chalk. Release the pressure, thoroughly wash soap solution off with clean water, wash with solvent, and allow to dry. Patch with a small quantity of sealant, fair, cure with an infrared lamp just below blistering point of the material, and retest. The whole operation can be done in 30 minutes. In an event of a leak in a casting away from a primed area due to a casting defect or around tallow fill plugs in the bearing sleeve, sandblast around leak, prime, seal, and retest.

c. After successful pressure testing, remove forward nipple and aft cap. Fill strut by gravity through forward hole with a antifreeze solution, if required. Replace cap on after-nipple and cover with sealant. Hot patch forward hole with sealant. Fill stern tube through funnel inserted in disconnected water service line opening in forward end of stern tube. Venting will take place around the funnel. All filling should be done through a funnel to eliminate the possibility of full line water pressure being applied to the seals.

Corrosion Preventive Solutions. For water lubricated stern tube and strut bearings of rubber, laminated phenolic, and lignum vitae material, the preservation compound used shall be prepared as follows:
a. In areas where the berthing water temperature remains above 0°C (32°F), stem tubes and bearings shall be filled with a preservative compound conforming to MIL-C-16173, Grade 2 (ESGARD).

1. The Material Safety Data Sheet (MSDS) and container labels for ESGARD PL-2 should be carefully reviewed regarding required precautionary measures prior to starting any procedure involving this material. All personnel working with ESGARD PL-2 should receive preassignment and periodic refresher training.

Critical aspects of this training should include a review of the potential hazards related to use of engineering controls and use of personal protective equipment and respiratory' protection, first aid, as well as damage control, spill cleanup and disposal procedures.

2. Personnel should avoid skin contact with ESGARD PL-2. Skin contact can result in dermatitis, folliculitis, or oil acne. It is recommended that rubber or oil resistant gloves, or other gloves of equivalent resistance to penetration by ESGARD PL-2, be worn to prevent skin contact with this material. Use of elbow-length gloves with large cuffs may also be required for some operations, particularly when coating vertical or overhead surfaces using a brush or roller. Use of other items of protective clothing (e.g. impervious apron, shoe covers or boots, impervious coveralls) may also be required, based on the type and magnitude of the operation. Personnel should wash all potentially

exposed skin areas with soap) and water at breaks, and at the conclusion of the operation or work shift. ESGARD PL-2 should be promptly removed from the skin using soap and water. Clothing contaminated with ESGARD PL-2 should be removed as soon as feasible and thoroughly laundered prior to reuse. Contaminated protective clothing anti equipment should be thoroughly cleaned with soap and water following use, prior to storage. Personnel should seek prompt medical attention in the event a dermatological condition, or other condition possibly related to exposure to ESGARD PL-2, is detected.

3. Eye contact with ESGARD PL-2 should be prevented by use of chemical worker's goggles, where supplemented by a full-length face shield, where splashing of the material could be a problem, unless equivalent protection is provided by use of a full-face piece respirator. An American National Standard Institute approved source of potable water (15 minute supply minimum) should be readily available for use near each work area. In the event of eye contact with ESGARD PL-2, personnel should immediately flush their eyes for a minimum of 15 minutes; then obtain prompt medical assistance.

4. Respiratory protection should be selected, based on recommendations from the local cognizant industrial hygienist, after reviewing the specific operation of concern. Vapors from ESGARD PL-2 can cause pulmonary irritation, dizziness, and nausea in exposed personnel. Where respiratory protection is considered necessary, it must be National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA) approved for this purpose. Use of a NIOSH/MSHA approved organic vapor respirator, equipped with a particulate prefilter, will probably be sufficient for many operations not performed within enclosed or confined areas. Operations performed in enclosed or confined areas, or major operations involving spray application of ESGARD PL-2, may require the use of a NIOSH/MSHA approved supplied-by-air respirator, based on specific guidance provided by the local cognizant industrial hygienist. Operations performed in confined areas should also receive special evaluation by the cognizant. Gas Free Engineer, who should certify the safety of the operation prior to allowing these preservative coating operations to begin.

5. Ventilation should be provided for all operations involving use of ESGARD PL-2, when mists and vapors could accumulate in work areas. Ventilation systems, where used, should be designed and located so as to capture mists and vapors at the point of generation, with discharge outside occupied spaces in a manner precluding recirculation of vapors and possible exposure of other personnel.

6. Decomposition products from ESGARD PL-2, as would be formed during a fire involving this material, are considered toxic. Personnel engaged in damage control efforts should be provided with NIOSH/MSHA approved positive pressure respiratory protection to preclude exposure to these products.

7. ESGARD PL-2 is incompatible with strong oxidizing agents.. In areas where the berthing water temperature remains 0°C (32°F), the corrosion-inhibiting solution shall be inhibiting antifreeze with four parts of freshwater. In place of corrosion inhibiting antifreeze, the stern tubes and bearings may be filled with a preservation compound conforming to MIL-P-20088.

Removal By Divers. The material should be peeled from water circulating holes and other areas where necessary water circulation might otherwise be impeded before turning the shaft.

Record. In the submission of Docking Reports, all work accomplished as instructed throughout this paragraph shall be indicated on the Docking Report and shall be entered into the Maintenance Data System (MDS), together with necessary instruction for removal by divers at time of activation. Photographs showing details of the bearing preservation appended to Docking Report are recommended as a valuable device to reduce the length of descriptive narrative in reports.

Alternate Boot Sealing Method. An alternate method of boot sealing was developed by rubber technologists working at the Puget Sound Naval Shipyard. The basic materials used are sheet rubber (MIL-S015058C, Type III), phosphor bronze flexible cables, and phosphor bronze cable terminals. (Refer to plans DD 667-S4302-H-1396279 and S4302-H-1492176 for details.) Sheet rubber is used to make a watertight cover approximating the contour of the bearing structure. Flexible cables are used to help secure the ends of the cemented rubber boot to the shaft, strut barrel, propeller hub, or stern tube extension. The seal shall have an outer protective jacket consisting of a laced-on corset of vinyl or neoprene-coated nylon cloth. This shall apply for both vacuum and gravity filled boot seals. Preservative Compound. The same preservative compound employed for the plastic seal should also be employed with this method.

Principle of Construction. Bearing preservation by the sheet rubber method involves nine steps. These are:

a. Inspection and cleaning of bearings prior to preservation.

b. Structural modifications involve construction of a circular metal band or rubber band to provide a smooth gasket sealing surface for one end of the boot. The other end of the boot is sealed onto the shaft after cementing a rubber band over the shaft.

c. Determination of size and shape of rubber boot to be cut from sheet rubber.

d. Construction of the lap seam of boot by skiving, overlapping the edges, and cementing together.

e. Cementing the ends of boot to the shaft, and to one of the structural modifications on the strut barrel, propeller hub, or stern tube extension as the case may be.

f. Clamp the two ends of the rubber boot.

g. Testing the boot for leaks.

h. Lacing on the outer jacket of vinyl or neoprene-coated glass cloth.

i. Filling the rubber boot with rust-preventive solution so that the bearings are immersed. Inspect and Clean.

a. Remove and check the fairwaters and rope guards, and determine that shafts have been inspected and repaired. Perform necessary cleaning of each bearing by use of air and water. Insert copper tubing

between each stave for the entire length of the bearing and force air and water to eject lodged sediments. Inspect the system to determine whether the bearings and journals are in good condition. Record clearances and renew bearing staves as needed to overcome excessive clearances. Propulsion shaft
bearing systems shall be determined to be in good condition by the following criteria:

1. The ship has been recently active and operating satisfactorily with no obvious defects having been detected by routine inspection while taking clearance readings during dry-docking.

2. The ship's bearings have been previously preserved with watertight seals (of any design), and the preservation docking report indicates that the bearings were clean and in good condition.

3. For all other cases, one or more randomly selected bearings must be pulled, and the shaft journal, shaft
protective coating, and bearing must be inspected to determine condition. If the condition of the randomly
selected bearing shaft and journal is good, all others may be assumed good. If the system needs cleaning or repair, all others must be pulled, cleaned, and repaired.

Structural Modifications. Structural modifications are made to provide a smooth gasket surface for securing the rubber boots. Smooth refers to a degree of finish that may be a sandblasted metal surface without the presence of pitting. The following modifications are acceptable:

a. On structures that do not provide sufficient smooth, pit-free cylindrical surface for securing one end of the rubber boot, such as wide-blade propellers without any forward hub area, a watertight metal band may be welded onto the strut barrel, propeller hub, or stern tube extension, as the case may be. This metal band consists of a steel, brass, or bronze ring, installed as a split ring. This is one device that is applicable to all conditions of strut barrel propeller hub, or stern tube extension, that may not permit the use of method 2 as follows. The selection of the type of metal shall be made based on reducing electrolytic action and/or to facilitate welding. NAVSEA Plans S4302-H-1492176, and DD667-S4302-H-1396279 show the use of a bolted flanged propeller hub extension. Both later mentioned devices also provide a satisfactory seal where there is insufficient land area for cable clamps.

b. On structures that provide a cylindrical surface for at least 3 inches, a rubber band shall be cemented to the strut barrel, propeller hub, or stern tube extension, as the case may be. The locations of the two metal rods and rubber band.

c. If a double-boot construction is employed, either the method described in 1 or 2 may be used. Two 3/16-inch steel rods may be tack-welded to the fairwater to prevent the cables from sliding downward on the gasket surface.

Metal Band Method

Band Clamp Compressed Tapered Rubber Gasket

Rubber Band Method

Determination of The Size and Shape of The Boot. Develop the pattern for the structure to be sealed. Decide whether one or two boots are necessary in order that the cemented boot will go over the structure
without a person resorting to excessive effort in fitting the boot.

a. Method 1 The single-boot construction is made from sheet rubber. The pattern is cut to make either a cylinder lampshade or a cone so that the cemented boot will fit snugly enough to permit it to be cemented over the fairwater, propeller hub, rope guard, shaft, or stern tube extension, as the case may be. Allow sufficient material to make a 3-inch lap seam. . The manner of marking out the pattern is to scribe arcs with chalk on the sheet rubber material. The circumferences of the small and large arcs shall be made to accommodate the shaft at one end and the structural modification at the other end, respectively. An allowance of three inches shall be made for the construction of the lap seam. An additional 2 inches in circumference is allowed for the boot employed in the heat-curing method as space is necessary to insert the heater. Boot pucker caused by heating element insertion or by other causes such as dimensional error, should be minimized so it may be compensated by the flexible cable clamp.

b. Method 2 The two-boot construction is used whenever one part of the structure may be sealed with a cylindrical boot and the remaining part with a conical section.

Construct The Lap Seam of The Boot. The boot in sheet form is laid over the open space of the shaft. The joint or lap seam shall be cemented by one of two methods.

a. Method 1. Heat-vulcanize the cemented joint that is made as follows:

(1.) The edges of the neoprene rubber boot to be cemented are skived and buffed with sandpaper and cleaned with rubber solvent.

(2.) Two coats of PSNS H-8 cement or one coat of Gaco catalyzed cement (1 part N-39 by volume to 16 parts of N-29) is applied. Allow a drying time of 30 minutes between coats for the PSNS H-8 cement.

(3.) When the last coat of cement is dried to a tacky feel, join the two surfaces together to form a 3-inch lap seam. Roll and stitch the seams together with a conventional rubber roller and stitcher, respectively, to work out trapped air.

(4.) Assemble the electric heater (fabricated locally). The cemented seam is positioned between the air Bag inflated to 10 psi, and the bottom plate of the electric heater.

(5.) Close the electric circuit to the heater. The rubber at the seam shall be heated from room temperature up to the specified time and temperature, which is 30 minutes between 280°F to 300°F for the PSNS H-8 cemented joint, and 30 minutes between 230°F to 250°F for the using cement (652-S-240-5) joint. Allow the rubber to cool under pressure for 30 minutes before dismantling the heater and removing the rubber boot.

(6.) Skive the ends of the boot where the cable clamps are employed to form a continuous surface without the abrupt change introduced by the lap joint.

b Method 2. When temperature in drydock exceeds 65°F, it is possible to cement the lap seam without the
application of external heat. This method is suited where space limitation precludes the use of a heater. The joint is made as follows:

(1.) The edges of the neoprene rubber boot to be cemented are skived and buffed with sandpaper and cleaned with rubber solvent.

(2.) One coat of catalyzed cement (652-S-240-5) is applied. Allow solvent to evaporate for about 1 hour before joining the surfaces. Experience has shown that drying time specified here is only suggestive.

(3.) Join the edges of the rubber boot together to form a 3 inch lap seam. Apply pressure on the cemented joint with a roller, and remove trapped air with a stitcher.

(4.) Allow the cemented rubber boot to be suspended on the shaft for 24 hours or longer.

(5.) Skive the ends of the rubber boot where the cable clamps are employed over the lap joint. Cement and Clamp The Two Ends of The Rubber Boot. The ends of the rubber boot are secured with cement and cable clamps. One end is secured on the gasketed shaft and the other end on the aforementioned metal or rubber band. The gaskets are cemented down using catalyzed cement (652-S-240-5) when adhered to rubber but when adhered to steel, two coats of primer of cement (652-S-240-18) must be used first. The gaskets should be skived and lapped carefully. After the rubber boot is drawn and cemented in place over the bearing structure, a hole is cut in it for the installation of the vent or filling fitting. The upper half of the vent or filling fitting is drawn down to the lower half to seal the joint, as shown on NAVSEA dwg S4302-H-1492176. After the cable clamps are secured circumferentially around the boot and the structure to be sealed, gradual compression of the rubber is made so that uniform pressure is exerted on the rubber to affect a secondary seal. Note 10 of NAVSEA dwg S4302-H-1492176 permits the alternate use of BAND-IT pipe and hose clamps in lieu of cable clamps for small diameter shafts. Although this wide band clamp does not conform to irregular surfaces or accommodate boot pucker as well as the capable clamp, care in installation will permit its use on small diameter shafts.

Test For Leakage. An air pressure, soap solution test to determine that the boot seal does not leak shall be performed for either gravity or vacuum filled systems. One psig air pressure shall be applied to boot seals to detect leaks. If any leaks occur, tightening of cable clamps, cemented sheet rubber or neoprene putty patches, or repairs to welds will stop any small leak that may be present.

Outer Jacket. The outer jacket of vinyl or neoprene coated nylon cloth must be laced over the rubber boot before introducing the solution, by either method 1 or 2, to mechanically protect the seal as well as to prevent the seal from ballooning in method 1. The outer jacket or corset seams are made with nylon thread (do not use cotton thread) and eyelets (SNSN G42-G-1410), which provide a means of lacing the corset over the rubber boot with one-quarter-inch nylon rope or 14 gage soft copper wire lacing (MIL-W-3861).

Filling The Boot With Rust-Preventive Solution. There are two methods that may be employed for filling the boot with rust-preventive solution; one is by vacuum feed and the other by gravity feed.

a. Method 1. The rust-preventive solution may be introduced under a vacuum. A minimum vacuum of 3 inches of mercury is ample. Introduce the solution at the lowest level fitting and apply a vacuum at the other fitting. Shut off all valve connections to the boot or boots before stopping the vacuum pump.

b. Method 2. When a vacuum pump is not available the rust-preventive solution may be fed in by gravity.
When employing method 2, it is necessary to prevent the solution from ballooning the rubber boot.

Removal By Divers. The following action is required of divers upon activation of a ship without prior dry-docking:

a. Laced-on outer jacket of vinyl or neoprene-coated nylon cloth; cut lacings and remove outer jacket.

b. . Boot seal secured by flexible cable clamps; cut boot only along cable and along longitudinal seams.

c. Boot seal with compressed tapered rubber gasket used for wide bladed propeller applications; remove wide bank clamp and gasket.

Material Selection. All materials used in fabrication of the boot seals and structural modifications described herein, where not covered by a specification, shall be selected based on electrolytic corrosion compatibility and corrosion resistance to seawater. Cable clamps are to be electrically grounded to the strut, stem tube, fairwater or other convenient hull appendage (not to the shaft or propeller) to eliminate any possible mal-effects from electrical current flow from cathodic protection.

UNDERWATER HULL INSPECTION PLAN

If it is the intention of the Museum to inspect the vessel's hull below the waterline and thereafter on a semi-annual basis to conduct an underwater inspection by OSHA-certified industrial dive team (under 29 CFR requirements), the following areas on the hull bottom should be viewed and reported:

1.) Inspect and report on all through-hull valves and covers,
2.) Inspect and report on all cathodic protection system anodes (to be cleaned as needed),
3.) Inspect and report condition of struts, propulsion shafting and propellers, and shaft annuluses,
4.) Inspect and report on condition of the pair of rudders,
5.) Inspect and report on the effects of shoaling with affected locations noted and quantities of material determined if possible.
6.) Inspect and report (with possible photogrammic/movie display) the general condition of paint system on

bottom shell plating,

7.) Inspect and report on the vessel's mooring chains and mooring system below the waterline. This would include the existing steel sheet pile wall and concrete casements.

SAFETY

The following safety items will be accomplished relative to the berthing of the vessel:

1.) A shipboard personnel training program will be initiated regarding hazardous materials, enclosed and confined space entry, electrical safety requirements, firefighting and ambulatory procedures.

2.) The local police, fire and ambulatory services will be made familiar with shipboard lay-out and systems.

3.) A ship's PROCEDURES MANUAL will be created giving all staff immediate information regarding emergency procedures for fire, flooding, ambulatory, intruder, electrical, plumbing situations. Also, contact agencies, critical Museum personnel and employees will have their names and pertinent phone numbers and other relative information within this manual.

TANKS

Fuel and Lubricating Oil Tanks. The following is general information for guidance in the preservation of fuel oil, diesel oil, lubricating oil, gasoline, and JP5 tanks and their contents.

Stripping Tanks. All fuel tanks of every kind including ship's propulsion, storage, service, settling and JP5 tanks shall be pumped empty and stripped of residual fuel. Tank vents shall be closed upon installation of desiccant bags and final closing of the tanks. Those tanks that were cleaned to remove all oil films shall be dried and sealed with desiccant bags unless ballasted with water.

Fuel Oil Seawater Compensating Tanks. The removal of seawater and residual fuel from compensating tanks for the purpose of tank cleaning requires a controlled process. The removing activity shall develop a procedure using the following references as a guide:

Standard Inactivation Or Safe Stow Inactivation. Tank vents shall remain open with flash screens installed, and tanks sealed from adjacent spaces (manhole covers installed).

Fuel Oil Storage, Service, Settling, JP5, FO Contamination, Waste Oil and Oily Waste Water Tanks.

Each fuel oil storage, service, settling, JP5, FO Contamination, Waste Oil and Oily Waste Water tank shall be pumped to empty. Water and sludge shall be stripped from all tanks.

AVGAS and MOGAS (Not Ship Propulsion) Tanks. All tanks and systems shall be completely emptied of all fuel and thoroughly flushed. The tanks and systems shall be cleaned and gas freed to meet the classification Safe For Men Safe For Hot Work in accordance with NSTM S9086-CH-STM-030 Chapter 074,

GAS FREE ENGINEERING.

Lubricating Oil Storage Tanks. These tanks shall be pumped empty and hand wiped. Tanks shall be protected by dynamic D/H. The vents shall be open.

Tanks Required to be Ballasted. Fuel tanks required to be ballasted will be cleaned and gas freed, then filled with fresh water. All other tanks required to be ballasted will be filled with clean fresh water. Required tanks as well as location are contingent upon the tow master's determination and NAVSEA SL740-AA-MAN-101 (U.S. Navy Towing Manual). Do not use corrosion inhibitors.

Since corrosion inhibitors are effective only below the level of the water, thin-film rust preventive, MIL-C-16173, Grade 2 or MIL-P-20305 should be applied to all areas above anticipated water line and to about two feet below. These areas shall be inspected as far as practical at the time of routine material inspections.

Tank Systems. . All pump rooms, cofferdams, steam smothering lines, heating lines, and cargo vent lines in their entirety shall be drained, cleaned, and gas freed as necessary to remove free fuels.

Cargo Tanks. Cargo tanks, cargo pipelines, and pumps shall be thoroughly stripped, cleaned, and gas free in accordance with the Manual for Cargo Tank Cleaning (NAVSEA 0900-016-0010). All pump rooms, cofferdams, steam smothering lines, heating lines, and cargo vent lines shall be drained, cleaned, and gas freed.

Cargo Tanks Preservation. Preservation of cargo tanks with tank coating systems (MIL-P-23236) applied shall be limited to cleaning and touchup of those localized areas where rust and corrosion are evident in accordance with NSTM S9086-VD-STM-010 Chapter 631, VOLUME 1, PRESERVATION OF SHIPS IN SERVICE

GENERAL. The tanks shall be closed and sealed from other sections of the ship and the atmosphere with no additional preservation coating applied or D/H airflow. The vents shall be left open with flash screens installed.

Rust and Scale. Cargo tanks [uncoated or coated with paints other than coatings (MIL-P-23236)]; shall have all loose rust and scale, exclusive of bonded scale, removed from the interior surfaces of the tanks.

The tanks shall be preserved by applying a coat of rust preventive compound MIL-C-16173, Grade 2, to all interior surfaces. Hatches and openings of tanks shall be closed and sealed. Vents of these tanks shall remain open with flash screens installed and tanks sealed from adjacent spaces under D/H.

050-3.5.5 Ballast and Freshwater Tanks. Ballast and freshwater tanks not used to ballast the ship shall be dried out, rough scraped, and placed under dynamic D/H or coated for long term preservation. Safety screens must be provided to cover those tanks placed under dehumidification.

The bilge gravity drain system and associated collection tanks shall be thoroughly drained. The collection tank internal surfaces shall be dry, rough scraped and left open to dehumidification. Safety screens shall be installed over tank openings.

Corrosion Inhibitor . Since the corrosion inhibitor is only effective below the water, thin-film rust prevention MIL-C-16173, Grade 2 should be applied to all areas above the anticipated waterline and to about two feet below. These areas shall be inspected as far as practical at the time of routine material inspections.

Bacteria. Anaerobic bacteria present in water may be responsible for corrosion of steel under conditions where oxygen is excluded. This type of activity results in the evolution of hydrogen sulfide gas, H_2S, with its characteristic odor of rotten eggs. If this condition is present, consider proper preservation and coating of this tank.

Ballasting Tanks. . The procedure for the preservation of ballasting tanks coated with flotation compound is as follows:

a. Thoroughly clean and remove all traces of flotation compound from ballast tanks that have been treated with flotation type rust preventive compound.

b. . After testing for absence of vapors per NSTM S9086-CH-STM-030 Chapter 074, VOLUME 3-GAS FREE ENGINEERING, place the tanks under dynamic D/H. Do not apply any type of protective coating.

050-3.5.6 Double Bottoms, Cofferdams, and Blisters. Open, rough scrape, and clean out loose debris from voids, double bottoms, cofferdams, and blisters; then leave open to dehumidified air with a safety screen installed across manholes in decks.

NOTE

In case of open ocean tows, secure voids, etc. for sea per tow master's determination and NAVSEA SL740-AA-MAN-101 (Subject: U.S. Navy Towing Manual). Hang safety screens in the vicinity of those tanks that will be reopened and placed under dehumidification.

Locked In Fresh Water Ballast Tanks and Voids. Test contents of tank or void for sodium chromate concentration. If above 5 ppm, remove ballast water and dispose of as a hazardous waste.

TEAK DECK MAINTENANCE & REPAIR

Surface Preparation of Underlying Steel Deck

GENERAL. There are many surface preparation methods. They include abrasive blast cleaning, power tool cleaning, and water jetting. Pickling (acid etch) is not a NAVSEA approved procedure for nonskid installations.

Abrasive blast cleaning encompasses direct-pressure blast (open blast), and vacuum-blast cleaning. The open blast process poses difficulties in containing the blast medium (aluminum oxide, garnet, etc.) and requires significantly longer cleanup times compared with the use of a vacuum system. An open blast process requires environmental containment and a full protective suit with a fresh air source must be worn because of all the debris in the air. When vacuum blasting is performed only safety glasses, safety shoes, ear protection and a dust mask as specified by the safety officer needs to be worn. Steel shot centrifugal-wheel vacuum-blast cleaning rapidly removes existing nonskid, but blast media that escapes causes extensive cleanup requirements. Since poor surface preparation is the cause of most coating failures, the procedures outlined herein shall be followed.

Water jetting relies on the energy of fresh water striking a surface to remove the existing coating. This technique eliminates dust pollution and disposal requirements for spent abrasives. High Pressure (HP) water jetting operates at pressures between 10,000 to 25,000 psi and Ultra High Pressure (UHP) operates at pressures above 25,000 psi. The primary advantages of water jetting include no dust pollution, significantly less waste to dispose, elimination of foreign object damage hazard (steel shot not used), and less disruption of other ship work in the vicinity of the nonskid work. The water jet facility shall comply with all local, state, and federal regulations regarding the proper storage, use, collection, and disposal of all abrasive materials and wastewater. Compliance with these requirements is the responsibility of the water jet facility.

WARNING

Storage of moist removed nonskid debris containing aluminum in a sealed container can cause an explosive situation due to formulation of hydrogen gas.

STEEL SURFACES. The environmental conditions addressed in Table 634-3-6 must be met from the beginning of surface preparation until the surface has been primed. All data shall be recorded at least hourly or as conditions dictate to ensure that the requirements are met.

Table 634-3-6. REQUIRED ENVIRONMENTAL CONDITIONS

Environmental Condition	Minimum	Maximum
Component Storage Temperature		
-Long Term, Note 1	55°F	100°F
-24 hours prior to mixing, Note 2 (Nonskid/ primer/color topping)	70°F	80°F
Ambient Air Temperature, Note 2	55°F	100°F
Deck Temperature, Note 2		
Primer	40°F	120°F
Nonskid	40°F	110°F
Relative Humidity	--------	85%
Dew Point	The deck temperature must be at least 5°F above the dew point.	
Wind, Note 3		15mph

Equipment including, but not limited to, lights, electrical cables, 1MC/5MC speakers, damage control equipment, deck drains and water wash-down systems which may be damaged during surface preparation shall be protected. Deck drains shall be sealed with damage control plugs or other suitable equipment. Deck drains shall be tested following the completion of the nonskid installation to ensure that the drains are not clogged. If blast media is used, plywood or net barriers shall surround the area being blasted to contain stray blast media or grit. When net barriers are used, the mesh size of the netting material shall be small enough to ensure that the blast media will be contained. In addition, net barriers, when used, shall be overlapped where attached to stanchions and anchored at the bottom for the entire net's length between stanchions. This will limit the cleanup and localize the blast medium. Blast media on a deck is a Foreign Object Damage (FOD) hazard.

All abrasively blasted steel surfaces shall be prepared to a near-white finish or better as defined by the National Association of Corrosion Engineers (NACE) or Steel Structures Painting Council (SSPC) (Table 634-3-7 and Table 634-3-8). Extreme care shall be taken to ensure that all blast media is removed from the surface before painting, and that no blast media is caught in joints, cracks near hangar doors, or wedged in crevices.

Table 634-3-7. NACE/SSPC ABRASIVE BLAST CLEANING STANDARDS

Standard	Title	Definition
NACE 1/SSPC-SP 5	White Metal	When viewed without magnification, the abrasive blasted surface shall be free of all visible oil, grease, dust, dirt, mill scale, coating, oxides, corrosion products and other foreign matter.
NACE 2/SSPC-SP 10	Near-White Metal	When viewed without magnification, the abrasive blasted surface shall be free of all visible oil, grease, dust, dirt, mill scale, coating, oxides, corrosion products and other foreign matter, except for staining. Random staining shall be limited to no more than 5% of each area of surface and may consist of light shadows, slight streaks, or minor discoloration caused by stains of rust, mill scale or stains of previously applied coating. Unit area for determining staining shall be approximately 9 sq. in. (80 mm x 80 mm).
NACE 3/SSPC-SP 6	Commercial Blast Cleaning	When viewed without magnification, commercial blast cleaned surface shall be free of all visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products and other foreign matter, except for staining. Random staining shall be limited to no more than 33% of each area of surface. Unit area for determining staining shall be approximately 9 sq. in. (80 mm x 80 mm).
NACE 4/SSPC-SP 7	Brush-Off Blast Cleaning	When viewed without magnification, brush-off blast cleaned surface shall be free of all visible oil, grease, dirt, dust, loose mill scale, loose rust and loose coating. Tightly adherent mill scale, rust and coatings are considered tightly adherent if they cannot be removed by lifting with a dull putty knife.

Table 634-3-8. SSPC ABRASIVE BLAST CLEANING STANDARDS

Standard	Title	Definition
SSPC-SP-5	White Metal	A white metal finish is defined as a surface with a gray-white, uniform metallic color, slightly roughened to form a suitable anchor pattern for coatings. The surface, when viewed without magnification, shall be free of all oil, grease, dirt, visible mill scale, rust, corrosion products, oxides, paint or any other foreign matter. The color of the clean surface may be affected by the particular abrasive medium used.
SSPC-SP-10	Near-White Metal	A near-white finish is defined as one from which all oil, grease, dirt, mill scale, rust corrosion products, oxides, paint or other foreign matter have been completely removed from the surface except for very light shadows, very slight streaks or slight discoloration caused by rust stain, mill scale oxides or slight, tight residues of paint or coating that may remain. At least 95% of each square inch of surface area shall be free of all visible residues, and the remainder shall be limited to the light discoloration mentioned above.

If steel shot is used, Type I shall conform to SAE J827. Steel grit, Type I shall conform to SAE J1993. Grit and shot sizes shall conform to SAE J444.

If surface preparation is to be accomplished by water jetting, acceptance criteria for surface preparation shall be in accordance with NACE No. 5/SSPC-SP-12 WJ-2. The maximum amount of flash rusting shall be Light. When viewed without magnification, the surface shall be free from visible oil, grease, dirt, loose rust, paint coatings, and foreign matter except for staining. Staining shall be limited to no more than five percent of each square inch of surface area water jetted and may consist of light shadows, slight streaks, or minor discoloration caused by stains of rust, mill scale or previously applied paint. Painting shall be accomplished before the steel begins to rust. The use of corrosion inhibitors is prohibited. Closed-loop water jetting equipment for preparing large areas is shown in Figure 634-3-4. There are closed-loop water-jetting attachments available for preparing corners, deck edges and pad eyes as shown in Figure 634-3-5.

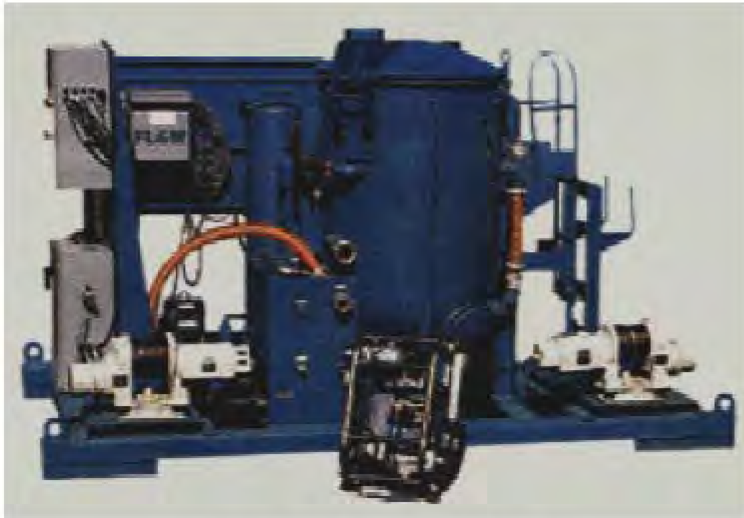

Figure 634-3-4. HYDROCAT

Figure 634-3-5. DECK EDGE ATTACHMENT

NOTE: A rotary peening deck machine can be used for providing a mechanical profile of 3 to 4.5 mils on both steel and aluminum substrates. The rotary peening flaps are fitted with tungsten carbide footpads and are configured to provide an acceptable anchor tooth profile similar to that of steel shot blasting. Areas of substrate from which nonskid has been removed by water jetting method, and where the anchor tooth profile has been measured to be less than 3 mils, shall have the profile reinstalled to a depth of 3 mils or greater with use of a roto-peen tool.

Areas which the centrifugal blast or water jet equipment cannot access (deck coaming, deck edges) shall be prepared to a surface cleanliness of SSPC-SP-11, as defined in Table 634-3-10. The following power tools, discussed in Table 634-4-11, may be used:

Table 634-3-8. SSPC ABRASIVE BLAST CLEANING STANDARDS - Continued

Standard	Title	Definition
SSPC-SP-6	Commercial Blast	A commercial finish is defined as one from which all oil, grease, dirt, mill scale, rust corrosion products, oxides, paint or other foreign matter have been completely removed from the surface except for very light shadows, very slight streaks, or slight discolorations caused by rust stain, mill scale oxides or slight, tight residues of paint or coating that may remain, if the surface is pitted, slight residues of rust or paint may be found in the bottom of the pits; at least two-thirds of each square inch of surface area shall be free of all visible residues and the remainder shall be limited to light discoloration, slight staining or tight residues mentioned above.
SSPC-SP-7	Brush-off Blast	A brush-off finish is defined as one from which all oil, grease, dirt, rust scale, loose mill scale, loose rust and loose paint or coatings are removed completely. Tight mill scale and tightly adhered rust, paint and coatings are permitted to remain provided that all mill scale and rust have been exposed to the abrasive blast pattern sufficiently to expose numerous flecks of the underlying metal fairly uniformly distributed over the entire surface.

Table 634-3-9. NACE/SSPC WATER JETTING CLEANING STANDARDS

Surface Preparation and Cleaning of Steel and Other Hard Materials by High-and Ultrahigh-Pressure Waterjetting Prior to Recoating		
Standard	**WJ Title**	**Definition**
NACE 5/SSPC-SP 12	WJ-1	A WJ-1 surface shall be free of all previously existing visible rust, coatings mill scale, and foreign matter and have a matte metal finish..([1] , [2] , [3])
	WJ-2	A WJ-2 surface shall be cleaned to a matte finish with at least 95% of the surface area free of all previously existing visible residues and the remaining 5% containing only randomly dispersed stains of rust, coatings and foreign matter..([1] , [2] , [3])
	WJ-3	A WJ-3 shall be cleaned to a matte finish with at least two-thirds of the surface free of all visible (except mill scale), and the remaining one-third containing only randomly dispersed stains of previously existing rust, coating and foreign matter..([1] , [3])
	WJ-4	A WJ-4 surface shall have all loose rust, loose mill scale and loose coatings uniformly removed.([3])

1. HP WJ and UHP WJ surfaces do not exhibit the hue of a dry abrasive-blasted steel surface. The matte finish color of cleaned steel immediately after water jetting will turn a golden hue unless an inhibitor is used or environmental controls are employed. On aged and previously coated steel surface that have areas of paint or are paint-free, the matte finish color will vary even though all visible surface material has been removed.

2. UHP WJ at pressures in excess of 35,000 psi are capable of removing mill scale, but production rates may or may not be cost effective in the effort to remove mill scale.

3. The experience of the contractor and, in many cases, the preparation of a sample area, determine the success of a specific level of HP WJ or UHP WJ in removing an existing coating or sheet lining materials, rust scale, rust nodules or tubercles, mill scale or other tightly adhered matter from the substrate.

Descobrader, power rotary brush, scaling hammers, needle scalers, sanders and grinders. Dust free power tools are shown in Figure in 634-3-6.

WARNING

Wear proper protective equipment during surface preparation (blasting, power tool cleaning), including appropriate eye, ear, and respiratory protection. Safety officer should be consulted.

NOTE: Power rotary brushes and sanders when used alone will not produce the required surface profile and may remove or degrade any existing profile to an unacceptable level.

Table 634-3-10. SSPC POWER TOOL CLEANING STANDARDS

Standard	Title	Definition
SSPC-SP 3	Power Tool Cleaning	Power tool cleaning removes all loose mill scale, loose rust, loose paint, and other loose detrimental foreign matter. It is not intended that adherent mill scale, rust, and paint be removed by this process. Mill scale, rust, and paint are considered adherent if they cannot be removed by lifting with a dull putty knife.
SSPC-SP 11	Power Tool Cleaning to Bare Metal	Metallic surfaces that are prepared according to this specification, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxide, corrosion products, and other foreign matter. Slight residues of rust and paint may be left in the lower portion of pits if the original surface is pitted. When painting is specified, the surface shall be roughened to a degree suitable for the specified paint system. The surface profile shall not be less than 1 mil (25 microns).

Table 634-3-11. POWER TOOLS

Tool	Use
Pneumatically Driven Tools (hammers/rotary hammers)	Dislodge stubbornly adherent materials.
Scalers (chisels, needle guns)	Remove all mill scale, rust, weld slag and paint. Effective in crevices, pits and grooves.
Rotary Impact Tools (Descobraders, deck crawlers)	The flap wheel (rotopeen) fractures and removes coatings and mill scale. Also, the substrate is peened, giving a one-mil minimum profile.
Wire Brushes	Remove paint, loose mill scale and weld slag. Polish the surface (will need additional tools to profile the surface).
Grinders or Sanders Equipped with Coated Abrasive	Remove paint, loose mill scale and rust. Remove some substrate.

A 3 to 4.5 mil anchor tooth profile shall be obtained for surfaces abrasively blasted. The depth of the profile is dependent upon the size of the blast medium and the speed of the blasting equipment. The deck profile shall be measured by using replica tape. Replica tape, such as Testex PRESS-O-FILM, used in conjunction with a micrometer, yields the most accurate measurement. Three profile readings shall be taken every 100 ft. 2 for the first 500 ft. 4. If the readings are consistent, only one reading every 1000 ft. 2 needs be taken thereafter.

Figure 634-3-6. ROTO-PEEN AND DUST FREE POWER TOOLS

The underside of aircraft securing fittings shall be checked with a dental mirror or similar instrument to ensure that all corrosion has been removed. Water jet surfaces will retain the surface profile of prior surface treatments. In areas where the substrate may have been smoothed, abrasive blasting or profile producing power tooling may be required to achieve the required 3 to 4.5 mil anchor tooth profile.

When preparation of the surface is completed, the substrate shall be free of the following:

a. Contaminants
b. Weld splatter
c. Skip welds (welds that are not continuous)
d. Rough welds (weld shall be smoothed as porosity allows for corrosion)
e. Laminations
f. Gouges
g. Sharp edges
h. Stray steel shot and other abrasives
i. Weld slag

If contaminants (dirt, dust, grease, and oil) are present, they shall be removed by using the nonskid manufacturer's recommended solvent that is compatible with their nonskid system or teak decking system.

Removal of dirt, dust or blast media shall be in compliance with local, state and federal regulations. After the solvent wipe has been performed, the deck shall be permitted to dry for at least 2 hours at ambient conditions before application of any primer.

NOTE: If solvents are used, ensure that all local, state and federal Volatile Organic Content (VOC) laws are observed. Minimize the use of Hazardous Air Pollutants (HAP) containing solvents.

WARNING

The solvent manufacturer's Material Safety Data Sheet (MSDS) should be consulted for health and safety precautions.

For surfaces that have been abrasively blasted or water jetted, a check for contamination of the substrate shall be taken. A surface chloride contamination check using the Bresle Patch Method or equivalent shall be made randomly over the prepared surface. At least one measurement per 1000 ft. 2 shall be made. If any direct measurement exceeds 5 micrograms per square centimeter of chloride, the substrate shall be blasted again until the chloride measurement is below 5 micrograms per square centimeter. For surface areas less than 1000 ft. 2 least one random measurement is required. Additional chloride checks as needed should be taken in areas which are stained (indicating removal of corrosion) to ensure QA confidence that chlorides have been satisfactorily removed from all areas of the uniformed substrates.

The surface shall meet the required surface preparation standard (e.g. SSPC SP-10 near-white metal blast) immediately prior to painting.

NOTE: Private contractors shall dispose of waste in accordance with local, state and federal laws.

Do not remove the protective nonskid coating if the area will not be primed within six hours.

If surface preparation is to be accomplished by water-jetting, acceptance criteria for surface preparation shall be in accordance with NACE NO. 5/SSPC-SP-12/WJ-2.

NOTE: When viewed without magnification, the surface shall be free from visible oil, grease, dirt, loose rust, paint coatings, and foreign matter. Painting should commence as soon as possible following surface preparation of the deck surface.

If using steel shot, Type I shall conform to SAE J827 steel grit, Type I shall conform SAE J1993 grit, and shot sizes shall conform to SAE J444. Areas which the centrifugal blast or water jet equipment cannot access (deck coaming, deck edges) shall be prepared to a surface cleanliness equivalent to SSPC-SP-11, as defined in Table 634-3-10. Tools that may be used include grinders or sanders equipped with 16-grit aluminum oxide abrasive pads (Table 634-3-11). Abrasive materials (pads, belts) should not have been previously used to prepare copper nickel metal for painting or to remove copper base anti-fouling paints.

The underside of all aircraft securing fittings shall be inspected with a dental mirror or similar instrument, to ensure that all corrosion has been removed.

Alternative methods to centrifugal-wheel vacuum-blast cleaning include direct-pressure blast (open blast), vacuum-blast cleaning, and water jetting. Garnet and aluminum oxide are among the permitted blast media. The abrasive materials used for blasting shall conform to CID A-A-59316. Abrasive materials shall not have been previously used on copper containing metals or on AF paints containing copper.

WARNING

Wear proper protective equipment during surface preparation (blasting, power tool cleaning), including appropriate eye, ear and respiratory protection. A safety officer shall be consulted.

A 3 to 4.5 mil anchor tooth profile shall be obtained for surfaces abrasively blasted. The deck profile is dependent upon the size of the blast medium and the speed of the blasting equipment. The deck profile shall be measured by using replica tape. Replica tape, such as Testex PRESS-O-FILM, used in conjunction with a micrometer yields the most accurate measurement. Three profile readings shall be taken every 100 ft. 2 for the first 500 ft. 2 . If the readings are consistent, only one reading every 1000 ft. 2 needs be taken thereafter.

WOOD DECK REPAIRS

INSTALLATION OF WOOD PLANKING OVER STEEL PLATING

The following measures are approved to upgrade and leak proof existing wood decks when repairs are to be made or on new installations:

1. Embed new wood planking in polyurethane underlay compound (see paragraph 634-5.3). Materials and installa-tion shall be as specified herein. This involves omission of formerly used thick-film rust-preventive compound beneath the planks, and the cotton and oakum in the seams.

2. Weld studs directly to longitudinals of 10.2 pounds and heavier plate. Where attachment to plate lighter than 10 pounds is unavoidable, a 5-pound steel pad shall be welded beneath the stud.

3. Polyurethane caulking compound shall be utilized in seams on carriers.

4. Other repairs specified include:
   a. Gunning compounds for treating existing leaks without removal of planking.
   b. Underlayment for jet warm-up area.

SYNTHETIC RUBBER UNDERLAYMENT

GENERAL. Synthetic rubber underlayment is a liquid polymer with lightweight aggregate. When applied over the steel plating of decks on which wood planking is placed, this material seals the deck and acts as a fairing to fill all spaces due to the irregularities of the steel deck.

STEEL SUBDECK CLEANING. Remove all oil, underlayment, and rust preventive grease; sandblast to bare steel. Primer shall be applied within 4 hours of the sandblasting.

Primer shall be of same brand as underlayment compound and as specified for steel by manufacturer. Rubber underlayment shall be formulated:

1. MIL-C-18255, type I, Polysulfide; 100 P/ W.

2. Phenolic micro balloons, Bakelite Corp. No. BJO-09030; 10 P/W.

PRIMER APPLICATION. Primers are furnished in either one- or two-part compounds. Special primers are required for steel and aluminum. When using two-part materials, the entire contents of a unit should be used if possible. Mix the materials as specified in the manufacturer's directions. Mixed primer should be used as soon as possible. Apply primer as specified in manufacturer's directions ensuring that no holidays are left when priming. It is of utmost importance for good adhesion of underlayment compound that the deck be dry, clean, and properly primed. See manufacturer's instructions for minimum and maximum primer curing time required before application of seam compound.

UNDERLAYMENT COMPOUND PREPARATION.

Polysulfide rubber compound is furnished in two parts, the base and the accelerator, which is of a paste consistency. It is packaged with the required amount of compound and accelerator. If other than full containers are used, the ratio should be that specified in the manufacturer's instructions. The compound will set up too fast if too much accelera-tor is added; if too little is added, the compound will not cure sufficiently.

1. The accelerator portion should be mixed into a smooth paste. Do not pour off the liquid portion. Slowly stir the thoroughly mixed accelerator into the compound in a slow-speed power-driven mixing chamber, or by hand. As little air as possible should be beaten into the batch. Mix the accelerator and base compound slowly (60 rpm) and thoroughly for a minimum of 10 minutes before adding micro balloons. Make sure that no specks of accelerator can be seen. Add micro balloons up to 10 percent by weight to suit consistency desired and continue to mix for 5 minutes.

2. It should be noted that low temperatures and low humidity will increase the curing time, higher temperatures and humidity will reduce the curing time. Do not mix the compound with accelerator unless it is to be applied directly after completion of the mixing operation. No solvent should be added to either the accelerator or compound.

LAY-DOWN.

The rubber underlay shall be poured, troweled, or broomed in place to the minimum depth which will fair the deck so that all voids under the planks are filled. The use of shims should be restricted to not more than 1 inch by 6 inches and only directly over a longitudinal. The amount of underlay which is not covered with planks shall be held to a minimum. The planks should be laid in place successively into the uncured underlay, tamped down well and secured with deck nuts, starting at the closed end and proceeding toward the open end. This forces any excess underlay ahead of each plank and completely fills all voids and the greater percentage of each seam. Cotton or oakum shall not be used in seams of planking installed over rubber underlay. Seams should be caulked as soon as the underlay is cured, using correct material.

GUNNING COMPOUNDS

The gunning-compound system for treating leaks is considered a temporary economy measure and should be utilized only when it is not practical to remove planking. Re-treatment should be expected. Due to the presence of the rust preventive compound under the wood planks, except in localized areas, a permanent seal would not be expected.

1. For each leak reported, a number of holes (5 to 12) are drilled radially through the wood decking from a central hole. A screw fitting is fastened in place and a high pressure lubricant gun and pump are used to inject sufficient compound to seal an individual leak. It usually is possible to cover approximately 10 square feet from one hole. The outlying periphery of holes will indicate the extent of flow of the compound. The holes are then sealed with a wood plug or caulking compound. Test area with water hose to determine if leaks still exist.
2. Underlayment having 3 to 5 percent by weight micro balloons shall be used as the gunning compound.

DECK PREPARATION.

The deck shall be cleaned to bright steel by abrasive blasting, wire brushing, or similar mechanical methods, and solvent-washed to remove grease and other residue. An expanded metal lath should be welded to the deck at 18-inch centers. The metal reinforcement should be lifted slightly above the deck to provide a keying action. Next, a surface wetting coat should be brushed onto the deck and metal lath, taking care to cover all parts of the deck and metal lath. Drying of this coating should generally be allowed to take place overnight, before application of the mastic.

SURFACE PREPARATION

Old wooden decks should be surfaced to sufficiently remove any loose or rotted wood fibers. If loose fibers are not removed, they will raise when wetted by PR 1539U Gray and become wicks to permit moisture penetration of protective coating. Generally, the use of the Tenant machine equipped with a spur tool is sufficient to prepare the wood. New deck planking requires only planing or sanding to level off existing planks. Prepare surfaces as follows:

a. All wood dust resulting from surfacing operations should be removed by vacuuming.

b. Grease or oil spots, which remain after surfacing, must be scrubbed with an organic solvent. Trichloroethane (Methyl Chloroform) is satisfactory. Permit area to dry at least 2 hours at ambient conditions before applying any primer where solvent is utilized.

c. Metal surfaces should be cleaned by sandblasting or grinding to obtain a corrosion-free surface. If surface is oily, degreasing should precede sandblasting or grinding. Prime cleaned surfaces immediately.

d. All terminating boundaries (between tie downs and planks, bounding bars and planks, landing lights and planks) should be routed out to 1/2-inch wide by 3/4-inch deep against the metal boundary. Fill the joint with polyurethane caulking compound, PR 3095, to be level with the plank surface. Oakum interference in seams should be driven in. All metal surfaces should be cleaned to bright metal. Prime clean sides of tie down fittings with wash primer 117 or other approved primer. Apply compound conforming to MIL-I-3064, type HF, around or along terminating boundaries to form a dam so topcoat will not flow into undesired areas such as tie down fittings or to permit proper buildup to topcoat.

e. Caulking compound that has no adhesion and can be readily pulled loose should be removed and the joint filled with MIL-S-24340 rubber caulk level with plank surfaces. Rubber caulking compounds firmly attached to the deck do not have to be removed. However, the best practice is to cut out a 1/2-inch depth minimum of the marine glue and fill at time of coating with MIL-S-24340.

f. Old wood decks should be permitted to dry out as much as possible before application of primer (at least 36 hours of drying should elapse after a rainstorm before application of primer, if the deck had been exposed to rain during that period; this time may be shortened by artificially drying the surface). Surface can be probed with moisture detector to 1/8-inch depth and if indicated that surface moisture content is less than 28 percent, primer can be applied. Shade covers over plank areas are recommended during primer application.

Temperature Conditions. The material generally should not be applied below 10°C (50°F) ambient temperature. However, the low temperature problem may be overcome by heating a covered area.

MATERIALS REQUIRED

a. Soap, Scrubbing FSN 9350-00-247-0543
b. Oxalic acid, dihydrate FSN 6810-00-264-3937
c. Detergent, general purpose FSN GS-09F-43513
d. Lemon/Lime mix NSN 8950-00-139-7526
e. Sand
f. Teak cleaner Available through Hocking International Chemical Corporation, 2121 Hoover Ave, National City, CA

EQUIPMENT REQUIRED

a. Firebrick FSN 9350-00-247-0543
b. Man helper FSN 7920-00-141-5452
c. #6 canvas FSN 8305-00-170-5385
d. Scrub brush FSN 7920-00-240-7171
e. Trash can FSN 7240-00-160-0441
f. Squeegee FSN 7920-00-224-8339

PROCEDURE

Fire Brick

1. Cut fire brick in half with band saw cutting across the length to make two equal size square sections.

2. Chip depression 1 inch deep by 2-1/2 inches in large surface of each brick to facilitate placement of man helper.

Liquid Mix

1. Mix 18 gallons of hot water, one gallon general purpose soap, one box scrubbing soap, and either one container of oxalic acid or 20 pkgs lemon/lime mix. Allow to set overnight until forming a pasty mixture.

Holystoning

1. Thoroughly wet deck with salt water.

2. Spread sand by hand, using a sweeping motion, over the area to be holystoned.

3. Swab deck using liberal amount of liquid mixture.

4. Line a maximum of 14 personnel in a straight line, positioning them about 16 inches apart, along the length of boards to be holystoned.
   a. Each man shall have a fire brick and man helper.
   b. Brick is placed flat on deck with depression for man helper facing up.
   c. Hold man helper behind right shoulder, over the right forearm with right wrist twisted to grip the man helper. Grip the man helper with the left hand placed just above the right hand. When the man

helper is placed in the depression, the man will be bent at the waist.

5. Rotate shoulders fore and aft, push and pull with left hand. By this method the brick will scrub approximately 20 inches of board.
   a. Each man's stroke will overlap the man's beside him.
   b. Use 10 strokes per board ensuring strokes are made with the grain of the board.

6. Hose off deck with fire hose and dry using squeegee.

Uneven Boards

1. Where edges of boards are not flush it may be necessary to use a long handled scrub brush with No. 6 canvas stapled around the bristle.

2. Use additional sand and follow procedure as directed above as fire brick will smooth the edges so boards are flush.

General Notes. Oxalic acid will yield the same results as the lemon/lime mix, however, the lemon/lime mix is more economical. Oxalic acid shall not be mixed with the lemon/lime mix nor any other type acid. Teak cleaner is very expensive and shall be used only for small areas requiring attention.

The following MIL STD for laminated teak deck replacement is included for informational purposes.

MIL-D-16285C(SHIPS)
AMENDMENT - 1
9 February 1962

MILITARY SPECIFICATION

DECKING, TEAK-DOUGLAS FIR, LAMINATED (FOR SHIP USE)

This amendment forms a part of Military Specification MIL-D-16285C (SHIPS), 15 May 1961.

Page 1, paragraph 2.2, line 6: Delete "Standard No. 14" and substitute "Standard No. 15"

Page 1, paragraph 3.1: Add the following sentence: "Qualification shall include a survey by the Bureau of Ships to determine whether the exhibitor's laminating facilities are suitable for producing products which will consistently conform to this specification."

Page 1, paragraph 3.3.3.1: Delete and substitute:

"3.3.3.1 Type I. - Douglas fir used in laminating shall conform to any one, or a combination thereof, of the grades specified in paragraphs 101c, 175 and 175b of the West Coast Lumberman's Association, Standard No. 15, with the added requirement that material shall be as dense as defined in paragraph 504c. If "C" Vertical Grain Finish of the above Standard is furnished, sapwood shall be limited to 1/3 of width on either or both faces."

Page 2, paragraph 3.3.3.2, first sentence: Delete and substitute: "Douglas fir used in laminating shall conform to any of the grades specified below of the West Coast Lumberman's Association, Standard 15, except that lumber shall be vertical grain and shall contain only heartwoods:

Paragraph 101d or better
Paragraph 151d or better
Paragraph 175b or better"

Pages 4 and 5, paragraph 4.1: Delete and substitute:

"4.1 Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. The government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements."

MIL-D-16285C(SHIPS)
15 MAY 1961
SUPERSEDING
MIL-D-16285B(SHIPS)
11 May 1953

MILITARY SPECIFICATION

DECKING, TEAK-DOUGLAS FIR, LAMINATED

(FOR SHIP USE)

1. SCOPE

1.1 Scope. - This specification covers laminated teak-Douglas fir decking for use on the flight decks of aircraft carriers and the weather decks of other types of ships where superior resistance to impact and abrasion is required.

1.2 Classification. - Laminated teak-Douglas fir decking shall be of the following types as specified, (see 6.1 and 6.2):

Type I - Decking and margin pieces for such applications as aircraft carrier flight decks.
Type II - Decking and margin pieces for such applications as decks for ships other than aircraft carriers.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein:

SPECIFICATIONS

FEDERAL
TT-A-468 - Aluminum-Pigment; Powder and Paste, for Paint.
TT-W-572 - Wood-Preservative; Water-Repellent.

MILITARY
MIL-V-1174 - Varnish, Spar, Water-Resisting (Formula No. 80).
MIL-M-15176 - Mica (Extender Pigment).
MIL-T-16098 - Teak (for Naval Shipboard Use).
MIL-A-22397 - Adhesive, Phenol and Resorcinol Resin Base (For Marine Service Use).

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

WEST COAST LUMBERMEN'S ASSOCIATION
Standard No. 14 - Grading and Dressing Rules.

(Application for copies should be addressed to the West Coast Lumbermen's Association, Portland, Oregon or 124-A, Cafritz Building, Washington 6, D.C.)

ASSOCIATION OF AMERICAN RAILROAD SPECIFICATION

(Application for copies should be addressed to the Association of American Railroads, 59 E. Van Buren St., Chicago 5, Ill.)

3. REQUIREMENTS

3.1 Qualification. - Teak-Douglas fir decking laminated furnished under this specification shall be a product which has been tested, and passed the qualification tests specified herein, and has been listed on or approved for listing on the applicable qualified products list.

3.2 Definition of laminated wood. - Laminated wood is a fabricated assembly consisting of layers of wood bonded together with a suitable adhesive to form a material which is equal or greater in strength than a solid piece of the same dimensions. Unless the term "cross laminated" is used, parallel laminates are usually implied. This specification covers a parallel laminated assembly of teak and Douglas fir.

3.3 Lumber. -

3.3.1 Teak (rough lumber). - Teak boards and strips shall conform to type F of Specification MIL-T-16098.

3.3.2 Defects in teak laminations. - The defects permitted in type F teak lumber will be permitted in the teak laminate of the assembly.

3.3.3 Douglas fir (rough lumber). -

3.3.3.1 Type I. - Douglas fir used in laminating shall conform to any one, or a combination thereof, of the grades specified in paragraphs 114 (V. G. finish only), 310 and 311 of the West Coast Lumbermen's Association, Standard No. 14, with the added requirement that material shall be as dense as defined in paragraph 224. If "C" Vertical Grain Finish of the above Standard is furnished, sapwood shall be limited to 1/3 of width on either or both faces.

FSC 5510

3.3.3.2 Type II. - Douglas fir used in laminating shall conform to any of the grades specified below of the West Coast Lumberman's Association, Standard No. 14, except that lumber shall be vertical grain and shall contain only heartwoods:

Paragraph 115 or better
Paragraph 303 or better
Paragraph 311 or better

Whenever practicable, the lower grade materials listed above should be used for this type of decking. Type II decking is intended for applications where a wearing surface rather than structural strength is the major consideration.

3.3.3.3 Defects in Douglas fir laminations. -

3.3.3.3.1 General requirements. - The Douglas fir used in the fabrication of laminated teak-Douglas fir decking shall be free from honeycomb, case-hardening, ring shake, splits and other defects which may affect the strength or serviceability, except as permitted in 3.3.3.1 and 3.3.3.2. No combination of the defects allowed as specified in 3.3.3.1 and 3.3.3.2 will be permitted which reduces the strength of the lumber at any point more than a single maximum defect. Douglas fir used in the assembly shall contain only sound heartwood.

3.3.3.3.2 Type I. - Slope of grain of Douglas fir used in decking shall be not more than 1 inch in a length of 12 inches. Material in the finished lamination shall average not less than 6 nor more than 20 annual rings per inch.

3.4 Preparation of lumber for laminating. -

3.4.1 Moisture content. - The moisture content of the lumber at the time of gluing shall be not less than 10 percent nor more than 15 percent. In any laminated member the variation in moisture content between the driest and wettest boards shall not exceed 5 percent. The moisture content of the core as determined by a distribution section (see fig. 1) taken from any board shall not vary from that of the shell by more than 2 percent.

3.4.2 Teak shall be one piece in thickness in all cases. Douglas fir laminations shall have a finished minimum thickness of 1/2 inch.

3.4.2.1 Type I. - The teak face on decking and margin pieces shall have a minimum thickness of 3/4 inch.

3.4.2.2 Type II. - The teak face on decking shall have a minimum thickness of 5/8 inch and on margin pieces a minimum thickness of 3/4 inch.

3.4.3 Edge - jointing of laminations. - Laminations shall be full width and where necessary shall consist of two or more strips of lumber placed side by side and edge glued. The minimum permissible width of strips used in preparing full width laminates shall be 1 inch, except that strips along the caulking edge shall be not less than 1-1/2 inches. Edge joints which will fall within 1/8 inch of the caulking edge of rough decking (without outgage) will be admitted since such joints will be removed by machining in finished decking. Edge glue joints in any two adjacent laminations shall be spaced not closer than the thickness of a lamination. Boards to be edge glued shall be machined true and smooth by straight line rip-sawing or other satisfactory manufacturing practice. Edge gluing shall precede the final surfacing, and glued edges shall show no open joints and shall be held under clamps until the adhesive is sufficiently cured to permit handling of the laminations without damage to the glue joint.

3.4.4 End joining of laminations. - The end-joints shall be glued using an adhesive conforming to 3.5 before final surfacing and shall be sufficiently cured to avoid breakage during machining and assembly gluing. No butt joints will be permitted. (A butt joint is the junction of two boards with the end grain of one butting against the end grain of the other with no serration or cuts to increase the surface area.) The number and spacing of end joints shall be limited as specified in 3.4.4.1 and 3.4.4.2. All scarf joints shall be sloped in the same direction in any one lamination.

3.4.4.1 End joints in type I. - End joints shall provide a gluing surface of not less than 12 times the area of the squared end. End joints in a single laminate shall be spaced not closer than 3 feet center to center. End joints in adjacent laminations shall be spaced not closer than 3 feet center to center. End joints in any two non-adjacent laminations shall be spaced not closer than 2 feet, center to center.

3.4.4.2 End joints in type II. - End joints shall provide a gluing surface of not less than 4 times the area of the squared end. End joints in laminations shall be spaced not closer than 2 feet, center to center. End joints in adjacent laminations shall be spaced not closer than 2 feet center to center. End joints in any two non-adjacent laminations shall be spaced not closer than 2 feet, center to center.

3.4.5 Surfacing of laminations. - Laminations shall be dressed to a uniform thickness throughout. The thickness variation of any lamination at the time of gluing shall not exceed 0.01 inch in teak laminations and shall not exceed 0.015 inch in Douglas fir laminations. [1] Lumber shall be dressed by

[1] The use of slip-on thickness gages for checking the thickness of dressed lumber is recommended.

removing equal thicknesses from each face. Wane will not be permitted. Surfaces shall not show manufacturing defects such as skip, torn grain, raised grain, chipped grain, chip marks, to an extent which will prevent sufficient contact between gluing surfaces for complete adhesion. Surfaces shall not be sanded to remove such defects after surfacing. The final surfaces for gluing shall be prepared not more than 24 hours before gluing is started. Surfaces at the time of gluing shall be clean and free from surplus oil, dirt crayon marks and other foreign material which will interfere with the bonding of the adhesive. At the time of gluing, after all surfacing, cup shall not exceed 1/64 inch for each inch of width.

3.5 Adhesive. -

3.5.1 Adhesive used for gluing shall be an approved adhesive, conforming to Specification MIL-A-22397.

3.5.2 Storage. - The adhesive shall be kept in controlled temperature storage. The storage temperature shall be above 40° Fahrenheit (F.) and below 70°F. unless otherwise recommended by the manufacturer. The adhesive shall be used only during the shelf life guaranteed by the manufacturer at the storage temperature used.

3.5.3 Mixing. - In all cases, the manufacturer's mixing instructions shall be followed precisely, measurements shall be made by weight, and no added extenders or fillers other than those originally put in the adhesive by the manufacturer shall be used. Containers for measuring and mixing the adhesive shall be kept clean.

3.5.4 Spreading. - Adhesive shall be applied uniformly to both faces of each lamination, except that adhesive shall be omitted from the outer faces of the assembly. The spread shall be not less than 30 pounds of liquid adhesive per 1,000 square feet of surface on each face of each lamination.

3.6 Assembly. -

3.6.1 General. - Working arrangements and equipment shall be such that the laminations are selected, spread, laid up, and clamped in rapid assembly. At the time of gluing, the temperature of lumber materials shall be 75 ± 15°F. The laminations after spreading shall be stacked in closed assembly within time limits specified by the manufacturer and clamped to pressure of at least 150 pounds per square inch (p.s.i.). Pressure shall not exceed the maximum recommended by the manufacturer. Where atmospheric temperatures in the glue room are above 80°F., the mixed adhesive shall be kept cool by immersing all adhesive pots in a water bath or by employing other suitable methods of maintaining the adhesive temperature at not more than 70°F., and not less than 40°F., to avoid shortening the working life of the mixed liquid adhesive. The glued assembly shall, between spreading and curing, be held at a temperature of not less than 50°F.

3.6.2 Clamping and pressures. - Cauls shall be at least 3/4 inch thick. Assembly pressures by fluid, hydraulic, or screw clamps exerting 150 pounds per square inch, with a plus tolerance of 50 pounds per square inch, as determined by suitable mechanical equipment shall be applied. The assembly pressure shall be rechecked 30 to 45 minutes after clamping up. Retaining clamps or equivalent pressing equipment shall be spaced close enough to develop pressure as specified at all points. The clear space between clamps or units shall be not more than 7 inches. Clamping shall begin at any one point and proceed progressively toward the ends. Retaining clamps with equalizing heads or equally effective pressing equipment shall be used.

3.7 Curing of laminated assembly. -

3.7.1 Procedure. - Curing at a temperature of at least 140°F. shall begin within 24 hours after gluing when the spreading is done at temperatures below 70°F. but may be delayed up to 48 hours when the spreading is done above 72°F. Curing shall continue for not less than 10 hours at 140°F. or 6 hours at 150°F. Time may be longer or temperature may be higher if required for the particular approved adhesive being used but shall not exceed 215°F. This temperature shall be determined at the innermost glue line while the assembly is under clamped or equivalent pressure. In all cases equipment and methods shall be adequate to produce laminated members sufficiently well cured to meet or exceed the tests specified in 4.6.2 and 4.6.3.

3.7.2 Equipment. - A dry kiln or equally effective curing chamber shall be used to obtain the required glue line temperatures. The curing chamber shall be provided with controls for maintaining constant moisture content in the laminated assembly.

3.7.3 The curing process shall include the following periods:

Heating period. - Time necessary to heat the curing chamber up to the required temperature after the clamped assembly is placed in the curing chamber; the curing chamber temperature shall not be increased more than 70°F. per hour in heating, using heating coils and steam spray. Steam spray for humidity control shall be applied sufficiently slow to avoid condensation of water on the clamped assembly. To avoid condensation, the wet-bulb temperature shall not exceed the surface temperature of the glued assembly.

Curing period. - Curing of completed assembly shall continue without interruption until a complete cure is effected, including time necessary to heat inner glue line to the curing temperature required for the particular approved adhesive being used plus curing period in which this temperature is maintained or exceeded at all glue lines. Relative humidity as required to insure that the moisture content of the charge remains constant shall be maintained during the curing period.

Cooling period (time necessary to cool member). - Curing chamber temperatures shall not be lowered more than 70°F. per hour in cooling the charge, under controlled humidity, maintained at a sufficiently high percentage to avoid surface checking of laminated members.

3.8 Resistance to delamination due to exposure. - The resistance to delamination due to exposure shall be determined by the exposure tests specified in 4.6.2. The maximum permissible delaminations shall be as specified in 3.8.1, 3.8.2, 3.8.3 and 3.8.4.

3.8.1 Joints between teak and Douglas fir laminations. - Delamination shall not exceed 8 percent of the total length of transverse glue lines on end grain surfaces of the exposure test specimen.

3.8.2. Joints between Douglas fir laminations. - Delamination shall not exceed 6 percent of the total length of transverse glue lines on end grain surfaces of the exposure test specimen.

3.8.3 Edge joints. - Delamination shall not exceed 8 percent of the total length of edge joint glue lines on end grain surfaces of the exposure test specimen.

3.8.4 End joints. - Delamination shall not exceed 10 percent of the total length of end joint glue lines on end grain surfaces of the exposure test specimen.

3.9 Block shear strength. - The average block shear strength shall not be less than 1050 p.s.i. with at least 75 percent wood failure when tested as specified in 4.6.3. No individual glue line represented in this average shall have a shear strength less than 660 p.s.i. When a single Douglas fir lamination is used, the block shear strength shall be not less than 1050 p.s.i. If the average block shear strength of a member is greater than 1400 p.s.i., the average wood failure may be less than 75 percent, provided the average delamination of an exposure test specimen from the same member does not exceed 4 percent of the total length of the glue lines, including end joints and edge joints.

3.10 Moisture content of finished decking. - The finished decking shall have a moisture content of not less than 10 percent nor more than 15 percent.

3.11 Coatings. -

3.11.1 Side coatings. - Side coatings shall not be specified if the laminated teak-Douglas fir decking is to be sawed, cut, or fabricated shortly after receipt by the bureau or agency concerned. Side coating with 2 coats of water repellent preservative conforming to Specification TT-W-572 shall be specified (see 6.2) if the laminated teak-Douglas fir is to be stored outdoors without cover, with the reservation of outgaged decking shall not be side coated.

3.11.2 End coatings. - After machining and prior to delivery, laminated assemblies shall be coated on ends with one liberal application of water-repellent preservative conforming to Specification TT-W-572 and allowed to dry for 24 hours. The ends of laminated teak-Douglas fir decking shall then be painted with 2 coats of aluminum or mica paint. Aluminum paint shall consist of 2 pounds of aluminum powder paste, conforming to type II, class A of Specification TT-A-468, and 1 gallon of phenolic varnish, conforming to Specification MIL-V-1174. Mica paint shall consist of two pounds of mica conforming to type I of Specification MIL-M-15176, and 1 gallon of phenolic varnish conforming to Specification MIL-V-1174. A drying interval of 24 hours shall elapse before applying a second coat. A second alternate end coating may be any commercial end coating satisfactory to the bureau or agency concerned. 1/

3.12 Marking. - Each decking plank shall be stamped with letters and numerals 1/2 inch or larger to a depth of approximately 3/32 inch to indicate the type, the contract or order number, and the date of manufacture. Marking shall be on the bottom surface in the central 1/3 section of the decking plank.

3.13 Finished material. -

3.13.1 Teak-Douglas fir decking shall be manufactured to the full dimensions required by the bureau or agency concerned (see 6.2).

3.13.2 When the contractor is required to machine a shape on the caulking edges, it shall be specified, (see 6.2), and drawings shall be furnished by the bureau or agency concerned.

3.14 Workmanship. - The workmanship shall be first class in every respect.

4. QUALITY ASSURANCE PROVISIONS

4.1 The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government.

1/ Coatings should be renewed as necessary when laminated teak-Douglas fir decking is stored outdoors.

Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Qualification tests 2/.- Qualification tests shall be conducted at a laboratory satisfactory to the Bureau of Ships. Qualification tests shall consist of the test specified in 4.6.

2/ Application for qualification tests shall be made in accordance with "Provisions Governing Qualification" (see 6.3 and 6.4).

4.3 Sampling.-

4.3.1 Lot.- For purposes of sampling, a lot shall consist of all decking presented for inspection at the same time which is of the same type, as defined in 1.2, which has been fabricated with a single lot of adhesive, which has been placed under full clamping pressure on the same working day, and which has been cured simultaneously in the same curing chamber.

4.3.2 Sampling for surface examination.- Random samples from each lot shall be selected for the examination specified in 4.4.2, with lot acceptance based on table I.

Table I - Sampling procedure for surface examination.

Number of decking members per lot	Number of decking members in sample	Acceptance number (defectives)	Rejection number (defectives)
8 and under	All	--	--
9 to 15	5	0	1
16 to 25	7	0	1
26 to 40	10	0	1
41 to 65	15	0	1
66 to 110	25	1	2
111 to 300	35	1	2
301 and over	50	2	3

4.3.3 Sampling for tests (at a laboratory satisfactory to the Bureau of Ships).-

4.3.3.1 Sampling for cyclical exposure tests.- For the cyclical exposure test, specimens shall be selected at random in accordance with table II. The specimens may be considered representative of all decking in the lot, if they will represent the quality of laminating for all decking in the lot. If process examination indicates that material may be suspect or if the test specimens do not adequately represent the lot, the sample shall be increased so that it represents all of the decking in the lot.

Table II - Cyclical exposure test sampling procedure.

Lot size, lineal feet of decking	Total number of specimens	Specimens without scarf-joint	Specimens with teak scarf-joint	Specimens with Douglas fir scarf-joint
1 - 150	1	0	--	--
151 - 350	2	1	1	--
351 - 600	3	1	1	1
601 - 900	4	1	2	1
901 - 1200	5	1	2	2
1201 - 1500	6	2	2	2
1501 - 2000	7	2	3	2
2001 - 3500	8	2	3	3
3501 - 6400	10	3	4	3

4.3.3.2 Sampling for block shear tests. - For block shear tests, random specimens shall be selected in accordance with table III. The specimens may be considered representative of all decking in the lot, if they will represent the quality of laminating for all decking in the lot. If process examination indicates that material may be suspect or if the specimens do not adequately represent the lot, the sample shall be increased so that it represents all of the decking in the lot.

Table III - Block shear test sampling procedures.

Lineal feet of decking per lot	Specimens for block shear
1 - 49	2
50 - 150	5
151 - 300	6
301 - 500	7
501 - 700	8
701 - 900	9
901 - 1200	10
1201 - 1500	11
1501 - 2000	12
2001 - 3500	14
3501 - 6400	17

4.4 Examination. -

4.4.1 Process control. - Continual examination during preparation of stock, assembly, and curing shall be made to assure that the materials and procedures are in accordance with this specification. In particular, a careful periodic check of the curing chart (or other evidence relating to temperature and humidity of the curing chamber and duration of cure), quality of lumber, suitability of adhesive, adequacy of pressure and type of coating shall be made.

4.4.2 Surface examination. - As a part of lot acceptance inspection each of the sample decking members selected in accordance with 4.3.2 shall be subjected to surface examination to determine conformance with 3.3, 3.4, 3.10, 3.11, 3.12, 3.13, and 3.14. If any laminated decking member in the sample does not conform to all requirements, it shall be considered defective and shall be rejected. If the number of such nonconforming laminated members in any sample exceeds the acceptance number for the sample, the lot represented by the sample shall be rejected.

4.4.3 Tests. -

4.4.3.1 Moisture content determination. - The contractor shall conduct moisture content determinations on at least five standard moisture samples for each kiln charge. Samples upon which moisture determinations are made shall be well distributed within the kiln. The moisture content shall be determined on shell and core sections shown on figure 1. The oven test shall be used.

4.4.3.2 Casehardening determination. - The contractor shall determine casehardening for each kiln charge.

4.4.3.3 Tests on lumber purchased in dry condition. - If lumber is purchased in dry condition, moisture content and casehardening shall be determined respectively from five samples from each 5,000 board feet or from each kiln charge, if the lumber can be identified by kiln charge.

4.4.3.4 Block shear test. - All teak-Douglas fir decking members shall be tested in block shear. Test specimens shall be prepared as specified in 4.6.3.1.

4.5 Production check tests. - The tests specified in 4.6.2 and 4.6.3 shall be conducted at a laboratory satisfactory to the bureau or agency concerned on the samples of decking members selected in accordance with tables II and III to determine that the laminated decking members are of equal quality to those that were subjected to the qualification tests. Failure of any of the sample members to pass these tests shall be basis for rejection of the lot involved and for withdrawal of qualification.

4.5.1 Cyclical exposure test specimen. - The dimensions of specimens for exposure tests shall be 3 inches in the direction of grain and the full cross section of the member. When specimens for testing end-joints are selected, the center of the end-joint shall fall at the center of the 3-inch test specimen.

4.5.2 Block shear test specimens. - The dimensions of specimens for block shear test shall be 4 inches in the direction of the grain and the full cross section of the member, from which the staircase block shear specimen shown on figure 2 can be prepared. Block shear test specimen and exposure test specimen (see 4.5.1), may be attached when both test specimens are subm''ted for test at the same time.

4.6 Qualification tests. -

4.6.1 Test beams. - Test beams shall be of the size and quantity specified by the Bureau of Ships. These members shall be prepared using actual production equipment.

4.6.1.1 Test specimens. - For qualification tests, the testing laboratory shall select block shear and exposure test specimens from the test beams specified in 4.6.1.

4.6.1.1.1 Cyclical exposure test specimen. - The dimensions of specimens for cyclical exposure test shall be 3 inches in the direction of the grain and the full cross section of the decking. When end-joints appear in the decking the center of the end-joint shall be so situated in the test specimen that they may be seen distinctly on both exposure faces.

4.6.1.1.2 Block shear test specimens. - Block shear test specimens shall be prepared as specified in 4.6.3.1 and as shown on figure 2.

4.6.2 Exposure test. -

4.6.2.1 Vacuum pressure cycle. - The specimens specified in 4.5.1 shall be placed in an autoclave, weighted down, and water at 65 to 80°F. shall be admitted into the autoclave in quantity sufficient to submerge the specimens completely. Thereafter, a vacuum of 20 to 25 inches of mercury shall be drawn and held for 2 hours. The vacuum shall then be broken, and a pressure of 80±5 p.s.i. shall be applied to the submerged specimens and held for 2 hours. The pressure shall then be released and a vacuum of 20 to 25 inches of mercury shall again be drawn and held for 2 hours while the specimens remain submerged. The vacuum shall be released again and a pressure of 80±5 p.s.i. applied to the submerged specimens and held for 2 hours.

4.6.2.2 Drying period. - The specimens shall be dried for a period of 88 hours (3-2/3 days) in air at 80 to 85°F. and 25 to 30 percent relative humidity, and circulating at the rate of at 500±50 f.p.m. During the drying the specimens shall be placed at least 2 inches apart and with the end surfaces parallel to the stream of air.

4.6.2.3 Duration of test. - The entire soaking-drying cycle shall be repeated twice to comprise a total test period of 12 days.

4.6.2.4 Measurement of delamination. - Measurement of delamination shall be made on all adhesive lines of both end (cross sectional) surfaces of the six test specimens during the drying period of the third cycle when delamination is at a maximum (usually during the fourth day of the period). Delamination shall be measured to the nearest 1/16 or 0.05 inch. The percent of delamination of the glue lines shall be calculated by dividing the total length of delamination measured along all adhesive lines (as stated above) by the length of the adhesive lines. 1/

4.6.3 Block shear test. -

4.6.3.1 Test specimens. - The test specimens shall be cut as shown on figure 2 so that the grain direction is parallel to the direction of loading during test. Care shall be taken in preparing the test specimens to make the loaded surfaces smooth and parallel to each other and perpendicular to the height. When sawing the bonded assembly, care shall also be exercised to insure that the saw cuts extend to, but not beyond, the adhesive line. The width and height of the specimen at the adhesive line shall be measured to the nearest 0.010 inch to determine the shear area.

4.6.3.2 Apparatus. - The testing machine shall be fitted with a compression shearing tool containing a self-aligning seat to insure uniform lateral distribution of the load. The machine shall be capable of maintaining a uniform rate of grip separation such that the load may be applied with a continuous motion of the movable head to maximum load at a rate of 0.025 inch per minute with a permissible variation of plus or minus 25 percent. The shearing tool shown on figure 3 has been found satisfactory.

4.6.3.3 Procedure. -

4.6.3.3.1 The test specimen shall be placed in the shearing tool so that the load may be applied as specified in 4.6.3.2. The position of the specimen in one type of shearing tool shall be as shown on figure 3. The loading shall be applied with a continuous motion of the movable head at a rate 0.025 inch per minute to failure.

4.6.3.3.2 The shear stress at failure shall be calculated in pounds per square inch, based on the adhesive line area between the two laminations measured to the nearest 0.01 square inch, and shall be reported for each specimen together with the estimated percentage of wood failure.

1/ Delamination is a term used to express separation of wood surfaces at the glue lines. When the separation is in the wood, even though very close to the glue line, it is termed "wood failure" or "checking". Magnification is often necessary to determine whether the failure is in the glue or wood. A feeler gage, 0.004 inch in thickness, is convenient for probing into the glue line to determine if separation actually exists.

4.7 Inspection for preparation for delivery.- The packaging, packing and marking of laminated teak-Douglas fir decking shall be subject to inspection to determine compliance with the requirements of Section 5 of this specification.

5. PREPARATION FOR DELIVERY

5.1 Domestic shipment and early use.-

5.1.1 Wood laminates.-

5.1.1.1 Packaging.- Laminated frame member shall be bundled in pairs or other suitable grouping, and each member within the bundle shall be suitably marked (see 3.12). Smaller laminated members should be bundled, when practicable. Bundles shall be secured by means of steel strapping. No screws, bolts, or spikes shall be inserted into the members for packaging and packing purposes. All members of the bundle shall be protected against cutting of the strapping by means of strips of plywood, metal, fiberboard or other protective material placed between the bundle members and the strapping. The packaging shall be sufficient to afford adequate protection against deterioration and physical damage during shipment from the supply source to the using activity and until early use.

5.1.1.2 Packing.- Packing shall be accomplished in a manner which will insure acceptance by carrier and will afford protection against physical damage during handling and direct shipment from the supply source to the using activity for early use. The wood laminates shall be shipped in open or closed cars according to size of the individual member. When loaded in open cars (gondola and flat car) loading shall be in strict accordance with Section 5 of the Association of American Railroads "Rules Governing the Loading of Forest Products on Open Top Cars". The wood laminates protected as specified (see 3.11) shall be covered with waterproof paper or other suitable weather resistant material. When loaded in closed freight cars or covered vans material shall be loaded in accordance with the methods recommended in Pamphlet No. 20 of the Association of American Railroads or other carrier regulations applicable to the mode of transportation.

5.1.1.3 Marking.- Shipment marking information shall be provided in accordance with the contractor's commercial practice. The information shall include nomenclature and type, contract or order number, contractor's name and address.

6. NOTES

6.1 Intended use.-

6.1.1 Type I.- Type I is intended for use as an alternate for solid decking in such applications as aircraft carrier flight decks and margin pieces in locations subject to high abrasion and where loading stresses are a critical design factor.

6.1.2 Type II.- Type II is intended for use as an alternate for solid decking in such applications as ship decks other than aircraft carrier flight decks and margin pieces where loading stresses are not a critical design factor.

6.2 Ordering data.- Procurement documents should specify the following:

(a) Title, number, and date of this specification.
(b) Type of decking required (see 1.2).
(c) That the thickness, width and length should be sufficient to provide full dimensions after all machining of decking.
(d) Whether side coatings are required (see 3.11.1).
(e) Whether caulking edges are to be shaped, with drawings of same (see 3.13.2), to be furnished by the bureau or agency concerned.
(f) That the loading of material should be done by the contractor.
(g) That bidders shall submit information to show that they or their prospective sub-contractors have adequate facilities for the production of laminated teak-Douglas fir and that they have adequate experience in manufacture to meet the requirements of this specification. The evidence furnished to establish reliability shall include data to show that the bidder or his prospective sub-contractor has adequate space for storage and inspection with lighting facilities equal in all respects to daylight. The right is reserved to require bidders to amplify the data furnished and to furnish additional data as may be necessary to establish the eligibility status of the bidder.

6.3 With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set for opening of bids, been tested and approved for inclusion in Qualified Products List QPL-16285 whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification, in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is the Chief of the Bureau of Ships, Department of the Navy, Washington 25, D. C., and information pertaining to qualification of products may be obtained from that activity. Application for Qualification tests shall be made in accordance with "Provisions Governing Qualification" (see 6.4).

6.4 Copies of "Provisions Governing Qualification" may be obtained upon application to Commanding Officer, Naval Supply Depot, 5801 Tabor Avenue, Philadelphia 20, Pa.

6.5 The right is reserved to reject bids of laminated teak-Douglas fir from manufacturers whose plant facilities have not been inspected by the Government inspector and found adequate.

Notice.- When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Preparing activity:
Navy - Ships
(Project 5510-N005Sh)

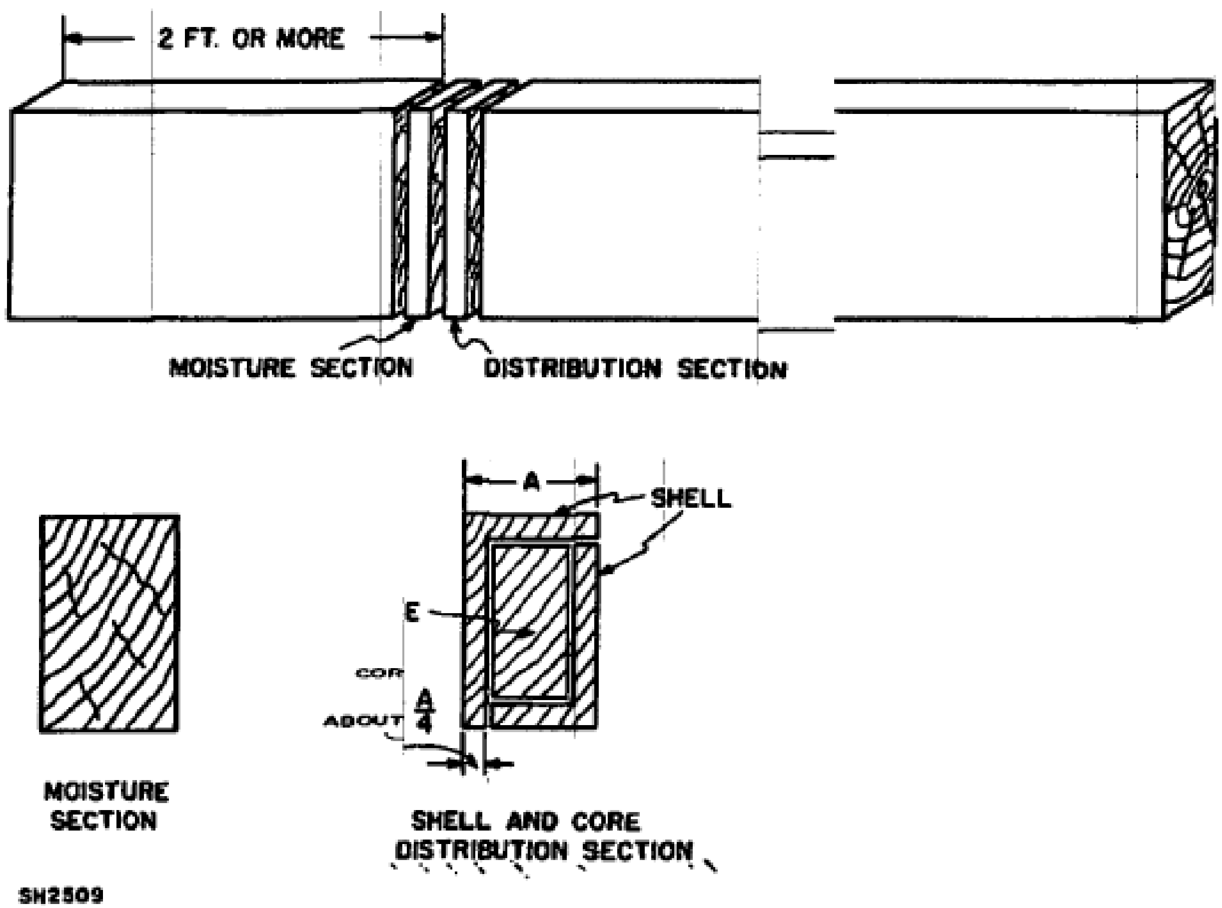

Figure I. - Moisture and case - hardening specimens.

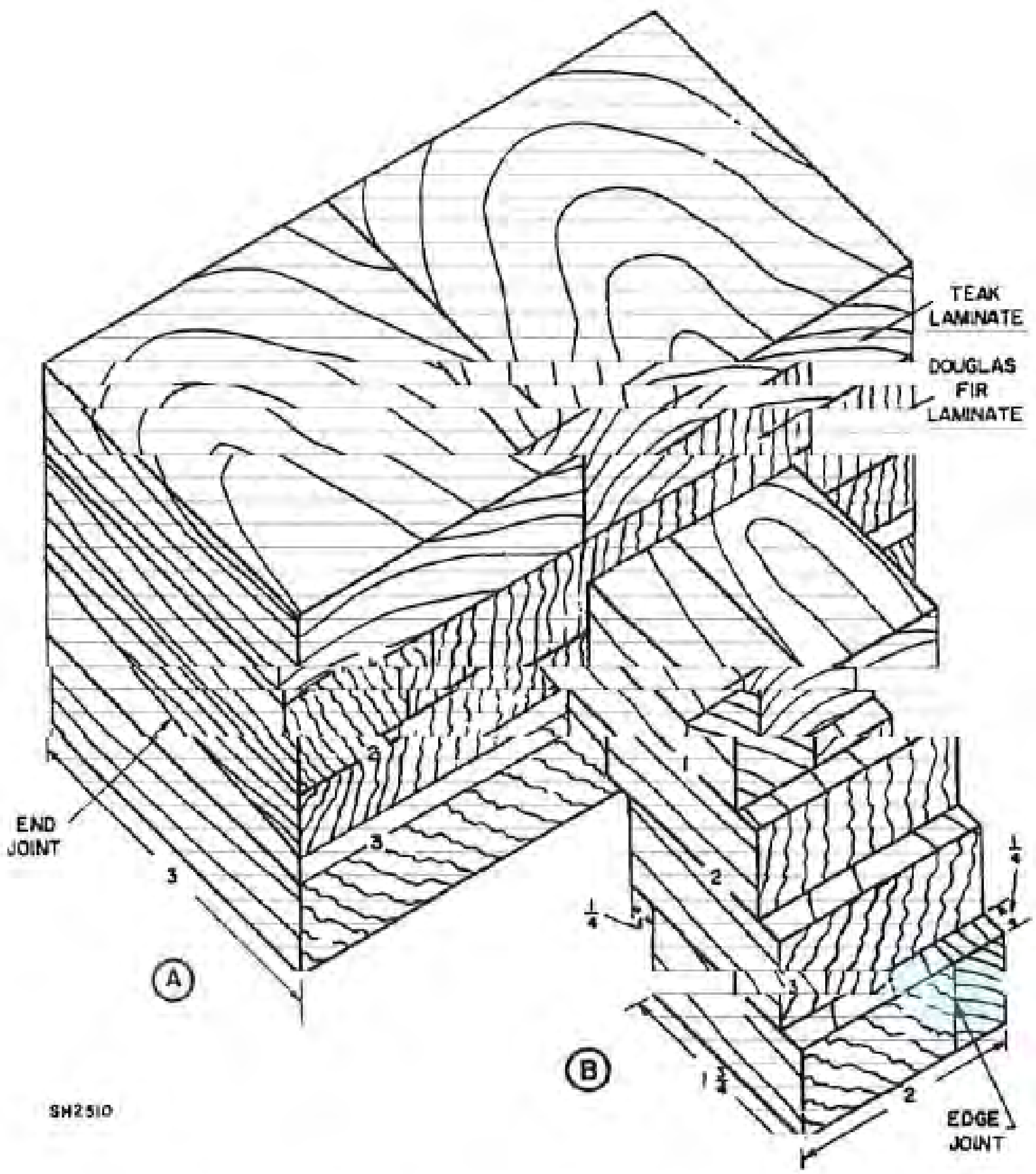

Figure 2.- Standard cyclical exposure test specimen (A), and staircase type shear test specimen (B), for testing glue joint.

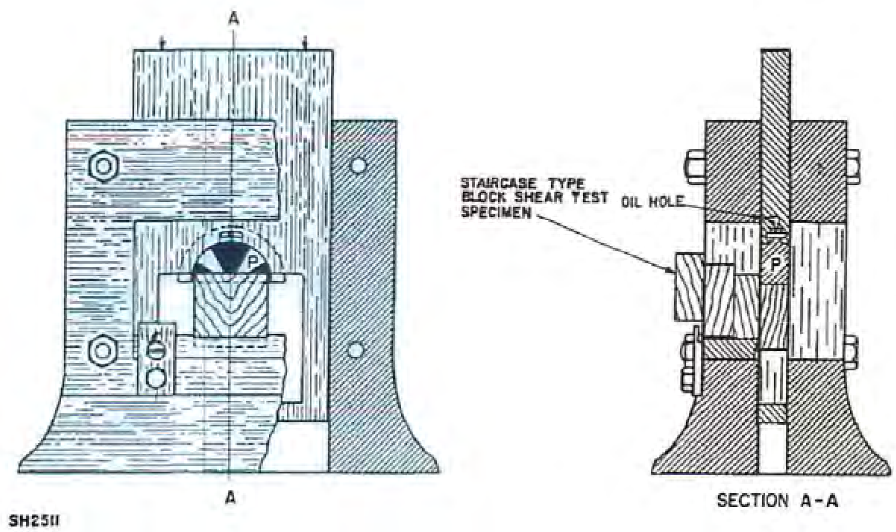

Figure 3. – Shearing tool.

VENTILATION SYSTEMS

Clean in accordance with approved onboard PMS procedures (see Curator for booklets). Blank external openings to prevent entry of moisture into dehumidified spaces.

NOTE

Observe PCB requirements when working/removing ventilation ducting.

Ventilation Systems. Inspect ventilation screens open to the weather; clean and repair as necessary. Reinstall screens in place after repair or replacement when the vent duct is blanked externally. Where removal of the screen is required for installation of blanks or where the installed blank is not external to the screen, do not reinstall screen but stow in a suitable location under D/H. Tag all items removed and make appropriate entries in stowage plan activation work package, or other ship's records to identify both stowage location and location for reinstallation.

Cleaning Ventilation Systems and Motors. Cleaning Ventilation Systems and Motors. Clean internal ventilation systems and associated motors in accordance with existing PMS.