Rule Requirements for
Materials and Welding
2000

Supplementary Requirements
for Naval Vessels

American Bureau of Shipping
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of The State of New York, 1862

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PART 2

Rule Requirements for Materials and Welding

Supplementary Requirements for Naval Vessels

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SECTION 1 General

1 Scope

When so ordered and agreed to by the Bureau, ABS Grade hull structural steel produced, tested, inspected and certified in accordance with Part 2, Chapter 1, of the Rules is to comply with the supplemental requirements in this Chapter. However, the responsibility for compliance with these supplemental requirements lies with the steel manufacturer.
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SECTION 2 Preservation, Packaging, Packing and Marking

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CHAPTER 11 Materials for Hull Construction

SECTION 2 Preservation, Packaging, Packing and Marking

1 General

When requested by the purchaser, structural plates, shapes and bars are to be cleaned and coated in accordance with the following requirements, and are to be preserved, packaged, packed, and marked in accordance with ASTM A700. Material so cleaned and coated is considered as Class P material for the purposes of ordering; no marking indicating Class P need be affixed or stamped. The conformance to the requirements is a matter of agreement between the manufacturer and the purchaser.

3 References

The following documents form a part of these supplementary requirements to the extent specified herein. Unless otherwise specified, the issue of the document is to be that listed in the Department of Defense Index of Specifications and Standards (DoDISS) and supplements thereto, cited in the solicitation. Unless otherwise specified, the issue of documents not listed in the DoDISS is to be the issue of the nongovernment documents which is current on the date of the solicitation. Copies of Government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.

3.1 Federal Standard

Fed-STD-595 – Colors

3.3 Federal Specifications

TT-P-645B – Primer, Paint, Zinc Molybdate, Alkyd Type
TT-P-664D – Primer Coating, Alkyd, Corrosion-Inhibiting, Lead and Chromate Free, VOC Compliant

3.5 American Society for Testing and Materials (ASTM)

3.7 Steel Structures Painting Council (SSPC)

SP 6 – Commercial Blast Cleaning

5 Cleaning Procedures for Class P Material

5.1 Descaling

The steel material, as prepared for coating, is to be in the descaled and cleaned condition and free of visible rust. Material is to be descaled by abrasive blast cleaning or acid pickling.

5.3 Abrasive Blast Cleaning

Abrasive blast cleaning is to result in a clean metal surface, suitable for painting, equivalent to a commercial blast cleaning, SSPC SP 6.

5.5 Acid Pickling

The acid pickling process is to be as follows:

5.5.1 Position

Material is to be tilted on edge throughout the steps of the procedure. Shapes are not to be positioned as to have a lower surface horizontal in the solution.

5.5.2 Pre-Pickling

Rust preventives, oils, greases, oil paints and other foreign matter are to be removed from the steel prior to pickling.

5.5.3 Bath Conditions

The pickling bath is to consist of sulfuric acid solution to which has been added a pickling inhibitor and 1.5 percent of sodium chloride. In making the solution initially, 20 liters (5 gallons) of concentrated sulfuric acid are to be used for each 400 liters (100 gallons) of solution. The acid concentration is not to be allowed to drop below 3.5 percent by volume. The inhibitor is to be used at the concentration recommended by the manufacturer. The bath temperature is to be maintained between 77°C (170°F) and 82°C (180°F). When the concentration of iron in the solution reaches 5 percent by weight, the entire bath is to be discarded.

5.5.4 Water Rinse

The steel is to be thoroughly rinsed with water after pickling. The water rinse is to consist of fresh circulating water maintained at a temperature of 77°C (170°F) to 82°C (180°F). The flow of fresh water is to be maintained so that a complete change of water occurs at least once every 24 hours. The combined concentrations of sulfuric acid and iron sulfate in the bath, calculated from the acid concentration and the ferrous iron concentration, are not to exceed 0.5 g/liter (2 grams per gallon). This determination is to be made at least once each week.
7 Coatings for Class P Material

Class P material is to be coated in accordance with any one of the following.

7.1 TT-P-645B

One coat of 0.05 mm (2.0 mils) dry film thickness, appropriately tinted. The VOC is not to exceed 340 g/l.

7.3 TT-P-664D

One coat of 0.05 mm (2.0 mil) dry film thickness, appropriately tinted. The VOC is not to exceed 420 g/l.

7.5 Commercially Available Anticorrosive Coating

One coat of 0.05 mm (2.0 mils) dry film thickness, of an appropriately tinted, commercially available lead and chromate free anticorrosive coating demonstrated to provide corrosion protection equivalent to the coatings in 2-11-2/7.1 or 2-11-2/7.3. Lead and chromate free is defined as 50 ppm maximum in the dry paint film. The VOC is not to exceed 420 g/l. The selection and use of a commercially available anticorrosive coating is to be agreed by the steel manufacturer and the purchaser.

9 Color of Coatings for Class P Material

The color of coatings for Class P material is to be in accordance with the following.

9.1 Ordinary Strength Steel

The color is to be a clear yellow, approximating color No. 33481 (yellow) in accordance with FED-STD-595, by removing the lampblack.

9.3 Higher Strength Steel

The color is to be a dark green, approximating color No. 34128 (dark green) in accordance with FED-STD-595, by adding sufficient and insoluble inorganic pigments.

11 Drying and Protection

11.1 Drying Time

The drying time at 23C (73F) for the coating specified in 2-11-2/7 is to be as follows:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Type</th>
<th>Drying Time (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT-P-645B</td>
<td>Formula 84D</td>
<td>6 hours 10 minutes (touch)</td>
</tr>
<tr>
<td>TT- P-664D</td>
<td>—</td>
<td>45 minutes (handling)</td>
</tr>
<tr>
<td>Commercially Available</td>
<td>—</td>
<td>As agreed by manufacturer</td>
</tr>
<tr>
<td>Anticorrosive Coating</td>
<td></td>
<td>and purchaser</td>
</tr>
</tbody>
</table>

Higher temperatures may be used to shorten drying time.
11.3 Length of Protection

The coatings specified in 2-11-2/7 are to be selected for the desired length of protection. Protection for approximately 9 months should be provided by cleaning, followed by:

i) one coat of alkyd zinc-molybdate primer, in accordance with TT-P-645B, or
ii) one coat of alkyd primer, in accordance with TT-P-664D, or
iii) one coat of commercially available anticorrosive primer (see 2-11-2/7.5)
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CHAPTER 11 Materials for Hull Construction

SECTION 3 Special Specifications

1 General

When the application of the material is intended to be hull structural steel on US military surface ships, the following paragraphs are to be used in requesting additions to the requirements in Part 2, Chapter 1.

3 Cold Cracking Susceptibility

Grades AH36, DH36 and EH36 up to 45 mm (1 3/4 in.) in thickness are to have a cold cracking susceptibility ($P_{cm}$) less than 0.27% as determined by the following equation.

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B \%$$

5 Impact Testing

Charpy V-notch impact tests may be waived for the higher-strength material equivalent to Grade AH36, 12.5 mm (1/2 in.) and less in thickness.
CHAPTER 11 Materials for Hull Construction

SECTION 4 Superseded Specifications

ABS Grades shown in 2-11-4/Table 1 and 2-11-4/Table 2 supersede the indicated US military specification material grades.

### TABLE 1
Superseded Plate Specifications

<table>
<thead>
<tr>
<th>Rule Steel Grade</th>
<th>MIL-S-22698C</th>
<th>MIL-S-22698A</th>
<th>MIL-S-16113</th>
<th>MIL-S-24113A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade A</td>
<td>Grade A</td>
<td>Class A</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Grade B</td>
<td>Grade B</td>
<td>Class B</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Grade D</td>
<td>Grade D</td>
<td>Class C</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Grade DH36*</td>
<td>Grade DH36</td>
<td>Class D</td>
<td>Grade HT-type I</td>
<td>Grade N</td>
</tr>
<tr>
<td>Grade EH36U*</td>
<td>Grade EH36T</td>
<td>—</td>
<td>Grade HT-type II</td>
<td>Grade N</td>
</tr>
</tbody>
</table>

Notes:
1. MIL-S-24113, Grade QT is no longer used. Supersession is by ASTM A537, Class 2 with a Charpy requirement of 40J (4.1 kg-m, 30 ft-lb) at minus 23C (minus 10F).

* For additional Requirements, see 2-11-3/3.

### TABLE 2
Superseded Bar and Shape Specifications

<table>
<thead>
<tr>
<th>Rule Steel Grade</th>
<th>MIL-S-22698C</th>
<th>MIL-S-20166</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade A</td>
<td>Grade A</td>
<td>Grades C, F and M</td>
</tr>
<tr>
<td>Grade B</td>
<td>Grade B</td>
<td>Grades C, F and M</td>
</tr>
<tr>
<td>Grade AH36*</td>
<td>Grade AH36</td>
<td>Grade HT-type I</td>
</tr>
<tr>
<td>Grade AH36U*</td>
<td>Grade AH36T</td>
<td>Grade HT-type II</td>
</tr>
</tbody>
</table>

Notes:
* For additional Requirements, see 2-11-3/3 and 2-11-3/5.
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SECTION 5 Substitute Material

Where agreed between the purchaser and the material manufacturer, the material listed in 2-11-5/Table 1 and 2-11-5/Table 2 may be accepted for US military surface ships in lieu of the ABS grades shown provided the additional requirements are complied with. In all cases, the steel is to be produced by an approved steel mill. No other substitutions are to be considered for hull structural steel intended for US military surface ships.

<table>
<thead>
<tr>
<th>Rule Steel Grade</th>
<th>Substitute Specification</th>
<th>Additional Requirements (1)(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade A</td>
<td>ASTM A36</td>
<td>None</td>
</tr>
<tr>
<td>Grade B</td>
<td>ASTM A29, Grades 1015 through 1022</td>
<td>Fine Grain Practice</td>
</tr>
<tr>
<td>Grade B</td>
<td>ASTM A131, Grade B</td>
<td>Si 0.15–0.35%</td>
</tr>
<tr>
<td>Grade B</td>
<td>ASTM A576, Grades 1015 through 1022</td>
<td>Si 0.15–0.35%</td>
</tr>
<tr>
<td>Grade AH36</td>
<td>ASTM A131, Grade AH36</td>
<td>None</td>
</tr>
<tr>
<td>Grade AH36</td>
<td>ASTM A322, Class 8620</td>
<td>Fine Grain Practice, and Normalized</td>
</tr>
<tr>
<td>Grade AH36</td>
<td>ASTM A588, Grades A or B</td>
<td>None</td>
</tr>
<tr>
<td>Grade DH36</td>
<td>ASTM A131, Grade DH36</td>
<td>None</td>
</tr>
<tr>
<td>Grade EH36</td>
<td>ASTM A131, Grade EH36</td>
<td>None</td>
</tr>
</tbody>
</table>

Notes:
1 The Surveyor is to verify the test data in all cases.
2 The mechanical properties of the substitute are to meet the Rule requirement for the supplanted grade.
3 The steel mill producing the substitute material must be approved to produce the supplanted grade in accordance with 2-1-2/3 or 2-1-3/3 as appropriate.
### TABLE 2
Substitutes for Bars for Reforging

<table>
<thead>
<tr>
<th>Rule Steel Grade</th>
<th>Substitute Specification</th>
<th>Additional Requirements $^\text{(1)(2)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade B</td>
<td>ASTM A131, Grade B</td>
<td>Si 0.15–0.35%</td>
</tr>
<tr>
<td>Grade B</td>
<td>ASTM A576, Grades 1015 through 1022</td>
<td>Si 0.15–0.35%</td>
</tr>
<tr>
<td>Grade DH36</td>
<td>ASTM A131, Grade DH36</td>
<td>None</td>
</tr>
<tr>
<td>Grade DH36</td>
<td>ASTM A541, Class 4</td>
<td>None</td>
</tr>
</tbody>
</table>

**Notes:**

1. The Surveyor is to verify the test data in all cases.
2. The mechanical properties of the substitute are to meet the Rule requirement for the supplanted grade.
3. The steel mill producing the substitute material must be approved to produce the supplanted grade in accordance with 2-1-2/3 or 2-1-3/3 as appropriate.
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CHAPTER 11 Materials for Hull Construction

SECTION 6 Aluminum/Steel Bimetallic Transition Joints

1 Scope

The following specification covers metallurgically bonded bimetallic transition joints intended for structural connections between aluminum and steel in an atmospheric or dry environment. When the end use is for a U.S. Naval Ship, these transition joints are to be produced in accordance with the aluminum requirements in Part 2, Section 4 (1997 Edition of Part 2 “Requirements for Materials and Welding – Aluminum, Fiber Reinforced Plastics (FRP)”) and the steel requirements in Part 2, Chapter 1, together with the modifying requirements in 2-11-6/3. (Note: These supplementary requirements are intended to replace MIL-J-24445A).

3 Supplementary Requirements for Naval Ships

Aluminum/steel bimetallic transition joints are to be produced, tested, inspected and certified in accordance the following supplementary requirements.

3.1 Reference Documents

The following documents of the issue in effect on the date of the material purchase form a part of this specification to the extent referenced herein.

- MIL-STD-1689 Fabrication, Welding, and Inspection of Ship Structures
- NAVSEA Technical Publication T9074-AS-GIB-010/271, Nondestructive Testing Requirements for Metals

3.3 Process of Manufacture

The bimetallic bond may be produced by explosion-bonding or by roll-bonding. In both cases, the material is to be produced in the form of plate, which will subsequently be cut into bar-like transition joints. Aluminum alloys in accordance with Part 2, Section 4 (1997 Edition of Booklet 2) and the steels in accordance with Part 2, Chapter 1, are considered suitable for use as transition joint material. The use of an intermediate aluminum material at the bond interface is permitted.
3.5 **Tensile Strength**

The ultimate tensile strength of the bond zone is to be determined by means of the ram tensile test described in 2-11-6/Figure 1. Test specimens machined to the dimensions in 2-11-6/Figure 2 are to be loaded in tension to failure. The minimum tensile strength is 75 N/mm² (8 kgf/mm², 11 ksi). Tests are to be made in the as-clad condition, and in the simulated welded condition.

3.5.1 **As-Clad Test**

No preliminary treatment is to be given to the specimens which are to represent the as-clad product. The testing is to be carried out at room temperature.

3.5.2 **Simulated Welded Test**

A preliminary heat treatment is to be given to the specimens which are to represent the product after welding. The test specimen is to be heat treated at 315°C ± 14°C (600°F ± 25°F) for 15 minutes. The testing is to be carried out at room temperature.

3.7 **Bend Test**

The integrity of the bond zone is to be evaluated by means of a full thickness guided bend test. Two bend specimens, see 2-4-3/Figure 5, are to be machined with the bond line transverse to the specimen longitudinal axis and at the approximate mid-length. The specimens are to be bent over ninety degrees to a radius of three times the thickness of the specimen. Openings at the bond line that are visible to the unaided eye and larger in size than 3.2 mm (1/8 in) are cause for rejection. The total length of permissible openings is not to exceed twenty percent of the bond length tested.

3.9 **Shear Test**

The ultimate shear strength of the bond zone is to be determined by means of the methods for the shear strength test in Figure 1 of ASTM A264, for Stainless Chromium-Nickel Steel-Clad Plate, Sheet, and Strip. Test specimens are to be loaded in shear to failure. The minimum shear strength is 55 N/mm² (6 kgf/mm², 8 ksi). Tests are to be made in the as-clad condition, and in the simulated welded condition.

3.9.1 **As-Clad Test**

No preliminary treatment is to be given to the specimens which are to represent the as-clad product. The testing is to be carried out at room temperature.

3.9.2 **Simulated Welded Test**

A preliminary heat treatment is to be given to the specimens which are to represent the product after welding. The test specimen is to be heat treated at 315°C ± 14°C (600°F ± 25°F) for 15 minutes. The testing is to be carried out at room temperature.

3.11 **Axial Fatigue Strength Test**

The axial fatigue strength of the welded transition joint is to be determined by means of specimens in 2-11-6/Figure 3, and is to meet the minimum specified loadings and endurance without decohesion at the bond line. The testing is to be repeated if the base metal fails before the specified number of cycles.
### TABLE 1
Fatigue Test Conditions and Requirements

<table>
<thead>
<tr>
<th>Tension Stress, in N/mm² (kgf/mm², ksi)</th>
<th>Compressive Stress, in N/mm² (kgf/mm², ksi)</th>
<th>Number of Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>35 (4.5)</td>
<td>100 (11, 15)</td>
<td>175,000</td>
</tr>
<tr>
<td>7 (0.7, 1)</td>
<td>100 (11, 15)</td>
<td>650,000</td>
</tr>
<tr>
<td>20 (2.3)</td>
<td>70 (7, 10)</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>

**3.13 Welded Tensile Test**

The axial tensile strength of the welded transition joint is to be determined by means of specimens in 2-11-6/Figure 3. The results are considered satisfactory provided the failure load is above that calculated for one of the web members based on the specified minimum tensile strength of the web material.

**3.15 Nondestructive Examination**

The bond zone is to be examined by means of ultrasonic inspection in accordance with NAVSEA Technical Publication T9074-AS-GIB-010/271 to detect areas that lack a bond. Each bimetallic bond is to be continuously scanned. Complete loss of back reflection resulting from a discontinuity at the bond interface is cause for rejection.

**3.17 Dimensional Tolerances**

The transition joint flatness, edge straightness and edge chamfer are to comply with the following.

- **3.17.1 Flatness**
  
The joints are to be flat to within 1.6 mm (0.062 in) over any 305 mm (12 in). The overall flatness is to be within 25.4 mm (1.0 in) for joints over 2.5 m (8 ft) in length, and 19.1 mm (0.75 in) for shorter joints.

- **3.17.2 Edge Straightness**
  
The joints are to be straight at the edge to within 3.2 mm (0.375 in) over any 305 mm (12 in). The overall straightness is to be within 12.5 mm (0.50 in).

- **3.17.3 Edge Chamfer**
  
The joint edges are to be chamfered to a minimum radius of 1.6 mm (0.062 in). The edge squareness is to be within 0.8 mm (0.031 in) for cut ends, and 1.6 mm (0.062 in) for cut edges.

**3.19 Sampling Lots**

A test lot consists of not more than ten (10) bimetallic bonded plates produced at one time and with the same set of manufacturing parameters. Changes to the manufacturing parameters listed below constitute a different lot.

- **3.19.1 Common Parameters**
  
  Manufacturing parameters common to both explosion-bonding and to roll-bonding are: alloy heat, plate thicknesses, base metal pre-cleaning, bonding agents, and assembly width and length.
3.19.2 Explosion-Bonding Parameters

Manufacturing parameters for explosion-bonding are: charge size, standoff distance, charge type, and process sequencing.

3-19-3 Roll-Bonding Parameters

Manufacturing parameters for roll-bonding are: roll pressure, roll temperature, and number of passes.

3.21 Test Sampling

One bonded plate from each lot is to be sampled for mechanical testing. The selected plate is to be sampled at diagonally opposite corners. Each sample is to be used for tensile strength testing, and bend testing. All plates are to 100% ultrasonically inspected, 2-11-6/3.15. All transition joints are to be dimensionally inspected, 2-11-6/3.17.

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Production Lot Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>Section</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>2-11-6/3.5</td>
</tr>
<tr>
<td>Bend</td>
<td>2-11-6/3.7</td>
</tr>
</tbody>
</table>

3.23 Retest Sampling

Rejected lots may be reconsidered on a plate-by-plate basis provided two tensile tests and two bend tests are carried out with satisfactory results. A plate with any mechanical test failure is not to be reconsidered for acceptance.

3.25 First Article Inspection

In accordance with 2-1-2/3, a first article inspection is to be carried out for each type of bimetallic joint to validate the bond zone properties and the manufacturing process. All bonding practices are to be recorded and to serve as a base-line for production. Where production practices are modified from the baseline, first article inspection may be required. First article testing is to include ultrasonic inspection, 2-11-6/3.15, and the following production tests and special tests:

<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>First Article Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>Section</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>2-11-6/3.5</td>
</tr>
<tr>
<td>Bend</td>
<td>2-11-6/3.7</td>
</tr>
<tr>
<td>Shear</td>
<td>2-11-6/3.9</td>
</tr>
<tr>
<td>Axial Fatigue Strength</td>
<td>2-11-6/3.11</td>
</tr>
<tr>
<td>Welded Tensile</td>
<td>2-11-6/3.13</td>
</tr>
</tbody>
</table>

Note

1 If the specimen contains three lugs for testing, then one specimen may be used. In this case, each lug is to be tested individually and the specimen suitably cleaned of testing damage so as to not influence testing and results of the subsequent lug.
3.27 Ordering Data

Procurement documents are to list the following items with appropriate requirements specified:

1. Specify title and number of ABS specification.
2. Specify ABS designation and UNS alloy number of bimetallic materials.
3. Specify ASTM specification, if applicable.
4. Specify dimensions or reference a drawing number.
5. Specify ABS certification, if required.
6. Specify special product marking, if required.
7. Specify first article inspection, 2-11-6/3.25, if required.

3.29 Superseded Specifications

This specification supersedes MIL-J-24445A in entirety.
FIGURE 1
Ram Tensile Test Setup

TOOL STEEL RAM

RAM TENSILE SPECIMEN

TOOL STEEL BASE BLOCK

ALUMINUM
BOND ZONE
STEEL
FIGURE 2
Ram Tensile Specimen

Notes
1 Sketch dimensions may be appropriately scaled for testing product less than 33 mm (1\(\frac{1}{16}\) in) in width.
2 The hole depth, \(D\), below the bond line is to be 1.62 mm (0.064 in) or greater in all cases.
Notes

1. The web members are to be of the same composition and thickness as those which are to be used for the service application.

2. The width of the transition joint is to be the same as the product furnished to the purchaser.

3. The welding filler material is to be chosen in accordance with the requirements of MIL-STD-1689. The test assembly is to be cut from the approximate center of the welded assembly and is to be a minimum of 50 mm (2 in) in length. The welded assembly is to incorporate the necessary load tabs.
PART 2
CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

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SECTION 5 Boiler and Superheater Tubes

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PART 2

CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 5 Boiler and Superheater Tubes

1 Scope

The following specifications cover four grades of steel tube designated H, J, K and P, and also cover two grades of austenitic stainless steel designated R and S. When the end use is for a U.S. Naval Ship, ABS grades of steel tube are to be produced in accordance with the requirements in Section 2-3-5 together with the modifying requirements in 2-13-5/3. (Note: These supplementary requirements are intended to replace MIL-T-16286.)

3 Supplementary Requirements for Naval Ships

Steel tube is to be produced, tested, inspected and certified in accordance with ASTM A192, ASTM A209, ASTM A210, ASTM A213 and ASTM A450, including section 30 (Government Procurement) as modified by Section 2-3-5 and the following supplementary requirements.

3.1 Referenced Documents

The following documents of the issue in effect on the date of the solicitation form a part of this specification to the extent referenced herein.

- ASTM A192 Standard Specification for Seamless Carbon Steel Boiler Tubes for High-Pressure Service
- ASTM A210 Standard Specification for Medium-Carbon Steel Boiler and Superheater Tubes
- ASTM A262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steel
- ASTM A450 Standard Specification for General Requirements for Carbon Ferritic Alloy and Austenitic Alloy Steel Tubes
3.3 Intended Use

Grades H, K, and J are intended for the following specified uses.

3.3.1 Grade H Tubes
Grade H tubes are intended for use as water tubes in steam generators operating at a steam pressure not to exceed 51.5 bar (5.17MPa, 750 psi).

3.3.2 Grade K Tubes
Grade K tubes are intended for use as water tubes in steam generators only when approved by the procuring activity.

3.3.3 Grade J Tubes
Grade J tubes are intended for use as water tubes in steam generators.

3.5 Heat Treatment

Hot finished grade H and J tubes are to be heat treated at a temperature of 650C (1200F) or higher. Grade R and S tubes are to be solution annealed at a minimum of 1100C (2000F) and then quenched in water or rapidly cooled by other means, followed by a stabilization anneal at 815C to 900C (1500F to 1650F).

3.7 Hydrostatic Testing

All tubes in all lots are to be hydrostatic tested in accordance with test requirements in 2-3-5/31. The nondestructive electric test in 2-3-5/33 is not to be substituted.

3.9 Nondestructive Testing

Eddy-current testing may be substituted for ultrasonic testing for all tubing having a specified wall thickness of 3.0 mm (0.120) inches or less.

3.11 Intergranular Corrosion

One specimen from each of two tubes from each lot of grades R and S is to be prepared and tested in accordance with ASTM A262 Practice E without the use of the rapid screening test. A lot is all tubes of same size and from the same heat which are heat treated in the same furnace charge, when heat treated in a batch-type furnace or all tubes of the same size and heat, heat treated in the same furnace at the same temperature, time at heat, furnace speed during an 8 hour period, when heat treated in a continuous furnace. The entire lot is to be rejected if the test results for either specimen show the presence of precipitated carbides.

3.13 Minimum Permissible Hardness

Tube that has hardness values less than the following is to be tensile tested.

<table>
<thead>
<tr>
<th>Tube Grade</th>
<th>Rockwell Hardness Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tubes 1.65 mm (0.065 in.) and over in wall thickness</td>
</tr>
<tr>
<td>KB J, P</td>
<td>B 65</td>
</tr>
<tr>
<td>R, S</td>
<td>B 70</td>
</tr>
</tbody>
</table>
3.15 Ordering Data

Procurement documents are to list the following items with appropriate requirements specified:

1. Specify title and number of ABS specification.
2. Specify ABS grade.
3. Specify applicable ASTM specification and ASTM grade.
4. Specify minimum wall thickness, length and outside diameter required and, if required, any additional dimensional tolerance or out of roundness requirements.
5. Specify levels of preservation, packaging and packing required and applicable specifications and standards.
7. Specify ultrasonic testing is required for all tubing per ASTM A450 section 30.
8. Specify if ABS certification is required.
9. Specify additional data certification requirements, if any.
10. Specify if chemical check analysis is required for grades H or J.

3.17 Class of Ordering Data

This ordering data has been classified to establish the minimum requirements for different applications. Class 1 requirements and ordering data are to be specified on every order unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are not required unless specifically required by the contract or drawing.

Class 1: Items 1 to 7 in 2-13-5/3.15 are Class 1.
Class 2: Items 8 and 10 in 2-13-5/3.15 are Class 2.

3.19 Superseded Specifications

The ABS grades shown below supersede the indicated specification grades.

<table>
<thead>
<tr>
<th>Rule Steel Tube Grade</th>
<th>ASTM Steel Tube Specification and Grade</th>
<th>MIL-T-16286E Class</th>
<th>MIL-T-16286D Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>A192</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>A210 Grade A-1</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>A209 Grade T1</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>A213 Grade T22</td>
<td>E</td>
<td>F</td>
</tr>
<tr>
<td>R</td>
<td>A213 Grade TP321</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>A213 Grade TP347</td>
<td>C</td>
<td></td>
</tr>
</tbody>
</table>
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CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 7 Steel Machinery Forgings

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1.1 Scope
The following specification covers two grades of carbon steel forgings, designated 2, and 4C. When the end use is for a U.S. Naval Ship, ABS grades of carbon steel forgings are to be produced in accordance with the requirements in 2-3-7/1 together with the modifying requirements in 2-13-7/1.3 (Note: These supplementary requirements are intended to replace MIL-S-24093A (SH).)

1.3 Supplementary Requirements for Naval Ships
Alloy steel forgings are to be produced, tested, inspected and certified in accordance with ASTM A668 and A788 as modified by 2-3-7/1 and the following supplementary requirements. Requirements in 2-3-7/1 that are different than the ASTM requirements are listed for reference:

2-3-7/1.1.1 General
2-3-7/1.3.1 Marking
2-3-7/1.7 Tensile Properties
2-3-7/1.9 Test Specimens
2-3-7/1.11 Number and Location of Tests

1.3.1 Reference Documents
The following documents of the issue in effect on the date of the material purchase form a part of this specification to the extent referenced herein:

ASTM A668 Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
ASTM A788 Standard Specification for Steel Forgings, General Requirements
ASTM A370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products
NAVSEA Technical Publication T9074-AS-GIB-010/271, Nondestructive Testing Requirements for Metals
1.3.2 Manufacture

1.3.2(a) Steel Making  When specified, the primary melting (including vacuum induction melting) may incorporate separate degassing or refining and may be followed by secondary melting using electroslag remelting (ESR), or vacuum arc remelting (VAR).

1.3.2(b) Bored Ingots  The centerline hole of bored ingots is to include the centerline of the ingot. The wall thickness of a bored ingot is to be reduced to at least 50% during forging, or alternatively, the reduction of area is to be not less than 3:1.

1.3.2(c) Heat Treatment  Grade 4C forging may be quenched and tempered. For all tempering heat treatments to all grades, the tempering temperature is not to be less than 565°C (1050°F). A stress relief may be applied after final machining. In this case, the stress relief temperature is to be at least 28°C (50°F) below that of the tempering temperature.

1.3.2(d) Thermal Cutting  No thermal cutting is permitted after final heat treatment and inspection of the forging.

1.3.2(e) Hot Rolled Bars  Unless otherwise specified, hot rolled bars may not be used in lieu of forgings; bar shapes are to be forged and furnished in the normalized and tempered condition.

1.3.3 Chemical Composition

An analysis of each heat (ladle analysis), and an analysis of each forging (product analysis) or lot are to be made to determine the percentages of the elements specified. The chemical composition thus determined is to conform to the requirements for the grade shown.

**TABLE 1**

**Chemical Composition (1), in percent**

<table>
<thead>
<tr>
<th>Element</th>
<th>Grade 2</th>
<th>Grade 4C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.30</td>
<td>0.44</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.10 to 0.30</td>
<td>0.10 to 0.30</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.25</td>
<td>-----</td>
</tr>
<tr>
<td>Chromium</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Copper</td>
<td>0.25</td>
<td>-----</td>
</tr>
</tbody>
</table>

*Note:*

1. Single values are maxima, unless noted.

1.3.4 Tension Properties

All forgings are to have a maximum tensile strength of 620 N/mm² (63 kgf/mm², 90 ksi). Grade 4C forgings are to have a minimum yield strength of 310 N/mm² (32 kgf/mm², 45 ksi). For determining the number of tension tests, the size demarcation between a small forging and an intermediate-sized forging is 455 kg (1000 lb).

1.3.5 Hardness Properties

Hardness properties are not required to be determined.
1.3.6 Impact Properties
When specified, a Charpy V-notch impact test is to be carried out in accordance with ASTM A370 for each forging which is tension tested. Longitudinal specimens are to be removed at least one inch below the surface from the top prolongation and machined with the notch perpendicular to the surface in accordance with 2-1-1/Figure 2. The material is to meet the following requirements:

**TABLE 2**
**Charpy V-notch Impact Properties (1)**

<table>
<thead>
<tr>
<th>Grades</th>
<th>Absorbed Energy, in J (kgf-m, ft-lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>20 (2.0, 15)</td>
</tr>
<tr>
<td>4C</td>
<td>20 (2.0, 15)</td>
</tr>
</tbody>
</table>

*Note:* 1 Test temperature is -12C (10F).

1.3.7 Inspection
Each forging is to be magnetic particle inspected in accordance with S18 of ASTM A788.

1.3.8 Ultrasonic Inspection
When specified, each forging is to be ultrasonically examined in accordance with NAVSEA Technical Publication T9074-AS-GIB-010/271, Nondestructive Testing Requirements for Metals, using axial and radial scanning. The presence of indications in excess of the calibration standard is cause for rejection of the forging.

1.3.9 Marking
Additional marking is to include the heat number, the forging number, and the heat treatment lot number. Forgings weighing more than 113 kg (250 lb) are also to be marked with the drawing number or die number.

1.3.10 Part Numbers
Information for part numbers in MIL-S-24093/2 is found in the cancellation notice.

1.3.11 Ordering Data
Procurement documents are to list the following items with appropriate requirements specified:

1. Specify title and number of ABS specification.
2. Specify ABS grade, 2-13-7/1.1.
3. Specify ASTM specification and class.
4. Specify a special melting practice, 2-13-7/1.3.2(a), if required.
5. Specify whether continuous casting is prohibited.
6. Specify virgin raw materials, if required.
7. Specify heat treatment, 2-13-7/1.3.2(c).
8. Specify transverse tension test, if required.
9. Specify form, dimensions, and tolerances or reference drawing number.
10. Specify level of preservation, packaging and packing required and applicable specifications and standards, if required.
Part 2 Supplementary Requirements for Naval Vessels
Chapter 13 Materials for Machinery, Boilers, Pressure Vessels and Piping
Section 7 Steel Machinery Forgings

11 Specify ABS certification, if required.
12 Specify Charpy V-notch impact testing, 2-13-7/1.3.6, if required.
13 Specify ultrasonic testing, 2-13-7/1.3.8, if required.
14 Specify alternative ultrasonic testing acceptance criteria, 2-13-7/1.3.8, if required.

1.3.12 Class of Ordering Data

This ordering data has been classified to establish the minimum requirements for different applications. Class 1 requirements and ordering data are to be specified on every order unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are not required unless specifically required by the contract or drawing.

Class 1: Items 1 to 10 in 2-13-7/1.3.11 are Class 1.
Class 2: Items 11 to 14 in 2-13-7/1.3.11 are Class 2.

1.3.13 Superseded Specifications

The ABS grades shown below supersede the indicated specification grades.

<table>
<thead>
<tr>
<th>ABS Rule Grades</th>
<th>ASTM Designation</th>
<th>MIL-S-24093A(SH) Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>A668 Class B</td>
<td>H</td>
</tr>
<tr>
<td>4C</td>
<td>A668 Class E</td>
<td>G</td>
</tr>
<tr>
<td>4C</td>
<td>A668 Class E</td>
<td>F</td>
</tr>
</tbody>
</table>

7 General Shipboard Alloy Steel Forgings

7.1 Scope

The following specification covers five grades of 255 mm (10 in) or smaller alloy steel forgings, designated A11, A12, A13, A14, and A15. The five grades may be produced to chemical composition requirements designated by a grade-suffix, A, B, and C, as indicated. When the end use is for a U.S. Naval Ship, ABS grades of alloy steel forgings are to be produced in accordance with the requirements in 2-3-7/7 together with the modifying requirements in 2-13-7/7 (Note: These supplementary requirements are intended to replace MIL-S-24093A (SH).)

7.3 Supplementary Requirements for Naval Ships

Alloy steel forgings are to be produced, tested, inspected and certified in accordance with ASTM A668 and A788 as modified by 2-3-7/7 and the following supplementary requirements. Requirements in 2-3-7/7 that are different than the ASTM requirements are listed for reference:

2-3-7/7.1.1 General
2-3-7/7.3.1 Marking
2-3-7/7.7.1 Tensile Properties
2-3-7/7.9 Test Specimens
2-3-7/7.11 Number and Location of Tests
7.3.1 Reference Documents

The following documents, of the issue in effect on the date of the material purchase, form a part of this specification to the extent referenced herein:

- ASTM A668 Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
- ASTM A788 Standard Specification for Steel Forgings, General Requirements
- ASTM A370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products
- NAVSEA Technical Publication T9074-AS-GIB-010/271, Nondestructive Testing Requirements for Metals

7.3.2 Manufacture

7.3.2(a) Steel Making  When specified, the primary melting (including vacuum induction melting) may incorporate separate degassing or refining and may be followed by secondary melting using electroslag remelting (ESR), or vacuum arc remelting (VAR).

7.3.2(b) Bored Ingots  The centerline hole of bored ingots is to include the centerline of the ingot. The wall thickness of a bored ingot is to be reduced to at least 50% during forging, or alternatively, the reduction of area is to be not less than 3:1.

7.3.2(c) Heat Treatment  All forging grades may be normalized and tempered. The tempering temperature is not to be less than the following. A stress relief may be applied after final machining. In this case, the stress relief temperature is to be at least 28C (50F) below that of the tempering temperature.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Temperature, in C (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A11</td>
<td>565 (1050)</td>
</tr>
<tr>
<td>A12</td>
<td>565 (1050)</td>
</tr>
<tr>
<td>A13</td>
<td>565 (1050)</td>
</tr>
<tr>
<td>A14</td>
<td>540 (1000)</td>
</tr>
<tr>
<td>A15</td>
<td>510 (950)</td>
</tr>
</tbody>
</table>

7.3.2(d) Thermal Cutting  No thermal cutting is permitted after final heat treatment and inspection of the forging.

7.3.2(e) Hot Rolled Bars  Hot roll processing may be used in lieu of forging for grade A14 bars not more than 50 mm (2 in) in size and heat treated to a normalized and tempered condition.

7.3.3 Chemical Composition

An analysis of each heat (ladle analysis), and an analysis of each forging (product analysis) or lot are to be made to determine the percentages of the elements specified. The chemical composition thus determined is to conform to the requirements for one of the following grade-suffix; ie A, B, or C. The permissible combinations of forging strength and chemical composition are represented by the grade-suffix as follows: A11A, A11B, A11C, A12A, A12B, A12C, A13A, A13B, A14A, A14B, and A15A.
TABLE 4
Chemical Composition (1), in percent

<table>
<thead>
<tr>
<th>Element</th>
<th>Grade AXAXA</th>
<th>Grade AXXB</th>
<th>Grade AXXC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.44</td>
<td>0.44</td>
<td>0.40</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.90</td>
<td>1.10</td>
<td>0.85</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.20 to 0.35</td>
<td>0.20 to 0.35</td>
<td>0.20 to 0.35</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
</tr>
<tr>
<td>Nickel</td>
<td>1.65 to 2.00</td>
<td>-----</td>
<td>3.25 to 3.75</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.70 to 0.95</td>
<td>0.80 to 1.10</td>
<td>-----</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.20 to 0.30</td>
<td>0.15 to 0.25</td>
<td>-----</td>
</tr>
</tbody>
</table>

Note
1. Single values are maxima, unless noted.

7.3.4 Tension Properties
The tension properties for forgings of any size, cross-section and critical thickness are to comply with the tension properties required for forgings of size less than 100 mm (4 in). For determining the number of tension tests, the size demarcation between a small forging and an intermediate-sized forging is 455 kg (1000 lb).

7.3.5 Hardness Properties
Hardness properties are not required to be determined.

7.3.6 Impact Properties
When specified, a Charpy V-notch impact test is to be carried out in accordance with ASTM A370 for each forging which is tension tested. Longitudinal specimens are to be removed at least one inch below the surface from the top prolongation and machined with the notch perpendicular to the surface in accordance with 2-1-1/Figure 2. The material is to meet the following requirements:

TABLE 5
Charpy V-notch Impact Properties (1)

<table>
<thead>
<tr>
<th>Grades</th>
<th>Absorbed Energy, in J (kgf-m, ft-lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A11, A12, A13</td>
<td>40 (4.1, 30)</td>
</tr>
<tr>
<td>A14, A15</td>
<td>20 (2.0, 15)</td>
</tr>
</tbody>
</table>

Note
1. Test temperature is -12C (10F).

7.3.7 Inspection
Each forging is to be magnetic particle inspected in accordance with S18 of ASTM A788.

7.3.8 Ultrasonic Inspection
When specified, each forging is to be ultrasonically examined in accordance with NAVSEA Technical Publication T9074-AS-GIB-010/271, Nondestructive Testing Requirements for Metals, using axial and radial scanning. The presence of indications in excess of the calibration standard is cause for rejection of the forging.
7.3.9 Marking
Additional marking is to include the grade-suffix, the heat number, the forging number, and the heat treatment lot number. Forgings weighing more than 113 kg (250 lb) are also to be marked with the drawing number or die number.

7.3.10 Part Numbers
Information for part numbers in MIL-S-24093/1 and MIL-S-24093/3 is found in the cancellation notice.

7.3.11 Ordering Data
Procurement documents are to list the following items with appropriate requirements specified:

1. Specify title and number of ABS specification.
2. Specify ABS grade and suffix, 2-13-7/7.3.3.
3. Specify ASTM specification and class.
4. Specify a special melting practice, 2-13-7/7.3.2(a), if required.
5. Specify whether continuous casting is prohibited.
6. Specify virgin raw materials, if required.
7. Specify heat treatment, 2-13-7/7.3.2(c).
8. Specify transverse tension test, if required.
9. Specify form, dimensions, and tolerances or reference drawing number.
10. Specify level of preservation, packaging and packing required and applicable specifications and standards, if required.
11. Specify ABS certification, if required.
12. Specify Charpy V-notch impact testing, 2-13-7/7.3.6, if required.
13. Specify ultrasonic testing, 2-13-7/7.3.8, if required.
14. Specify alternative ultrasonic testing acceptance criteria, 2-13-7/7.3.8, if required.

7.3.12 Class of Ordering Data
This ordering data has been classified to establish the minimum requirements for different applications. Class 1 requirements and ordering data are to be specified on every order unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are not required unless specifically required by the contract or drawing.

Class 1: Items 1 to 10 in 2-13-7/7.3.11 are Class 1.
Class 2: Items 11 to 14 in 2-13-7/7.3.11 are Class 2.
7.3.13 Superseded Specifications
The ABS grades shown below supersede the indicated specification grades.

<table>
<thead>
<tr>
<th>ABS Rule Grades</th>
<th>ASTM Designation</th>
<th>MIL-S-24093A(SH) Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>A11</td>
<td>A668 Class J</td>
<td>E</td>
</tr>
<tr>
<td>A12</td>
<td>A668 Class K</td>
<td>D</td>
</tr>
<tr>
<td>A13</td>
<td>A668 Class L</td>
<td>C</td>
</tr>
<tr>
<td>A14</td>
<td>A668 Class M</td>
<td>B</td>
</tr>
<tr>
<td>A15</td>
<td>A668 Class N</td>
<td>A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ABS Rule Grade-Suffix</th>
<th>MIL-S-24093A(SH) Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>AXXA</td>
<td>I</td>
</tr>
<tr>
<td>AXXB</td>
<td>II</td>
</tr>
<tr>
<td>AXXC</td>
<td>III</td>
</tr>
</tbody>
</table>
PART 2

CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 12 Steel Piping

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PART 2

CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 12 Steel Piping

1 Scope

The following specifications cover five grades of steel pipe designated 4, 5, 11, 13, and 14, and ten grades of austenitic stainless steel. When the end use is for a U.S. Naval Ship, ABS grades of steel pipe are to be produced in accordance with the requirements in Section 2-3-12 together with the modifying requirements in 2-13-12/3. (Note: These supplementary requirements are intended to replace MIL-P-24691, MIL-P-24691/1, MIL-P-24691/2, and MIL-P-24691/3.)

3 Supplementary Requirements for Naval Ships

Steel pipe is to be produced, tested, inspected and certified in accordance with ASTM A106, ASTM A312, ASTM A335 and ASTM A530, including section 26 (Government Procurement) as modified by Section 2-3-12 and the following supplementary requirements. Austenitic stainless steel pipe is to comply with the following supplementary requirements

3.1 Referenced Documents

The following documents of the issue in effect on the date of the solicitation form a part of this specification to the extent referenced herein.

- ASTM A312 Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes
- ASTM A335 Standard Specification for Seamless Ferritic Alloy-Steel Pipe for High Temperature Service
- ASTM A530 Standard Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe
- ASTM E213 Standard Practice For Ultrasonic Examination of Metal Pipe and Tubing
- NAVSEA Technical Publication S9074-AR-GIB-010/278, Requirements for Fabrication, welding and Inspection and Casting Inspection and Repair for Machinery, Piping and Pressure Vessels
3.3 Tube

Section 2-3-12 does not cover tubing. The ASTM specifications listed below together with 2-13-12/3.9 Ordering Data requirements are to be used.

<table>
<thead>
<tr>
<th>MIL Specification Number Code</th>
<th>ASTM Specification Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>M24691/1</td>
<td>A106</td>
</tr>
<tr>
<td>M24691/2</td>
<td>A335</td>
</tr>
<tr>
<td>M24691/3*</td>
<td>A312</td>
</tr>
</tbody>
</table>

* see 2-13-12/3.13

3.5 Sampling for Flattening and Flaring Test and for Visual and Dimensional Examination

The sampling plan in ASTM A530 section 26.1.3 is to be invoked only when specified in 2-13-12/3.9.

3.7 Stainless Steel

Section 2-3-12 does not cover stainless steel pipe or tubing. Stainless steel pipe and tube are to be in accordance with ASTM A312, together with 2-13-12/3.9 Order Data requirements. The grade designation is the same as the corresponding ASTM grade designation. Additional requirements are listed below.

3.7.1 Intergranular Corrosion Test

Corrosion test sampling is to be the same as sampling for tension test in accordance with ASTM A312. Corrosion test method is to be in accordance with ASTM A312, Supplementary Requirement S7.

3.7.2 Flattening Test

Flattening test sampling is to be in accordance with ASTM A312. Flattening test method is to be in accordance with ASTM A312, Supplementary Requirement S3 except for sampling.

3.7.3 Ultrasonic Inspection

When specified, each pipe and tube in each lot is to be inspected. Testing is to be in accordance with ASTM A530, section 26, and ASTM E213. The calibration standard is to have two longitudinal notches. One longitudinal notch is to be on the inside surface and one on the outside surface. Pipe or tube producing a signal equal to or greater than the calibration defect is to be subject to rejection. When each pipe or tube is subjected to an approved nondestructive electric test as a regular procedure during the process of manufacture, and affidavit covering this test may be accepted by the Surveyor.

3.9 Ordering Data

Procurement documents are to list the following items with appropriate requirements specified.

1. Specify title and number of ABS specification.
2. Specify ABS grade, if any.
3. Specify applicable ASTM specification and ASTM grade.
4. Specify whether pipe or tube required.
5 Specify nominal pipe size and schedule for pipe and nominal outside diameter and wall thickness for tube.

6 Specify whether stainless steel to be seamless or welded.

7 Specify levels of preservation, packaging and packing required and applicable specifications and standards.

8 Specify special sampling plan in ASTM A530 section 26.1.3 is required.

9 Specify if special identification marking is required.

10 Specify if ABS certification is required.

11 Specify if special marking for shipment required.

12 Specify if ultrasonic inspection required.

13 Specify if ultrasonic inspection is required as specified in 2-13-12/3.5.

14 Specify additional data certification requirements, if any.

15 Specify identification marking to ensure heat traceability for P-1 systems.

3.11 Class of Ordering Data

This ordering data has been classified to establish the minimum requirements for different applications. Class 1 requirements and ordering data are to be specified on every order unless specifically excluded in the contract or drawing. Class 2 ordering requirements and ordering data are to be specified on all orders used in P1 piping applications (P1 - as defined in NAVSEA Technical Publication S9074-AR-GIB-010/278) unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are not required for all orders used in non-P1 piping systems unless specifically required by the contract or drawing. Class 3 requirements and ordering data are not required unless specifically required by the contract or drawing.

Class 1: Items 1 to 7 in 2-13-12/3.9 are Class 1.

Class 2: Items 8 and 9 in 2-13-12/3.9 are Class 2.

Class 3: Items 10 to 15 in 2-13-12/3.9 are Class 3.

3.13 Superseded Specifications

The ABS grades shown below supersede the indicated specification grades.

M24691/1 P 12 A 040

Pipe schedule/Tube wall thickness*
Material grade code
Nominal pipe size**/Nominal tube outside diameter**
Pipe(P)/Tube (T)***
Specification Number Code

* Tube wall thickness in thousandths of an inch
** Size and outside diameter in eighths of an inch
*** See 2-13-12/3.3 for tube
<table>
<thead>
<tr>
<th>Number Code</th>
<th>Grade Code</th>
<th>ASTM Grade</th>
<th>ABS MW 2-13-12 Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIL-S-24691</td>
<td>A</td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td>M24691/1</td>
<td>B</td>
<td>B</td>
<td>5</td>
</tr>
<tr>
<td>M24691/2</td>
<td>C</td>
<td>P11</td>
<td>11</td>
</tr>
<tr>
<td>M24691/2</td>
<td>D</td>
<td>P22</td>
<td>13</td>
</tr>
<tr>
<td>M24691/2</td>
<td>E</td>
<td>P5</td>
<td>14</td>
</tr>
<tr>
<td>M24691/3</td>
<td>F</td>
<td>TP304</td>
<td>TP304</td>
</tr>
<tr>
<td>M24691/3</td>
<td>G</td>
<td>TP304L</td>
<td>TP304L</td>
</tr>
<tr>
<td>M24691/3</td>
<td>H</td>
<td>TP304N</td>
<td>TP304N</td>
</tr>
<tr>
<td>M24691/3</td>
<td>J</td>
<td>TP316</td>
<td>TP316</td>
</tr>
<tr>
<td>M24691/3</td>
<td>K</td>
<td>TP316L</td>
<td>TP316L</td>
</tr>
<tr>
<td>M24691/3</td>
<td>L</td>
<td>TP316N</td>
<td>TP316N</td>
</tr>
<tr>
<td>M24691/3</td>
<td>M</td>
<td>TP317</td>
<td>TP317</td>
</tr>
<tr>
<td>M24691/3</td>
<td>N</td>
<td>TP317L</td>
<td>TP317L</td>
</tr>
<tr>
<td>M24691/3</td>
<td>P</td>
<td>TP321</td>
<td>TP321</td>
</tr>
<tr>
<td>M24691/3</td>
<td>Q</td>
<td>TP347</td>
<td>TP347</td>
</tr>
</tbody>
</table>
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CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 14 Nickel-Aluminum Bronze Castings

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CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 14 Nickel-Aluminum Bronze Castings

1 Scope

The following specifications cover one grade of bronze intended for propeller castings and intended for general application seawater static castings and centrifugal castings. When the end use is for a U.S. Naval Ship, ABS Type 4 bronze castings are to be produced in accordance with the requirements in Section 2-3-14 together with the modifying requirements in 2-13-14/3. (Note: These supplementary requirements are intended to replace MIL-B-24480A.)

3 Supplementary Requirements for Naval Ships

Nickel-aluminum bronze castings shall be produced, tested, inspected and certified in accordance with ASTM B148 including supplementary requirements S4 and S7, and ASTM B271 as modified by Section 2-3-14 and the following supplementary requirements.

3.1 Referenced Documents

The following documents of the issue in effect on the date of the material purchase form a part of this specification to the extent referenced herein.

- ASTM B271 Standard Specification for Copper Base Alloy Centrifugal Castings
- ASTM B208 Practice for Preparing Tension Test Specimens for Copper Based Alloys for Sand, Permanent Mold, Centrifugal, and Continuous Castings
- DOD-STD-2185 Requirements for Repair and Straightening Of Bronze Naval Ship Propellers
- MIL-STD-2035 Nondestructive Testing Acceptance Criteria
- NAVSEA T9074-AS-GIB-010/271, Requirements For Nondestructive Testing Methods
- NAVSEA S9074-AQ-GIB-010/248, Requirements For Welding and Brazing Procedure and Performance Qualification.
- NAVSEA Technical Publication S9074-AR-GIB-010/278, Requirements For Fabrication Welding and Inspection, and Casting Inspection and Repair For Machinery, Piping, and Pressure Vessels
3.3 **Chemical Composition**

The chemical composition is to meet the requirements of 2-13-14/Table 1. A check analysis is to be carried out for the finished propeller casting.

3.5 **Tensile Properties**

The tensile properties are to be determined by testing specimens removed from separately cast keel block castings. If more than one ladle is used to pour the casting, a single test specimen is to be removed and tested from each ladle pour. The tension specimen is to be in accordance with 2-3-1/Figure 2 and the results are to meet the requirements of 2-13-14/Table 2.

3.7 **Heat Treatment**

All castings that are intended for use in application other than propellers are to be heat treated (temper anneal) at 675°C ±10°C (1250°F ±50°F) for 6 hours, minimum. Weld repaired castings are to be post weld heat treated at 675°C ±10°C (1250°F ±50°F) for 6 hours, minimum. In all cases, cooling should be as fast as practicable. Propellers are not required to be heat treated.

3.9 **First Article Inspection**

When specified, a first article inspection is to be carried out to validate the casting properties and the manufacturing process. Foundry practices are to be recorded and to serve as a base-line for production. Where production practices are modified from the baseline, first article inspection may be required. Prior to invoking a first article retest, the seller and customer are to agree to the extent of process changes allowed. Unless otherwise specified, a first article inspection is to include mechanical testing from high-stressed areas of the castings, and is to include radiographic examination in accordance with NAVSEA T9074-AS-GIB-010/271, and meet the acceptance criteria specified in NAVSEA S9074-AR-GIB-010/278, and shown in 2-13-14/Table 3a and 2-13-14/Table 3b.

3.11 **Hydrostatic Test**

When specified, pressure containing castings are to be tested in accordance with associated specification, or in accordance with the appropriate material, system or equipment specifications.

3.13 **Welding Repair to Castings**

All welding repair to castings, other than propellers, are to be in accordance with Part 2, Chapter 4. Propeller weld procedures and welding operators are to be qualified in accordance with NAVSEA S9074-AQ-GIB-010/248 except that there is no lower material thickness limit for test plate qualified, there is no upper thickness limit for test plate thicknesses 38.1 mm (11/2 in) or greater, and the acceptance criteria for the tensile test is to be 72,000 psi. Propellers are to be welded in accordance with DOD-STD-2185.

3.15 **Nondestructive Examination**

Unless otherwise specified, propellers are to be inspected in accordance with 2-3-14/3.21. All finished propeller surfaces, regardless of propeller size, are to be visually and liquid penetrant inspected in accordance with NAVSEA T9074-AS-GIB-010/271. Unless otherwise specified, the acceptance criteria is to be in accordance with MIL-STD-2035. Castings intended for applications other than propellers or propeller blades are to be inspected in accordance with NAVSEA T9074-AS-GIB-010/271, and meet the acceptance criteria specified in NAVSEA S9074-AR-GIB-010/278, and shown in 2-13-14/Table 3a and 2-13-14/Table 3b, or are to be inspected in accordance with the purchase order.
3.17 Finish and Workmanship

The surface of the casting is to be free of adhering sand, cracks and hot tears. Other surface discontinuities are to meet visual acceptance standards agreed upon between manufacturer and purchaser. Propellers are to conform to 2-3-14/3 requirements as modified herein.

3.19 Dimensions

The manufacturer is responsible for the dimensional accuracy of the castings. When specified, the Surveyor is to verify that the manufacturer confirmed the final dimensions and recorded the inspections.

3.21 Sampling

When specified, sample pieces are to be selected at random in accordance with the table below for the visual, nondestructive and dimensional examinations.

<table>
<thead>
<tr>
<th>Number of Pieces in Lot</th>
<th>Number of Sample Pieces to be Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 8</td>
<td>Entire Lot</td>
</tr>
<tr>
<td>9 to 90</td>
<td>8</td>
</tr>
<tr>
<td>91 to 150</td>
<td>12</td>
</tr>
<tr>
<td>151 to 280</td>
<td>19</td>
</tr>
<tr>
<td>281 to 500</td>
<td>21</td>
</tr>
<tr>
<td>501 to 1,200</td>
<td>27</td>
</tr>
<tr>
<td>1,201 to 3,200</td>
<td>35</td>
</tr>
<tr>
<td>3,201 to 10,000</td>
<td>38</td>
</tr>
<tr>
<td>10,001 to 35,000</td>
<td>46</td>
</tr>
</tbody>
</table>

If one or more sample pieces fail any test or examination, then the lot that it represents is to be rejected. For non-destructive testing, if a lot is rejected as a result of sample tests, then each piece in the lot may be tested and those which pass may be accepted. Tension test bars used in chemical, hardness and tensile requirements may be either separately cast or removed from a casting as agreed upon between the manufacturer and purchaser. Propellers are to receive a 100% sampling.

3.23 Marking

Marking for castings intended for applications other than propellers and propeller blades is to be in accordance with ASTM B148. Propellers are to be marked in accordance with the applicable drawing notes with additional markings, if any, required by the purchaser.

3.25 Ordering Data

Procurement documents are to list the following items with appropriate requirements specified:

1. Specify title and number of ABS specification.
2. Specify ABS Type and UNS alloy number.
3. Specify ASTM specification and grade.
5. Specify dimensional inspection methods and tolerances or reference a drawing number.
6. Specify level of preservation, packaging and packing required and applicable specifications and standards.

7. Specify identification marking, including lot identification marking, if required.

8. Specify special marking for shipment, if any.

9. Specify hydrostatic testing, 2-13-14/3.11, if required.

10. Specify if ABS certification, if required.

11. Specify special sampling plan for visual and dimensional inspection, 2-13-14/3.21, if required. This plan is not to be specified for propellers.

12. Specify additional data requirements, if required.

13. Specify check chemical analysis on finished or semi-finished products, 2-13-14/3.3, if required.

14. Specify criticality level of NAVSEA S9074-AR-GIB-010/278 for nondestructive testing.

15. Specify NDT alternate methods to NAVSEA S9074-AR-GIB-010/278, 2-13-14/3.15, if required.

16. Specify NDT acceptance criteria alternates to NAVSEA S9074-AR-GIB-010/278, 2-13-14/3.15, if required.

### 3.27 Class of Ordering Data

This ordering data has been classified to establish the minimum requirements for different applications. Class 1 requirements and ordering data are to be specified on every order unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are not required unless specifically required by the contract or drawing.

**Class 1:** Items 1 to 9 in 2-13-14/3.25 are Class 1.

**Class 2:** Items 10 to 15 in 2-13-14/3.25 are Class 2.

### 3.29 Superseded Specifications

The ABS bronze type 4 supersedes MIL-B-21230, Alloy 1 and MIL-B-24480.
### TABLE 1
**Chemical Composition**

<table>
<thead>
<tr>
<th>Element</th>
<th>Content, in percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>79.0 min.</td>
</tr>
<tr>
<td>Nickel (1), (2)</td>
<td>4.0 to 5.0</td>
</tr>
<tr>
<td>Aluminum</td>
<td>8.5 to 9.5</td>
</tr>
<tr>
<td>Iron (2)</td>
<td>3.5 to 4.5</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.8 to 1.5</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.10 max.</td>
</tr>
<tr>
<td>Lead</td>
<td>0.03 max.</td>
</tr>
<tr>
<td><strong>Total (Cu, Ni, Al, Fe, Mn)</strong></td>
<td><strong>95.5 min</strong></td>
</tr>
</tbody>
</table>

**Notes**
1. Includes cobalt.
2. Iron content is not to exceed the nickel content.

### TABLE 2
**Tensile Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength, in N/mm² (kgf/mm², psi)</td>
<td>586 (60, 85,000)</td>
</tr>
<tr>
<td>Yield Strength (1), in N/mm² (kgf/mm², psi)</td>
<td>241 (25, 35,000)</td>
</tr>
<tr>
<td>Elongation (2), in percent</td>
<td>15</td>
</tr>
</tbody>
</table>

**Notes**
1. Yield strength is to be determined as the stress producing an elongation under load of 0.5%.
2. Elongation gage length is 50.8 mm (2 in); specimen is 2-3-1/Figure 2.
### TABLE 3a

**Category 1, Non-pressure Containing Castings in Machinery or Pressure Vessels**

*(Does not apply to turbine parts or propulsion reduction gears.)*

<table>
<thead>
<tr>
<th>Cat</th>
<th>Application Rules</th>
<th>Stress Due to (2)</th>
<th>Stress Level, percentage of yield</th>
<th>NDT Requirements</th>
<th>Sub Cat</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Castings which by failure of any one casting would prevent normal steering, diving or propulsion and for which there is no standby capability (1)</td>
<td>Dynamic loads</td>
<td>All</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>High Impact Shock Grade A</td>
<td>&gt; 2/3</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>&lt; 2/3</td>
<td>--</td>
<td>X</td>
<td>X</td>
<td>A3</td>
</tr>
<tr>
<td></td>
<td>Static loads</td>
<td>All</td>
<td>--</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>B</td>
<td>Castings which by failure of any one casting would reduce the capability of the ship to launch, land or transfer aircraft between flight and hanger decks</td>
<td>Dynamic Loads</td>
<td>All</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>High Impact Shock Grade A</td>
<td>&gt; 2/3</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>&lt; 2/3</td>
<td>--</td>
<td>X</td>
<td>X</td>
<td>B3</td>
</tr>
<tr>
<td></td>
<td>Static Loads</td>
<td>All</td>
<td>--</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>C</td>
<td>Castings for weapons handling systems, which by failure of any one casting would: (a) Result in dropping or damaging a weapon or (b) Result in reduction of weapons service to any space or aircraft by 50% or more</td>
<td>Dynamic Loads</td>
<td>All</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>High Impact Shock Grade A</td>
<td>&gt; 2/3</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>&lt; 2/3</td>
<td>--</td>
<td>X</td>
<td>X</td>
<td>C3</td>
</tr>
<tr>
<td></td>
<td>Static Loads</td>
<td>All</td>
<td>--</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>D</td>
<td>Other than A, B and C</td>
<td>Dynamic Loads or High Impact Shock Grade A (2)(3)</td>
<td>&gt; 2/3</td>
<td>Wt &gt; 100 lb</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 2/3</td>
<td>Wt &lt; 100 lb</td>
<td>--</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>D3</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>--</td>
<td>--</td>
<td>X</td>
<td>D4</td>
</tr>
</tbody>
</table>

**Notes**

1. Ship propellers are to be subject to VT with PT used only as an aid in locating discontinuities. RT is not required.
2. For purposes of clarification, castings stressed by dynamic loads are castings with areas designed for normal service dynamic loads of a degree and frequency that such loads are used in the strength equations to determine dimensions of the area.
3. Includes static or dynamic loaded castings in weight handling equipment where stress levels under maximum test conditions exceed 2/3 of yield strength of the material.
### TABLE 3b
**Category 2, Pressure Containing Castings**  
**Machinery or Pressure Vessel Castings**

<table>
<thead>
<tr>
<th>Application Rules</th>
<th>Pressure (lb/in²) (1)</th>
<th>Size (2) (inches)</th>
<th>NDT Requirements (3)</th>
<th>SubCat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lethal or gasoline service</td>
<td>All</td>
<td>All</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Oxygen or hydrogen service</td>
<td>All</td>
<td>All</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Steam service</td>
<td>≥ 300</td>
<td>≥ 2 1/2</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Gas other than lethal, oxygen or hydrogen</td>
<td>≥ 1000</td>
<td>≥ 2 1/2</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Water or hydraulic service</td>
<td>300 to 1000</td>
<td>≥ 2 1/2</td>
<td>--</td>
<td>X</td>
</tr>
<tr>
<td>Special shipboard systems:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Weapons service - all ships castings for weapons handling</td>
<td>All</td>
<td>All</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>(b) Submarine service: pressure castings associated with boundary and subject to submergence pressure</td>
<td>All</td>
<td>All</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>(c) Aircraft carrier service: castings failure of which would reduce the capability to launch, transfer or land aircraft</td>
<td>All</td>
<td>≥ 2 1/2</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>(d) Combatant surface ships: castings for normal steering systems</td>
<td>All</td>
<td>≥ 2 1/2</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Castings not covered above</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>X</td>
</tr>
</tbody>
</table>

**Notes**
1. Pressure is the design pressure of the system in which the casting is to be used.
2. For machinery and pressure vessel castings the size shown is the inside diameter (or an equivalent cross sectional area).
3. For nonferrous castings PT is required only on submergence pressure boundary surfaces.
PART 2

CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 16 Seamless Copper Piping

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3.5 Eddy-current Test .......................................................... 64

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1 Scope

The following specifications cover seven grades of copper pipe designated C1, C2, C3, C4, C5, C6 and C7. When the end use is for a U.S. Naval Ship, ABS grades of copper pipe are to be produced in accordance with the requirements in Section 2-3-16 together with the modifying requirements in 2-13-16/3. (Note: These supplementary requirements are intended to replace MIL-P-24107B for copper pipe.)

3 Supplementary Requirements for Naval Ships

Copper pipe is to be produced, tested, inspected and certified in accordance with ASTM B42, including supplementary requirements S1 to S4, as modified by Section 2-3-16 and the following supplementary requirements.

3.1 Referenced Documents

The following documents of the issue in effect on the date of the material purchase form a part of this specification to the extent referenced herein.

- ASTM B42 Standard Specification for Seamless Copper Pipe, Standard Sizes
- ASTM B251 Standard Specification for General Requirements for Wrought Seamless and Copper and Copper-Alloy Tube
- ASTM E243 Standard Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes
- NAVSEA Technical Publication S9074-AR-GIB-010/278, Requirements for Fabrication welding and Inspection and Casting Inspection and Repair for Machinery, Piping and Pressure Vessels

3.3 Expansion Test

The minimum expansion of the outside diameter is to be 30 percent for pipe over $\frac{3}{4}$ inch actual size and 40 percent for smaller sized pipe.
3.5 Eddy-current Test

When specified, eddy-current testing is to be performed on each length of pipe from 1/8 to 2 1/2 NPS inclusive or within the capabilities of the eddy-current tester. Testing should be in accordance with ASTM E 243 except that “end effect” should be avoided. Calibration standard notch depth is to be 10% of the nominal wall thickness of the pipe being tested. Notch depth dimension should be calculated and then rounded to the nearest 0.025 mm (0.001 inches). Notch depth tolerance should be 0.013 mm (0.0005 inches). Alternatively, a 0.3% maximum imbalance signal may be used with speed insensitive equipment that is capable of selecting a maximum imbalance signal. Pipe that does not actuate the signaling device of the eddy-current tester is acceptable.

3.7 Sampling

When specified, sample pieces of pipe are to be selected at random in accordance with the table below for the visual and dimensional examination.

<table>
<thead>
<tr>
<th>Number of Pieces in Lot</th>
<th>Number of Sample Pieces to be Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 8</td>
<td>Entire Lot</td>
</tr>
<tr>
<td>9 to 90</td>
<td>8</td>
</tr>
<tr>
<td>91 to 150</td>
<td>12</td>
</tr>
<tr>
<td>151 to 280</td>
<td>19</td>
</tr>
<tr>
<td>281 to 500</td>
<td>21</td>
</tr>
<tr>
<td>501 to 1,200</td>
<td>27</td>
</tr>
<tr>
<td>1,201 to 3,200</td>
<td>35</td>
</tr>
<tr>
<td>3,201 to 10,000</td>
<td>38</td>
</tr>
<tr>
<td>10,001 to 35,000</td>
<td>46</td>
</tr>
</tbody>
</table>

If one or more sample pieces fail any test or examination, then the lot that it represents is to be rejected. For non-destructive testing, if a lot is rejected as a result of sample tests, then each tube in the lot may be tested and those which pass may be accepted.

3.9 Finish and Workmanship

Contaminants from lubricants used in forming, machining or other processing and marking materials used for in-process identification are to be removed from the material prior to any heat treatment. Tubing is to be bright annealed in an inert or reducing atmosphere or be cleaned after heat treating. Small defects may be removed by grinding using resin or rubber bonded wheels with 120 or finer iron-free alumina grit, machining or filing with a clean file provided the bottom radius of the repaired area is at least three times the depth of the defect and the wall thickness is not reduced below the specified minimum.

3.11 Ordering Data

Procurement documents are to list the following items with appropriate requirements specified.

1. Specify title and number of ABS specification.
2. Specify UNS alloy number.
4. Specify temper required.
5. Specify nominal or Standard Pipe Size (diameter), length and Schedule (wall thickness).
6 Specify tube required for bending.
7 Specify if tubing is to be straight lengths or coils.
8 Specify special marking for shipment, if any.
9 Specify if threaded ends required.
10 Specify level of preservation, packaging and packing required and applicable specifications and standards.
11 Specify identification marking, including lot identification, if required, if any.
12 Specify special sampling plan in 2-13-16/3.7 is required.
13 Specify if ABS certification is required.
14 Specify if special finish working or heat treatment required.
15 If pipe is for torpedo use specify that the straightness is to be the same as required for drawn tube in ASTM B251.
16 Specify if pipe is to be supplied in other than mill lengths. If so, specify lengths.
17 Specify if a hydrostatic test pressure over 69 bar (70.3 kgf/cm², 1,000 psi) is to be used. If so, specify pressure.
18 Specify if 100% eddy-current testing is required.
19 Specify identification marking to ensure heat traceability for P1 and P3a systems.
20 Specify if weld seam reinforcement tolerances are not required.

3.13 Class of Ordering Data

This ordering data has been classified to establish the minimum requirements for different applications. Class 1 requirements and ordering data are to be specified on every order unless specifically excluded in the contract or drawing. Class 2 ordering requirements and ordering data are to be specified on all orders used in P1 and P3a piping applications (As defined in NAVSEA Technical Publication S9074-AR-GIB-010/278) unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are not required for all orders used in non-P1 and P3a piping systems unless specifically required by the contract or drawing. Class 3 requirements and ordering data are not required unless specifically required by the contract or drawing.

Class 1: Items 1 to 11 in 2-13-16/3.11 are Class 1.
Class 2: Item 12 in 2-13-16/3.11 is Class 2.
Class 3: Items 13 to 20 in 2-13-16/3.11 are Class 3.

3.15 Superseded Specifications

The ABS grades shown below supersede the indicated US military specification grades.

<table>
<thead>
<tr>
<th>Rule Pipe Grade</th>
<th>MIL-T-24107B Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>C10100</td>
</tr>
<tr>
<td>C2</td>
<td>C10200</td>
</tr>
<tr>
<td>C3</td>
<td>C10300</td>
</tr>
<tr>
<td>C4</td>
<td>C10800</td>
</tr>
<tr>
<td>C5</td>
<td>C12000</td>
</tr>
<tr>
<td>C6</td>
<td>C12200</td>
</tr>
<tr>
<td>C7</td>
<td>C14200</td>
</tr>
</tbody>
</table>
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CHAPTER 13  Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 18  Seamless Copper Tubes

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CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 18 Seamless Copper Tubes

1 Scope

The following specifications cover seven grades of copper tubing designated CA, CB, CC, CD, CE, CF and CG. When the end use is for a U.S. Naval Ship, ABS grades of copper tubing are to be produced in accordance with the requirements in Section 2-3-18 together with the modifying requirements in 2-13-18/3. (Note: These supplementary requirements are intended to replace MIL-P-24107B for copper tubing.)

3 Supplementary Requirements for Naval Ships

Copper tubing is to be produced, tested, inspected and certified in accordance with ASTM B75 and ASTM B251 including supplementary requirements S1 to S4 as modified by Section 2-3-18 and the following supplementary requirements.

3.1 Referenced Documents

The following documents of the issue in effect on the date of the material purchase form a part of this specification to the extent referenced herein.

ASTM B75 Standard Specification for Seamless Copper Tubes
ASTM B251 Standard Specification for Wrought Seamless Copper and Copper-Alloy Tube
ASTM E243 Standard Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes
NAVSEA Technical Publication S9074-AR-GIB-010/278, Requirements for Fabrication welding and Inspection and Casting Inspection and Repair for Machinery, Piping and Pressure Vessels
3.3 **Eddy-current Test**

When specified, eddy-current testing is to be performed on each length of tube from 1/8 to 2 1/2 NPS inclusive or within the capabilities of the eddy-current tester. Testing should be in accordance with ASTM E 243 except that “end effect” should be avoided. Calibration standard notch depth is to be 10% of the nominal wall thickness of the tube being tested. Notch depth dimension should be calculated and then rounded to the nearest 0.025 mm (0.001 inches). Notch depth tolerance should be 0.013 mm (0.0005 inches). Alternatively, a 0.3% maximum imbalance signal may be used with speed insensitive equipment that is capable of selecting a maximum imbalance signal. Tube that does not actuate the signaling device of the eddy-current tester should be considered acceptable.

3.5 **Embrittlement Test**

The embrittlement test is to be carried out in accordance with ASTM B75.

3.7 **Sampling**

When specified, sample pieces of tube are to be selected at random in accordance with the table below for the visual and dimensional examination.

<table>
<thead>
<tr>
<th>Number of Pieces in Lot</th>
<th>Number of Sample Pieces to be Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 8</td>
<td>Entire Lot</td>
</tr>
<tr>
<td>9 to 90</td>
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<tr>
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<td>27</td>
</tr>
<tr>
<td>1,201 to 3,200</td>
<td>35</td>
</tr>
<tr>
<td>3,201 to 10,000</td>
<td>38</td>
</tr>
<tr>
<td>10,001 to 35,000</td>
<td>46</td>
</tr>
</tbody>
</table>

If one or more sample pieces fail any test or examination, then the lot that it represents is to be rejected. For non-destructive testing, if a lot is rejected as a result of sample tests, then each tube in the lot may be tested and those which pass may be accepted.

3.9 **Finish and Workmanship**

Contaminants from lubricants used in forming, machining or other processing and marking materials used for in-process identification are to be removed from the material prior to any heat treatment. Tubing is to be bright annealed in an inert or reducing atmosphere or be cleaned after heat treating. Small defects may be removed by grinding using resin or rubber bonded wheels with 120 or finer iron-free alumina grit, machining or filing with a clean file provided the bottom radius of the repaired area is at least three times the depth of the defect and the wall thickness is not reduced below the specified minimum.

3.11 **Ordering Data**

Procurement documents are to list the following items with appropriate requirements specified.

1. Specify title and number of ABS specification.
2. Specify UNS alloy number.
4 Specify temper required.
5 Specify tube size (diameter), length and wall thickness.
6 Specify tube required for bending.
7 Specify if tubing is to be straight lengths or coils.
8 Specify special marking for shipment, if any.
9 Specify if threaded ends required.
10 Specify level of preservation, packaging and packing required and applicable specifications and standards.
11 Specify identification marking, including lot identification, if required.
12 Specify special sampling plan in 2-13-18/3.7 is required.
13 Specify if ABS certification is required.
14 Specify if special finish working or heat treatment required.
15 If tube is for torpedo use specify that the straightness is to be the same as required for drawn tube in ASTM B251.
16 Specify if tube is to be supplied in other than mill lengths. If so, specify lengths.
17 Specify if a hydrostatic test pressure over 69 bar (70.3 kgf/cm², 1,000 psi) is to be used. If so, specify pressure.
18 Specify if 100% eddy-current testing is required.
19 Specify identification marking to insure heat traceability for P1 and P3a systems.
20 Specify if weld seam reinforcement tolerances are not required.

3.13 Class of Ordering Data

This ordering data has been classified to establish the minimum requirements for different applications. Class 1 requirements and ordering data are to be specified on every order unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are to be specified on all orders used in P1 and P3a piping applications (As defined in NAVSEA Technical Publication S9074-AR-GIB-010/278) unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are not required for all orders used in non-P1 and P3a piping systems unless specifically required by the contract or drawing. Class 3 requirements and ordering data are not required unless specifically required by the contract or drawing.

Class 1: Items 1 to 11 in 2-13-18/3.11 are Class 1.
Class 2: Item 12 in 2-13-18/3.11 is Class 2.
Class 3: Items 13 to 20 in 2-13-18/3.11 are Class 3.
3.15 Superseded Specifications

The ABS grades shown below supersede the indicated US military specification grades.

<table>
<thead>
<tr>
<th>Rule Tube Grade</th>
<th>MIL-T-24107B Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>C10100</td>
</tr>
<tr>
<td>CB</td>
<td>C10200</td>
</tr>
<tr>
<td>CC</td>
<td>C10300</td>
</tr>
<tr>
<td>CD</td>
<td>C10800</td>
</tr>
<tr>
<td>CE</td>
<td>C12000</td>
</tr>
<tr>
<td>CF</td>
<td>C12200</td>
</tr>
<tr>
<td>CG</td>
<td>C14200</td>
</tr>
</tbody>
</table>
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CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 19 Condenser and Heat Exchanger Tubes

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CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 19 Condenser and Heat Exchanger Tubes

1 Scope

The following specifications cover two grades of seamless copper-nickel tubes designated CNA and CNB. When the end use is for a U.S. Naval Ship, ABS grades of copper-nickel tubing are to be produced in accordance with the requirements in Section 2-3-19 together with the modifying requirements in 2-13-19/3. (Note: These supplementary requirements are intended to replace MIL-T-15005G.)

3 Supplementary Requirements for Naval Ships

Copper-nickel tube is to be produced, tested, inspected and certified in accordance with ASTM B111, including supplementary requirements S1 to S4, as modified by Section 2-3-19 and the following supplementary requirements.

3.1 Referenced Documents

The following documents of the issue in effect on the date of the material purchase form a part of this specification to the extent referenced herein.

ASTM B111 Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock Wire Nails, Spikes and Staples

ASTM E213 Standard Practice For Ultrasonic Examination of Metal Pipe and Tubing

3.3 Nondestructive Electric Test (NDET)

Each tube is to be eddy-current tested in accordance with 2-3-19/17 except the depth of the notches on the calibration standard is to be 5 percent of the wall thickness or 0.013 mm (0.005 inches), whichever is greater and there is to be one 0.061 mm (0.025 inch) diameter drilled hole in addition to the notches. The artificial discontinuities are to be separated from each other and the end of the tube by a minimum of 35 mm (1.5 inches). One notch is to be on the inside of the tube and oriented in the longitudinal direction.
3.5 Ultrasonic Testing

When specified, each tube is to be ultrasonically inspected in accordance with ASTM E213. The standard is to have two longitudinal notches. One longitudinal notch is to be on the inside surface and one on the outside surface. Each notch is to be 3 percent of the wall thickness or 0.013 mm (0.005 inches), whichever is greater. Any portion of a tube which produces an indication equal to or greater than the standard is to be rejected. Tube inspected by ultrasonic inspection is to be circumferentially gauged ultrasonically along its entire length. Tube not meeting the minimum wall thickness is to be rejected. Laminar discontinuities are to be considered to be a reduction in wall thickness.

3.7 Hydrostatic Test

Each tube is to be hydrostatic tested in accordance with 2-3-19/19. This hydrostatic testing specified is to be done in addition to any eddy-current or ultrasonic inspection that is required.

3.9 Expansion Test

The expansion test is to be done in accordance with 2-3-19/13 except the required expansion is to be 50% for the annealed temper (O61) and 35 percent for the drawn tempers (H55 and HR50).

3.11 Finish and Workmanship

Contaminants from lubricants used in forming, machining or other processing, and marking materials used for in-process identification are to be removed from the material prior to any heat treatment. Tubing is to be bright annealed in an inert or reducing atmosphere or be cleaned after heat treating.

3.13 Dimensions

Unless otherwise specified, the outer diameter tolerance is to be plus 0.0 and minus twice the tolerance permitted in 2-3-19/27.1. Tube is to be supplied to minimum wall requirements unless otherwise specified.

3.15 Sampling

When specified, sample pieces of tubing are to be selected at random in accordance with the table below.

<table>
<thead>
<tr>
<th>Number of Pieces in Lot</th>
<th>Number of Sample Pieces to be Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 8</td>
<td>Entire Lot</td>
</tr>
<tr>
<td>9 to 90</td>
<td>8</td>
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<td>91 to 150</td>
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<tr>
<td>501 to 1,200</td>
<td>27</td>
</tr>
<tr>
<td>1,201 to 3,200</td>
<td>35</td>
</tr>
<tr>
<td>3,201 to 10,000</td>
<td>38</td>
</tr>
<tr>
<td>10,001 to 35,000</td>
<td>46</td>
</tr>
</tbody>
</table>

This table is for non-destructive testing only. If one or more sample pieces fails any test or examination, then the lot that it represents is to be rejected. If a lot is rejected as a result of sample tests, then each tube in the lot may be tested and those which pass may be accepted.
3.17 Mercury Contamination

The tube is to be free of all contamination. During the manufacturing process, tests and inspections the product to be offered for acceptance is to not have come into contact with mercury or any of its compounds nor with any mercury bearing device employing a single boundary of containment.

3.19 Ordering Data

Procurement documents are to list the following items with appropriate requirements specified:

1. Specify title and number of ABS specification.
2. Specify ABS grade and UNS alloy number.
4. Specify temper required. Annealed (061) temper is to be supplied unless otherwise specified.
5. Specify wall thickness, length and outside diameter required. Specify whether wall thickness is minimum or nominal. Tube wall thickness is to be to minimum wall requirements unless otherwise specified.
6. Specify level of preservation, packaging and packing required and applicable specifications and standards.
7. Specify identification marking, including lot identification marking, if required.
8. Specify special marking for shipment, if any.
9. Specify both hydrostatic testing and eddy-current testing of all tubes is required.
10. Specify if ABS certification is required.
11. Specify if special sampling plan, 2-13-19/3.15 is required for visual and dimensional inspection
12. Specify additional data requirements, if required.
13. Specify if check chemical analysis is required on finished or semi-finished products.
14. Specify if tensile testing required.
15. Specify if ultrasonic testing required.

3.21 Class of Ordering Data

This ordering data has been classified to establish the minimum requirements for different applications. Class 1 requirements and ordering data are to be specified on every order unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are not required unless specifically required by the contract or drawing.

Class 1: Items 1 to 9 in 2-13-19/3.19 are Class 1.

Class 2: Items 10 to 15 in 2-13-19/3.19 are Class 2.

3.23 Superseded Specifications

The ABS grades shown below supersede the indicated specification grades.

<table>
<thead>
<tr>
<th>MIL-T-15005 Composition</th>
<th>ABS Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>C70600 (formerly 90-10)</td>
<td>CNA</td>
</tr>
<tr>
<td>C71500 (formerly 70-30)</td>
<td>CNB</td>
</tr>
</tbody>
</table>
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CHAPTER 13  Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 20  Copper-Nickel Tubes and Pipes

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CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 20 Copper-Nickel Tubes and Pipes

1 Scope

The following specifications cover four grades of welded and seamless copper-nickel tubes and pipes designated CN1, CN2, CN3, and CN4. When the end use is for a U.S. Naval Ship, ABS grades of copper-nickel tubing are to be produced in accordance with the requirements in Section 2-3-20 together with the modifying requirements in 2-13-20/3. (Note: These supplementary requirements are intended to replace MIL-T-16420(SH).)

3 Supplementary Requirements for Naval Ships

Copper-nickel pipe or tube is to be produced, tested, inspected and certified in accordance with ASTM B466 and ASTM B251 including supplementary requirements S1 to S4 of ASTM B467 and supplementary requirements S1 to S4 of ASTM B251, as modified by Section 2-3-20 and the following supplementary requirements.

3.1 Referenced Documents

The following documents of the issue in effect on the date of the material purchases form a part of this specification to the extent referenced herein.

- ASTM A342 Standard Test Methods for Permeability of Feebly Magnetic Materials
- ASTM B251 Standard Specification for Wrought Seamless Copper and Copper-Alloy Tube
- ASTM B466 Standard Specification for Seamless Copper-Nickel Pipe and Tube
- ASTM E213 Standard Practice For Ultrasonic Examination of Metal Pipe and Tubing
- MIL-STD-2035 Nondestructive Testing Acceptance Criteria
- NAVSEA Technical Publication T9074-AS-GIB-010/271, Nondestructive Testing Requirements for Metals
- NAVSEA Technical Publication S9074-AR-GIB-010/278, Requirements for Fabrication welding and Inspection and Casting Inspection and Repair for Machinery, Piping and Pressure Vessels
3.3 **Tension Test**

In addition to the tensile properties required in 2-3-20/11.3, seamless grades CN1 and CN2, temper O60, are to have a minimum elongation of 30%, and grade CN1, temper H55, is to have a minimum elongation of 15%.

3.5 **Tubing Schedule**

Tubing schedules are to conform with the standards in 2-13-20/Table 1.

3.7 **Tube Grade Restrictions**

Class 50 (see 2-13-20/Table 1) is to be either grade CN1 or CN3. Classes 700 and 1650 (see 2-13-20/Table 1) are to be either grade CN2 or CN4. Classes 3300 and 6000 (see 2-13-20/Table 1) are to be grade CN2 (see 2-13-20/Table 1).

3.9 **Finish and Workmanship**

Contaminants from lubricants used in forming, machining or other processing and marking materials used for in-process identification are to be removed from the material prior to any heat treatment. Tubing is to be bright annealed in an inert or reducing atmosphere or be cleaned after heat treating. Small defects may be removed by grinding using resin or rubber bonded wheels with 120 or finer iron-free alumina grit, machining or filing with a clean file provided the bottom radius of the repaired area is at least three times the depth of the defect and the wall thickness is not reduced below the specified minimum. Unless otherwise required, the outside weld reinforcement on grade CN3 and CN4 tube is to be smooth for the entire length of the tube. Unless otherwise specified the inside surface or the weld is to be flush or have a uniform reinforcing crown not to exceed 0.75 mm (1/32 inch), if the wall thickness is under 6mm (0.250 inches), 1.5 mm (1/16 inches), if the wall thickness is from 6mm (0.250 inches) to 12.5 mm (0.500 inches) and 2.3 mm (3/32 inches) if the wall thickness is 12.5 mm (0.5 inches) and over.

3.11 **Dimensions**

The outer diameter tolerance is to be plus 0.0 and minus twice the tolerance permitted in 2-3-20/27.1.

3.13 **Sampling**

When specified, visual and dimensional inspection of classes 50 and 200 (see 2-13-20/Table 1) are to be sampled at random in accordance with the table below in lieu of the sampling plan in 2-3-20/13.1, and classes 700, 1650, 3300 and 6000 (2-13-20/Table 1) are to be given 100% inspection. All other testing is to be sampled in accordance with Section 2-3-20.

<table>
<thead>
<tr>
<th>Number of Pieces in Lot</th>
<th>Number of Sample Pieces to be Taken</th>
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</thead>
<tbody>
<tr>
<td>1 to 8</td>
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<td>9 to 90</td>
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<td>91 to 150</td>
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<td>501 to 1,200</td>
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<td>1,201 to 3,200</td>
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<td>3,201 to 10,000</td>
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<tr>
<td>10,001 to 35,000</td>
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</table>
If one or more sample pieces fails any test or examination, then the lot that it represents is to be rejected. For non-destructive testing, if a lot is rejected as a result of sample tests, then each tube in the lot may be tested and those which pass may be accepted.

### 3.15 Nondestructive Examination

#### 3.15.1 Ultrasonic Testing

Each class 700 and higher tube, and class 50 and 200 tube, when required by item 15 of 2-13-20/3.25 is to be ultrasonic inspected in accordance with ASTM E213 with the additional requirement that the inspection is to be conducted in two opposite circumferential directions. The calibration standard is to have two longitudinal notches, one on the inside surface and one on the outside surface. Each notch is to be 5 percent of the wall thickness or 0.013 mm (0.005 inches), whichever is greater. Any portion of a tube which produces an indication equal to or greater than the standard is to be rejected. Tube inspected by ultrasonic inspection is to be circumferentially gauged ultrasonically every 18 inches. Tube not meeting the minimum wall thickness is to be rejected. Laminar discontinuities are to be considered to be a reduction in wall thickness. Eddy current inspection may be substituted for ultrasonic inspection for wall thickness less than 0.100 inches.

#### 3.15.2 Eddy Current (EC) Inspection

When specified for class 200 in 2-3-20/19, and when substituted for ultrasonic testing for class 700 and higher, tube with wall thickness less than 0.100 inches is to be eddy current (EC) inspected in accordance with 2-3-20/17.1 except the depth of the notches on the calibration standard is to be 5 percent of the wall thickness or 0.013 mm (0.005 inches), whichever is greater. One notch is to be on the inside of the tube and oriented in the longitudinal direction. Eddy current inspection is not permitted for wall thickness greater than 0.100 inches unless the eddy current inspection procedure is demonstrated to produce the same defect detection capability as ultrasonic inspection per 2-13-20/3.15.1. When eddy current inspection is required and not permitted, due to wall thickness, ultrasonic inspection is to be done in accordance with 2-13-20/3.15.1.

#### 3.15.3 Radiographic Inspection

Unless otherwise specified, radiographic examination of welds per NAVSEA Technical Publication T9074-AS-GIB-010/271 is required for grades CN3 and CN4. The entire seam weld of classes 700 and 1650 (see 2-13-20/Table 1) is to be radiographed. The weld seam of classes 50 and 200 (see 2-13-20/Table 1) is to be radiographed every 50 feet of the overall welding seam length. The radiographs are to meet the requirements of MIL-STD-2035, Class 1. Defects may be repaired and reradiographed and, for classes 50 and 200 (see 2-13-20/Table 1), an additional spot is to be radiographed on each side of the failing spots. Ultrasonic inspection, using a procedure and acceptance standards approved by NAVSEA, may be substituted for radiographic inspection.

### 3.17 Hydrostatic Test

When specified in 2-3-20/19 for class 50 and class 200 and when specified in item 17 of 2-13-20/3.25 for class 700 and higher, tube is to be hydrostatic tested in accordance with the requirements of 2-3-20/19 except the internal pressure for class 200 and higher is to be 150% of the maximum working pressure (see 2-13-20/Table 1). This hydrostatic testing is to be done in addition to any eddy-current or ultrasonic inspection that is required.
3.19 Inspection of Flat Stock

When specified, grade CN3 and CN4 tubes are to be fabricated from flat stock that has been ultrasonically inspected in accordance with 2-13-22/3.9.

3.21 Magnetic Permeability Test

When specified, each grade CN1 and CN3 tube is to be magnetic permeability tested per ASTM A342. The magnetic permeability is not to exceed 1.05.

3.23 Etch

Grade CN1 and CN2 tubes, produced in a mill which manufactures welded pipe that is not marked in accordance with S3 of ASTM B251 are to be etched and shown to be weld free.

3.25 Ordering Data

Procurement documents are to list the following items with appropriate requirements specified.

1. Specify title and number of ABS specification.
2. Specify ABS Grade and UNS alloy number.
4. Specify special marking for shipment, if any
5. Specify temper required.
6. Specify wall thickness, length and outside diameter required (see 2-13-20/Table 1).
7. Specify level of preservation, packaging and packing required and applicable specifications and standards.
8. Specify a semi-finished or finished product chemical analyses is required.
9. Specify identification marking, including lot identification marking, if required
10. Specify special sampling plan in 2-13-20/3.13, if required.
11. Specify identification marking to ensure heat traceability for P1 systems.
12. Specify suffix ‘M’ added to grade marking per S3 of ASTM B251.
13. Specify if ABS certification is required.
14. Specify if magnetic permeability testing required for grades CN1 and CN3 (alloy 706) tube.
15. Specify if ultrasonic inspection per 2-13-20/3.15.1 is required in place of eddy current inspection per 2-13-20/3.15.2
16. Specify if grade CN3 and CN4 tube is to be fabricated from ultrasonically inspected flat products.
17. Specify if hydrostatic pressure testing per 2-13-20/3.17 is required for class 700 or higher tube.
18. Specify special fabrication requirements, if any.
19. Specify if radiographic inspection per 2-13-20/3.15.3 of weld grade CN3 and CN4 tube is not required.
20. Specify if weld seam reinforcement tolerances are not required.
3.27 Class of Ordering Data

This ordering data has been classified to establish the minimum requirements for different applications. Class 1 requirements and ordering data are to be specified on every order unless specifically excluded in the contract or drawing. Class 2 ordering requirements and ordering data are to be specified on all orders used in P1 piping applications (P1 - as defined in NAVSEA Technical Publication S9074-AR-GIB-010/278) unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are not required for all orders used in non-P1 piping systems unless specifically required by the contract or drawing. Class 3 requirements and ordering data are not required unless specifically required by the contract or drawing.

Class 1: Items 1 to 9 in 2-13-20/3.25 are Class 1.

Class 2: Items 10 to 11 in 2-13-20/3.25 are Class 2.

Class 3: Items 12 to 20 in 2-13-20/3.25 are Class 3.

3.29 Superseded Specifications

The ABS Grades shown below supersede the indicated US military specification grades.

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<tr>
<th>MIL-T-16420</th>
<th>Composition</th>
<th>Type</th>
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### TABLE 1
Standard Tubing Schedules

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**Note**
Nonstandard tube is to be classified on the basis of its calculated working pressure and, for purposes of identifying the mandatory requirements of the specification, classified as the next lower maximum working pressure listed in this table.
PART 2

CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 21 Monel Tubes and Pipes

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PART 2

CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 21 Monel Tubes and Pipes

1 Scope

The following specification covers four grades of nickel-copper (Monel) pipe and tube, seamless and welded, designated M1, M2, M3, and M4. When the end use is for a U.S. Naval Ship, ABS grades of monel pipe and tube are to be produced in accordance with the requirements in Section 2-3-21 together with the modifying requirements in 2-13-21/3. (Note: These supplementary requirements are intended to replace MIL-T-1368.)

3 Supplementary Requirements for Naval Ships

Monel tube is to be produced, tested, inspected and certified in accordance with ASTM B165, including S1 through S4, ASTM B730, and ASTM B751 as modified by Section 2-3-21 and the following supplementary requirements. Requirements in Section 2-3-21 that are different than the ASTM requirements are listed for reference:

2-3-21/7 Marking
2-3-21/15 Flare Test
2-3-21/17 Flange Test
2-3-21/19 Number of Tests

3.1 Referenced Documents

The following documents of the issue in effect on the date of the solicitation form a part of this specification to the extent referenced herein.

ASTM B165 Standard Specification of Nickel-Copper Alloy (UNS N04400) Seamless Pipe and Tube
ASTM B725 Standard Specification for Welded Nickel (UNS N02200/UNS N02201) and Nickel Copper Alloy (UNS N04400) Pipe
ASTM B730 Standard Specification for Welded Nickel (UNS N02200/UNS N02201) and Nickel Copper Alloy (UNS N04400) Tube
3.3 Manufacture

The material used in the fabrication of the tube and pipe is to be such as to produce items that are in full conformance with chemical and physical requirements of this specification. Pipe or tube 125 mm (5 in.) and less in diameter are to be seamless. Pipe or tube larger than 125 mm (5 in.) in diameter may be seamless or may be welded. Pipe or tube is not to contain any circumferential welds. Material rejected for surface defects may be refurbished by grinding or machining and resubmitted for inspection, however, in no case is the wall thickness in way of the refurbishment to be less than that permitted by the dimensions and tolerances.

3.5 Chemical Composition

The material is to conform to the chemical requirements specified below.

<table>
<thead>
<tr>
<th>Element</th>
<th>Content (1), in percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nickel</td>
<td>63.0 min.</td>
</tr>
<tr>
<td>Copper</td>
<td>28.0 to 34.0</td>
</tr>
<tr>
<td>Iron</td>
<td>2.5</td>
</tr>
<tr>
<td>Manganese (2)</td>
<td>2.0</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.5</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.5</td>
</tr>
<tr>
<td>Carbon</td>
<td>0.2</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.015</td>
</tr>
</tbody>
</table>

Notes
1  Single values are maxima, unless noted.
2  When specified, the manganese content is to be 1.25 percent maximum

3.7 Tension Test

Grades M3 and M4 pipe or tube are to be subjected to a transverse tension test of the longitudinal weld. A tension test specimen is to be cut circumferentially from one end, straightened when hot, and machined to shape. The weld bead reinforcement is to be removed flush before testing. The resulting properties may be those of annealed material as indicated in 2-3-21/11.3.

3.9 Flattening Test

Grade M1 pipe or tube 76 mm (3 in.) and over in diameter is to be subjected to a flattening test in accordance with 2-3-21/13. The flattened specimen is to show no cracking, breaks or ruptures on any surface when viewed with the unaided eye.
3.11 Bending Test

Grade M3 pipe or tube is to be subjected to a bending test. A strip measuring approximately 38 mm (1 1/2 in.) wide by 250 mm (10 in.) long is to be circumferentially removed from the sample, hot flattened, and the weld reinforcement is to be removed from both sides of the weld. The test specimen is to be bent in a guided-bending jig in accordance with ASTM E190, Guided Bend Test for Ductility of Metals, while the root of the weld (ie ID surface) is in tension. The test specimen is to show no cracks or openings.

3.13 Tolerances

When specified, the following tolerances are to be used for dimensional examination. Note: These tolerances are intended for use with existing applications and designs.

3.13.1 Diameter

The outside diameter or inside diameter, including ovality, is to not exceed the following permissible variations.

<table>
<thead>
<tr>
<th>Nominal Outside Diameter in mm (in.)</th>
<th>Over Tolerance in mm (in.)</th>
<th>Under Tolerance in mm (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 10 (0.400)</td>
<td>0.10 (0.004)</td>
<td>0</td>
</tr>
<tr>
<td>10 (0.400) to 16 (5/8) excl.</td>
<td>0.13 (0.005)</td>
<td>0 (3)</td>
</tr>
<tr>
<td>16 (5/8) to 38 (11/2), incl.</td>
<td>0.13 (0.005)</td>
<td>0.13 (0.005)</td>
</tr>
<tr>
<td>Over 38 (1 1/2) to 114 (4 1/2), incl.</td>
<td>0.25 (0.010)</td>
<td>0.25 (0.010)</td>
</tr>
<tr>
<td>Over 114 (4 1/2) to 152 (6), incl.</td>
<td>0.38 (0.015)</td>
<td>0.38 (0.015)</td>
</tr>
<tr>
<td>Over 152 (6) to 190 (7 1/2), incl.</td>
<td>0.51 (0.020)</td>
<td>0.51 (0.020)</td>
</tr>
<tr>
<td>Over 190 (7 1/2) to 219 (8 5/8), incl.</td>
<td>0.64 (0.025)</td>
<td>0.64 (0.025)</td>
</tr>
</tbody>
</table>

Notes

1 The permissible variations in the above table apply to individual measurements, including out-of-roundness (ovality), except for the following conditions:

   Thin-Wall Pipe and Tube

   For thin-wall pipe and tube having a nominal wall thickness of 3 percent or less of the nominal outside diameter, in all conditions (temper), the mean outside diameter or mean inside diameter are to conform to the permissible variations of the above table and individual measurements (including ovality) are to conform to the plus and minus values of the table, with the values increased by 0.5 percent of the nominal outside diameter.

   Annealed Tube and Pipe over 114 mm (4-1/2 in) Nominal Outside Diameter

   For annealed tube and pipe over 114 mm (4-1/2 in) in nominal outside diameter with a nominal wall thickness greater than 3 percent of the nominal outside diameter, the mean outside diameter or mean inside diameter is to conform to the permissible variations of the above table and individual measurements are not to exceed twice the permissible variations of the above table.

2 For pipe and tube, in all tempers, with an inside diameter of less than 12.5 mm (1/2 in) which cannot be successfully drawn over a mandrel, the inside diameter is to be governed by the outside diameter and the wall thickness variations.

3 When inside diameter is specified, tubes with an inside diameter of 12.5 mm (1/2 in) or over and with an outside diameter of under 16 mm (5/8 in) are to have a permissible variation in inside diameter of plus and minus 0.13 mm (0.005 in).
3.13.2 Wall Thickness

The wall thickness is to not exceed the following permissible variations.

<table>
<thead>
<tr>
<th>Nominal Outside Diameter in mm (in.)</th>
<th>Wall Thickness $^{(1), (2), (3)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Over Tolerance in mm (in.)</td>
</tr>
<tr>
<td>Under 10 (0.400)</td>
<td>10</td>
</tr>
<tr>
<td>10 (0.400) to 16 (3/8) excl.</td>
<td>12.5</td>
</tr>
<tr>
<td>16 (5/8) to 38 (1/2), incl.</td>
<td>10</td>
</tr>
<tr>
<td>Over 38 (1/2) to 114 (41/2), incl.</td>
<td>10</td>
</tr>
<tr>
<td>Over 114 (41/2) to 152 (6), incl.</td>
<td>12.5</td>
</tr>
<tr>
<td>Over 152 (6) to 190 (71/2), incl.</td>
<td>12.5</td>
</tr>
<tr>
<td>Over 190 (71/2) to 219 (85/8), incl.</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Notes

1. For pipe and tube in all tempers with an inside diameter less than 50 percent of the outside diameter, which cannot be successfully drawn over a mandrel, the inside diameter may vary over or under by an amount equal to 10 percent of the nominal wall thickness and the wall thickness may vary plus or minus 12.5 percent.

2. Eccentricity

The variation in wall thickness in any one cross section of any one tube or pipe is not to exceed plus or minus 10 percent of the actual (measured) average wall of that section (defined as the average of the thickest and the thinnest wall in the section).

3. When minimum wall tube or pipe is required, the wall tolerance will be the total of the plus and minus wall tolerance from the table all applied to the plus side, e.g., in the case of an O.D. 10 mm (0.400 in) and under the wall tolerance would be plus 20 percent minus 0.

3.15 Silver Brazing

Tubing intended for silver brazing is not to have a diameter over tolerance. The under tolerance is to be equal to the total range of the outside diameter tolerances.

3.17 Ends

Tubing is to be furnished with sawed or machine square cut and deburred ends, unless ends beveled for welding or threaded ends are specified in the order.

3.19 Tube Bending

Tubing which is to be bent in fabricating should be ordered at a thickness sufficient to assure the required wall thickness at the thinnest point of the tube.

3.21 Nuclear Applications

When material is intended for nuclear applications, agreement is to be reached, prior to placement of the order, as to applicable non-standard or non-destructive test requirements, as well as to details of testing techniques and standards for acceptance and rejection.

3.23 Alloy Identity

Where random mill lengths are to be furnished prior to shipping the lengths are to be tested for alloy identity by a method, such as metal-sorter, check spectrograph, or wet chemical analyses.
3.25 Inspection

The contractor is responsible for the performance of all inspection requirements. The government reserves the right to perform inspection if deemed necessary. When requested, the product is to be subject to inspection by the government or the purchaser at the place of manufacture prior to shipment. The manufacturer is to afford the inspector all reasonable facilities to satisfy that the product is being furnished in accordance with the specification. All inspections and tests are to be so conducted so as not to interfere with the operations of the manufacturer.

3.27 Sampling

When specified, sample pieces of pipe and tube are to be selected at random in accordance with the table below for the visual and dimensional examinations. The table is to be used instead of the sampling table in 2-3-21/19.3.

<table>
<thead>
<tr>
<th>Number of Pieces in Lot</th>
<th>Number of Sample Pieces to be Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 8</td>
<td>Entire Lot</td>
</tr>
<tr>
<td>9 to 90</td>
<td>8</td>
</tr>
<tr>
<td>91 to 150</td>
<td>12</td>
</tr>
<tr>
<td>151 to 280</td>
<td>19</td>
</tr>
<tr>
<td>281 to 500</td>
<td>21</td>
</tr>
<tr>
<td>501 to 1,200</td>
<td>27</td>
</tr>
<tr>
<td>1,201 to 3,200</td>
<td>35</td>
</tr>
<tr>
<td>3,201 to 10,000</td>
<td>38</td>
</tr>
<tr>
<td>10,001 to 35,000</td>
<td>46</td>
</tr>
</tbody>
</table>

If one or more sample pieces fail any inspection or examination, then the lot that it represents is to be rejected. If a lot is rejected as a result of sample inspections, then each piece in the lot may be inspected and those which pass may be accepted. Rejected material may be refurbished by grinding or machining and resubmitted for inspection.

3.29 Ordering Data

Procurement documents are to list the following items with appropriate requirements specified.

1. Specify title and number of ABS specification.
2. Specify ABS grade and UNS alloy number.
4. Specify NPS schedule, or tube diameter and wall thickness (minimum or nominal).
5. Specify low manganese, 2-13-21/3.5, if required.
6. Specify special tolerances, 2-13-21/3.13, if required.
7. Specify type of end, 2-13-21/3.17.
8. Specify tube intended for silver brazing, 2-13-21/3.15, if required.
10. Specify continuous marking, if required.
11. Specify special identification marking, if any.
12. Specify lot identification marking, if required.
13 Specify special marking for shipment, if any.
14 Specify level of preservation, packaging and packing and applicable specifications and standards, if required.
15 Specify ABS certification, if required.
16 Specify special sampling plan, 2-13-21/3.27, if required.
17 Specify alloy identity check, 2-13-21/3.23, if required.
18 Specify intended for nuclear applications and special testing, 2-13-21/3.21, if required.

3.31 Class of Ordering Data

This ordering data has been classified to establish the minimum requirements for different applications. Class 1 requirements and ordering data are to be specified on every order unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are not required unless specifically required by the contract or drawing.

Class 1: Items 1 to 14 in 2-13-21/3.29 are Class 1.

Class 2: Items 15 to 18 in 2-13-21/3.29 are Class 2.

3.33 Superseded Specifications

The ABS grades shown below supersede the indicated US military specification grades.

<table>
<thead>
<tr>
<th>ABS Grade</th>
<th>ASTM Specification</th>
<th>MIL-T-1368C Class</th>
<th>MIL-T-1368B Type and Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>B165, N04400</td>
<td>Class A</td>
<td>Type I, Condition 1</td>
</tr>
<tr>
<td>M2</td>
<td>B165, N04400</td>
<td>Class B</td>
<td>Type I, Condition 2</td>
</tr>
<tr>
<td>M3</td>
<td>B730, N04400</td>
<td>Class C</td>
<td>Type II, Condition 1</td>
</tr>
<tr>
<td>M4</td>
<td>B730, N04400</td>
<td>Class D</td>
<td>Type II, Condition 2</td>
</tr>
</tbody>
</table>
PART 2

CHAPTER 13 Materials for Machinery, Boilers, Pressure Vessels and Piping

SECTION 22 Copper-Nickel Flats and Sections

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   3.23 Superseded Specifications ................................. 102
1 Scope

The following specifications cover four grades of copper-nickel flats (plate, sheet, strip, flat bar) and sections (solid bar, rod, wire) designated A1, A2, B1 and B2 for use in applications in seawater service. When the end use is for a U.S. Naval Ship, these grades of copper-nickel are to be produced in accordance with the requirements in ASTM B122 for rolled plate, sheet, strip, and bar, and the requirements of ASTM B151 for rod and wire, together with the modifying requirements in 2-13-22/3. (Note: These supplementary requirements are intended to replace MIL-C-15726F.)

1.1 ASTM Designation

The grades are in substantial agreement with ASTM as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>ASTM Designation</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>B122, UNS C70600</td>
<td>Plate, Sheet, Strip, and Bar</td>
</tr>
<tr>
<td>B1</td>
<td>B122, UNS C71500</td>
<td>Plate, Sheet, Strip, and Bar</td>
</tr>
<tr>
<td>A2</td>
<td>B151, UNS C70600</td>
<td>Rod and Wire</td>
</tr>
<tr>
<td>B2</td>
<td>B151, UNS C71500</td>
<td>Rod and Wire</td>
</tr>
</tbody>
</table>

3 Supplementary Requirements for Naval Ships

Copper-nickel flats and sections are to be produced, tested, inspected and certified in accordance with ASTM B122, ASTM B151, and S2 of ASTM B248 and ASTM B249 as appropriate as modified by the following supplementary requirements.

3.1 Referenced Documents

The following documents of the issue in effect on the date of the material purchase form a part of this specification to the extent referenced herein. In the event of a conflict between these Rules and the references cited herein, the Rules take precedence. Nothing in these Rules, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

ASTM B122 Standard Specification for Copper-Nickel-Zinc Alloy (Nickel Silver), and Copper-Nickel Alloy Plate, Sheet, Strip, and Rolled Bar

ASTM B151 Standard Specification for Copper-Nickel-Zinc Alloy (Nickel Silver), and Copper-Nickel Rod and Bar
3.3 Manufacture and Temper

The material is to be of the quality and purity necessary for the finished product to have specified properties and characteristics. The material is to be produced by hot-working or cold-working or both. Heat treatment may be used to meet the specified properties. Alternate manufacturing processes will be specially considered. The material is to be produced to the following tempers.

### Product Tempers

<table>
<thead>
<tr>
<th>Product</th>
<th>Grade A1</th>
<th>Grade B1</th>
<th>Grade A2</th>
<th>Grade B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet</td>
<td>H01 or O60</td>
<td>H01 or O60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strip</td>
<td>H01 or O60</td>
<td>H01 or O60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plate</td>
<td>M20, Hard</td>
<td>M20, Hard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bar</td>
<td>M20, Soft</td>
<td>M20, Soft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rod</td>
<td></td>
<td>O60 or H04</td>
<td>O60 or H01</td>
<td></td>
</tr>
<tr>
<td>Wire</td>
<td></td>
<td>O60</td>
<td>O60</td>
<td></td>
</tr>
</tbody>
</table>

3.5 Chemical Analysis

Material is to meet the chemical composition requirements for welded applications, unless specified otherwise. The copper content is to be directly determined. Analysis by subtraction from the sum of the specified elements is not permitted.

3.7 Tension Properties

The tension properties are to be determined, and the results are to be in accordance with the ASTM B122 and ASTM B151 except as modified by the following tables. A rejected lot may be resubmitted for acceptance testing only after performing necessary rework to correct the nonconforming condition without adversely affecting the conforming properties. If the rejected lot is re-heat treated to correct a nonconforming characteristic, all mechanical properties, including those which were initially conforming, are to be determined. Alternatively, when a rejected lot consists of more than one piece, each remaining piece in the lot may be resubmitted for testing for the nonconforming characteristics and each piece that conforms to all specified requirements may be offered for acceptance.

### Tension Properties – Grade A1 Sheet and Strip in H01 Temper

<table>
<thead>
<tr>
<th>Thickness, in mm (in)</th>
<th>Up to 610 mm (24 in) in Width</th>
<th>Over 610 mm (24 in) in Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>Maximum</td>
<td>Tensile (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tensile (1)</td>
</tr>
<tr>
<td>4.8 (0.1875)</td>
<td>380 (39, 55)</td>
<td>205 (20, 30)</td>
</tr>
</tbody>
</table>
### Tension Properties – Grade A1 Plate

<table>
<thead>
<tr>
<th>Thickness, in mm (in)</th>
<th>Up to 610 mm (24 in) in Width</th>
<th>Over 610 mm (24 in) in Width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>4.8 (0.1875)</td>
<td>9.5 (0.375)</td>
<td>380 (39, 55)</td>
</tr>
<tr>
<td>9.5 (0.375)</td>
<td>12.5 (0.50)</td>
<td>345 (35, 50)</td>
</tr>
<tr>
<td>12.5 (0.50)</td>
<td>76 (3.0)</td>
<td>275 (28, 40)</td>
</tr>
<tr>
<td>76 (3.0)</td>
<td>125 (5.0)</td>
<td>260 (27, 38)</td>
</tr>
</tbody>
</table>

### Tension Properties – Grade A1 Bar

<table>
<thead>
<tr>
<th>Diameter or Thickness, in mm (in)</th>
<th>Tensile (1)</th>
<th>Yield (2)</th>
<th>Elong (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>Maximum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.8 (0.1875)</td>
<td>-----</td>
<td>260 (27, 38)</td>
<td>105 (11, 15)</td>
</tr>
</tbody>
</table>

### Tension Properties – Grade A2 Wire, Sheet and Strip in O60 Temper

<table>
<thead>
<tr>
<th>Diameter, in mm (in)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5 (0.021)</td>
<td>4.8 (0.1875)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tensile (1)</th>
<th>Yield (2)</th>
<th>Elong (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>Maximum</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>260 (27, 38)</td>
<td>105 (11, 15)</td>
</tr>
<tr>
<td>0.5 (0.021)</td>
<td>4.8 (0.1875)</td>
<td>260 (27, 38)</td>
</tr>
</tbody>
</table>

### Tension Properties – Grade B1 Sheet and Strip in H01 Temper

<table>
<thead>
<tr>
<th>Thickness, in mm (in)</th>
<th>Up to 610 mm (24 in) in Width</th>
<th>Over 610 mm (24 in) in Width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>----</td>
<td>4.8 (0.1875)</td>
<td>415 (42, 60)</td>
</tr>
</tbody>
</table>

### Tension Properties – Grade B1 Plate

<table>
<thead>
<tr>
<th>Thickness, in mm (in)</th>
<th>Up to 610 mm (24 in) in Width</th>
<th>Over 610 mm (24 in) in Width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>4.8 (0.1875)</td>
<td>9.5 (0.375)</td>
<td>415 (42, 60)</td>
</tr>
<tr>
<td>9.5 (0.375)</td>
<td>12.5 (0.50)</td>
<td>380 (39, 55)</td>
</tr>
<tr>
<td>12.5 (0.50)</td>
<td>-----</td>
<td>310 (32, 45)</td>
</tr>
</tbody>
</table>

### Tension Properties – Grade B1 Bar

<table>
<thead>
<tr>
<th>Diameter or Thickness, in mm (in)</th>
<th>Tensile (1)</th>
<th>Yield (2)</th>
<th>Elong (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>Maximum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>63.5 (2.5)</td>
<td>345 (35, 50)</td>
<td>140 (14, 20)</td>
</tr>
<tr>
<td>63.5 (2.5)</td>
<td>-----</td>
<td>310 (32, 45)</td>
<td>125 (13, 18)</td>
</tr>
</tbody>
</table>
### Tension Properties – Grade B2 Wire, Sheet and Strip in O60 Temper

<table>
<thead>
<tr>
<th>Diameter, in mm (in)</th>
<th>Minimum</th>
<th>Maximum Tensile (1)</th>
<th>Yield (2)</th>
<th>Elong. (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63.5 (2.5)</td>
<td>345 (35, 50)</td>
<td>140 (14, 20)</td>
<td>30</td>
</tr>
</tbody>
</table>

Notes for above Tables:
1. Minimum tensile strength, in N/mm$^2$ (kgf/mm$^2$, ksi).
2. Minimum yield strength by 0.5% extension under load, in N/mm$^2$ (kgf/mm$^2$, ksi).
3. Minimum elongation in 50 mm (2 in) or 4 times the diameter, in percent. The elongation requirements do not apply to material under 0.25 mm (0.010 in) in thickness.

### 3.9 Nondestructive Examination

When specified, product is to be examined in accordance with NAVSEA Technical Publication T9074-AS-GIB-010/271 by ultrasonic inspection or by liquid penetrant testing.

#### 3.9.1 Ultrasonic Inspection

Plate, bar and rod are to be examined by means of a longitudinal wave transducer calibrated to the following flat bottom reference hole sizes. The hole is to extend perpendicularly to the calibrating material mid-thickness for material not thicker than 38 mm (1.5 in), and for thicker material at least to a depth of 19 mm (0.75 in) up to the mid-thickness. Reference holes may be made in equivalent defect-free material or in production material, provided that the production material is not adversely impaired. The reflection from the reference hole is to be adjusted to between 25 percent and 100 percent of the full screen height.

<table>
<thead>
<tr>
<th>Ultrasonic Reference Holes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
</tr>
<tr>
<td>Plate</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Bar or Rod</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Plate is to be continuously scanned on 200 mm (8 in) grid including one diagonal from each grid. Rounds are to be circumferentially or helically scanned in a radial orientation, and bars are to be scanned perpendicularly to each side or surface. Material with indication heights greater than that of the comparable reference hole, and material which demonstrates a complete loss of back reflection are to be rejected.

#### 3.9.2 Liquid Penetrant Inspection

All inspected material is to be free from linear indications, and linearly-disposed (four or more in a line and separated by 1.6 mm (0.063 in) or less) round indications. The acceptance criteria for scattered round indications are shown below.
### Allowable Non-Linear Round Indication

<table>
<thead>
<tr>
<th>Indication Size, in mm (in)</th>
<th>Cumulative Number per cm² (in²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\leq 0.8) (0.031)</td>
<td>0.3 (20)</td>
</tr>
<tr>
<td>(&gt;0.8) (0.031) and (\leq 1.6) (0.063)</td>
<td>0.15 (10)</td>
</tr>
<tr>
<td>(&gt;1.6) (0.063)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

### 3.11 Cleanliness

Prior to any heat treatment, the material surface is to be free from contaminants such as sulfur and sulfur bearing lubricants, marking agents, etc. The material is not to come into contact with mercury or compounds of mercury.

### 3.13 Alloy Identity

When specified, each random mill length, prior to cutting to the ordered length, is to be tested for conformance to the ordered metallurgical alloy, ie alloy C70600 or alloy C71500. Qualitative spot testing is an acceptable method. Material not complying to the ordered alloy is to be rejected.

### 3.15 Sampling

When specified, sample pieces are to be selected at random in accordance with the table below for the visual and dimensional examinations.

<table>
<thead>
<tr>
<th>Number of Pieces in Lot</th>
<th>Number of Sample Pieces to be Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 8</td>
<td>Entire Lot</td>
</tr>
<tr>
<td>9 to 90</td>
<td>8</td>
</tr>
<tr>
<td>91 to 150</td>
<td>12</td>
</tr>
<tr>
<td>151 to 280</td>
<td>19</td>
</tr>
<tr>
<td>281 to 500</td>
<td>21</td>
</tr>
<tr>
<td>501 to 1,200</td>
<td>27</td>
</tr>
<tr>
<td>1,201 to 3,200</td>
<td>35</td>
</tr>
<tr>
<td>3,201 to 10,000</td>
<td>38</td>
</tr>
<tr>
<td>10,001 to 35,000</td>
<td>46</td>
</tr>
</tbody>
</table>

If one or more sample pieces fail any inspection or examination, then the lot that it represents is to be rejected. If a lot is rejected as a result of sample inspections, then each piece in the lot may be inspected and those which pass may be accepted. Rejected material may be refurbished by grinding or machining and resubmitted for inspection.

### 3.17 Marking

When specified, marking is to conform to the supplementary requirements, S3 and S4, in ASTM B248, or B249, as appropriate, and the marking is to include the lot number and the contract number.
3.19 Ordering Data

Procurement documents are to list the following items with appropriate requirements specified:

1. Specify title and number of ABS specification.
2. Specify ABS grade and UNS alloy number.
3. Specify ASTM specification and copper alloy number.
4. Specify a specific manufacturing technique, 2-13-22/3.3, if required.
5. Specify temper for sheet, strip and rod, 2-13-22/3.3.
6. Specify form and dimensions or reference a drawing number.
7. Specify type of edge, if required.
8. Specify whether tolerances are all plus or all minus, if required.
9. Specify identification marking, 2-13-22/3.17, including lot identification marking, if required.
10. Specify ABS certification, if required.
11. Specify level of preservation, packaging and packing required and applicable specifications and standards, 2-13-22/3.17, if required.
12. Specify special sampling plan, 2-13-22/3.15 for visual and dimensional inspection, if required.
13. Specify additional data requirements, if required.
14. Specify nondestructive testing, 2-13-22/3.9, if required.
15. Specify alloy identity check and method, 2-13-22/3.13, if required.

3.21 Class of Ordering Data

This ordering data has been classified to establish the minimum requirements for different applications. Class 1 requirements and ordering data are to be specified on every order unless specifically excluded in the contract or drawing. Class 2 requirements and ordering data are not required unless specifically required by the contract or drawing.

Class 1: Items 1 to 9 in 2-13-22/3.19 are Class 1.

Class 2: Items 10 to 15 in 2-13-22/3.19 are Class 2.

3.23 Superseded Specifications

The copper-nickel grades shown below supersede the indicated, previous specification alloy. MIL-C-15726F does not cover forgings found in MIL-C-15726E.

<table>
<thead>
<tr>
<th>Grade</th>
<th>ASTM Designation</th>
<th>Products</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>MIL-C-15726F</td>
</tr>
<tr>
<td>A1</td>
<td>B122, UNS C70600</td>
<td>Plate, Sheet, Strip, and Bar</td>
<td>Alloy C70600</td>
</tr>
<tr>
<td>B1</td>
<td>B122, UNS C71500</td>
<td>Plate, Sheet, Strip, and Bar</td>
<td>Alloy C71500</td>
</tr>
<tr>
<td>A2</td>
<td>B151, UNS C70600</td>
<td>Rod and Wire</td>
<td>Alloy C70600</td>
</tr>
<tr>
<td>B2</td>
<td>B151, UNS C71500</td>
<td>Rod and Wire</td>
<td>Alloy C71500</td>
</tr>
</tbody>
</table>
PART 2

CHAPTER 13  Materials for Machinery, Boilers, Pressure Vessels and Piping

APPENDIX 1  Guide for Impregnation of Castings and Powder Metal Parts

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<td>119</td>
</tr>
<tr>
<td>5.3 Supercession of MIL-I-17563C</td>
<td>119</td>
</tr>
</tbody>
</table>
Foreword

The recommendations in this Guide are applicable to the material requirements and process requirements for impregnated structurally sound castings and powdered metal components. Alloy systems covered are aluminum, magnesium, copper, ferrous (excluding steel), and zinc.

1.1 General

This section covers the requirements and tests for the impregnation of structurally sound but porous castings and for the impregnation of powder metal components. The materials and alloy systems covered include: aluminum, magnesium, copper, ferrous (excluding steel), and zinc. It is also applicable to test specimens used for evaluating impregnating materials in accordance with 2-13-A1/3.

1.3 Approval

Castings and components intended for use in classed ships may be impregnated when approved by ABS. Casting and components intended for use in non-classed applications may be impregnated in accordance with this guide when approved by the owner or authorized agent.

1.3.1 Acceptable Methods

Impregnation is to be by one of the methods described in 2-13-A1/1.5.3 through 2-13-A1/1.5.5 at the discretion of the contractor. The manufacturer is to adhere to the approved process and procedures.

1.3.2 Approval Process

The manufacturer is to submit to an ABS Technical Office the following information:

- Description of the process intended to be used
- Procedures for the impregnating process
- Approval documentation and test data for the impregnant to be used
- Testing procedures
- Inspection procedures
- Material of the part
- Intended application for the finished part
- Quality procedures and checks
Upon satisfactory review of the above information, an ABS Surveyor is to carry out a plant survey and witness the process. Testing results in accordance with 2-13-A1/1 and 2-13-A1/3 are to be submitted to support initial approval of the process. The Surveyor may at his discretion request that testing be carried out in his presence.

1.3.3 Special Approval
When impregnation is not specified on the drawing or by design, but is necessary to satisfy performance requirements, special approval may be obtained by agreement between ABS and the owner or the end user. In these cases, the process is to be approved as per 2-13-A1/1.3.2. Under the special situations listed below, impregnation is only permitted by agreement between the manufacturer and the end user.

- The component service includes exposure to fluids other than those approved by compatibility testing in accordance with 2-13-A1/3
- The impregnating material is other than that specified in 2-13-A1/3.
- The impregnating method is other than that specified in 2-13-A1/1.5.3 to 2-13-A1/1.5.5.

1.5 Process Requirements

1.5.1 Preliminary Pressure Tightness
Casting are to be thoroughly cleaned and completely machined prior to all hydrostatic or pneumatic pressure testing by the applicable drawing or directive, or as specified in 2-13-A1/1.5.9. If pressure tests are made on components before final machining and threading of bolt holes, the components are to be retested after final machining and before impregnation. Components which leak through the wall during this test may be repaired by impregnation provided they meet all the requirements specified herein.

1.5.2 Component Preparations
Unless otherwise specified, all heat treating, welding, brazing, and machining operations are to be performed prior to impregnation. Final surface finishing is to be performed after impregnating. The following detailed requirements apply as appropriate.

- 1.5.2(a) Cleaning Components are to be thoroughly cleaned free of oils and other machining compounds. If a water rinse is used after cleaning, the components are to be dried by heating to 66°C (150°F) to 82°C (180°F) for a minimum of one hour, and are to be brought to ambient temperature before impregnating. If vapor degreasing is used for cleaning, no drying is necessary.

- 1.5.2(b) Surface preparation Rough magnesium castings are to be treated to remove surface skin to a depth of approximately 0.05 mm (0.002 in) by mechanical treatment before impregnating.

1.5.3 Internal Pressure Method (individual castings)
The casting to be impregnated is used as the process pressure vessel and thus only one casting may be impregnated at a time. This method is primarily applicable to large castings.

All openings in the casting, except for the ports needed during the impregnation process are to be plugged. The impregnant is to be injected to completely fill the casting, or the impregnant is to be circulated through the casting under pressure. The applied pressure is to be from 3.4 bar (3.5 kgf/cm², 50 psi) to 5.2 bar (5.3 kgf/cm², 75 psi) above the prescribed test pressure, if the safety factor of the casting will permit. The applied pressure is to be maintained for an empirically determined length of time, or until the liquid is observed on the outside surface seeping from the pores. In cases of minute porosity in heavy walls, 6 hours or more under
pressure may be required to effect complete penetration of the solution through the wall. Loss of solution by seepage may be stopped by spot curing, care being taken not to heat the casting to the cure temperature over a larger volume than is to be cured.

1.5.4 Dry Vacuum and Pressure (batch immersion)

The component to be impregnated is placed in a vacuum to evacuate air, water, and other foreign material from the porosity, and subsequently the casting is impregnated and sealed under pressure.

Clean and dry components are to be placed in an empty pressure vessel. The vessel is to be closed and evacuated until a vacuum of not less than 740 mm (29 in) of mercury is attained. If the vapor pressure of the impregnant solution prohibits using a minimum vacuum of 740 mm (29 in) of mercury, the maximum vacuum compatible with the solution is to be used, but is not to be less than 686 mm (27 in) of mercury. The impregnating solution is to be drawn into the tank at such a rate that the above specified vacuum is maintained. When the tank contains a sufficient amount of solution to cover the components by at least 50 mm (2 in), the vacuum is to be released and pressure applied. The period of time under pressure is to have been empirically determined. After holding for the specified time the pressure is to be released, the tank emptied of solution, and the parts removed. Sectioning of actual parts or test samples may be required to determine penetration.

1.5.5 Wet Vacuum and Pressure (batch immersion)

The component to be impregnated is placed in an impregnating bath and under vacuum to evacuate air, water, and other foreign material from the porosity. Subsequently the casting is sealed under pressure. Impregnation with sodium silicate is not permitted.

Clean and dry components are to be placed in a pressure vessel and covered with impregnating solution under a vacuum as in 2-13-A1/1.5.4 except that the vacuum is to be 740 mm (29 in) of mercury. The vacuum is to be maintained for a period empirically determined to be sufficient for complete air removal. At the end of the vacuum cycle, a pressure of not less than 3.4 bar (3.5 kgf/cm², 50 psi) is to be applied for a period shown by experience to be sufficient for complete porosity sealing. The pressure is to then be released and the castings removed from the solution. For components with a wall thickness not exceeding 12.5 mm (0.5 in), the pressure cycle may be omitted.

1.5.6 Impregnating Prohibition

Impregnation is to not be performed under any circumstances in the following situations:

1.5.6(a) Service Temperature Castings are to be exposed to temperatures greater than the maximum specified by the manufacturer for the specific impregnant used, except for properly cured sodium silicate impregnants.

1.5.6(b) Service Oxygen Castings are to be exposed to oxygen gas at any pressure. Since sodium silicate is totally inorganic, it can be used in contact with oxygen.

1.5.6(c) Post Impregnant Welding During fabrication, castings must be welded after impregnation.

1.5.6(d) NDT Defects Castings exhibit rejectable structural defects as defined by the specified radiographic standards.

1.5.7 Post-Impregnation Treatments

Components are to be well drained and the surface, including ducts, vents, and pockets, thoroughly rinsed in aqueous solution to remove excess impregnant. A corrosion inhibitor additive may be added to the final rinse water. The components are to be cured in accordance with the procedure and instruction from the impregnant solution manufacturer.
1.5.8 Hazardous Waste

All hazardous waste generated by these processes, is to be disposed in accordance with local and federal regulations.

1.5.9 Proof Pressure Test

Each finished component is to be subjected to a pressure test, either hydrostatic or pneumatic, in accordance with the applicable drawings, directives, or specifications. If the proof pressure test requirement or other testing requirements are not specified, the requirements of 2-13-A1/1.5.9(a) or 2-13-A1/1.5.9(b) are to apply. If a soap solution is used for testing, it is to be thoroughly rinsed from the parts. Parts are to be dry inside and out before storage. Machined surfaces of ferrous components are to be protected from rusting.

In the event machining is necessary after impregnation, the final proof pressure test is to be performed after machining.

1.5.9(a) Pneumatic Proof Pressure Test  The proof pressure to which the components are to be subjected is to be twice the normal working pressure, but in no case less than 0.7 bar (0.7 kgf/cm², 10 psi). Air is to be forced into the castings at the required pressure for not less than 2 minutes while the part is immersed in water. As an alternate to immersion in water, a neutral soap solution or kerosene may be brushed on the external surfaces of the part. Bubbling observed in the water or bubbles emanating through the soap solution or kerosene is to indicate failure.

1.5.9(b) Alternate Hydrostatic Proof Pressure Test   Components may alternatively be filled with water, kerosene, or other liquid compatible with the end use of the casting, and the component subjected to an internal pressure as per 2-13-A1/1.5.9(a). Any evidence of leakage through the wall is to indicate failure.

1.5.10 Reimpregnation and Rejection

Components may be reimpregnated once, unless there is reason to doubt the quality of the impregnation process or of the component. Parts which leak after one reimpregnation are to be rejected. However, where machining after impregnation is required, one additional impregnation is to be permitted before final rejection.

1.7 Impregnant Requirements

1.7.1 Approval of Impregnants

The materials used to impregnate components are to be subject to approval by ABS, except that filled sodium silicate is considered a suitable alternative where it can be demonstrated that all the restrictions of 2-13-A1/1.7.2 have been met. Compliance with the requirements in Section 2 is the basis for approval of impregnating materials.

1.7.2 Sodium Silicate Impregnant Restriction

Filled sodium silicate impregnants are not to be used unless the application complies with all of the following conditions.

1.7.2(a) Leak Rate  The measured air leak rates are less than 740 cm³/min (0.75 in³/sec).

1.7.2(b) Service Temperature  The maximum service temperature of the casting is 120°C (250°F) or less. Temperatures to 430°C (800°F) are acceptable provided the impregnant is step cured to the maximum service temperature.

1.7.2(c) Drying Time  The minimum drying time at ambient temperature is to be 48 hours. The drying may be carried out at 80°C to 90°C (175°F to 200°F) for 2 hours followed by polymerizing at the specified operating temperature.
1.7.2(d) Service Environment  The service for the impregnated castings is not to include concentrated acid or hydrogen peroxide.

1.7.2(e) Specific Gravity  The specific gravity of the uncured filled sodium silicate impregnant is to be at least 28 degrees Baume.

1.9 Inspection

1.9.1 Visual Inspection
After completion of all impregnation, final machining and pressure testing, each part is to be visually examined.

1.9.2 Discoloration
Discoloration which does not affect the quality of impregnation or the serviceability of the part is not to be cause for rejection.

1.11 Marking and Reports

1.11.1 Marking
Each component which has been impregnated is to be marked “IMP” and is to be marked with the ABS report number on the stamping pad or in a conspicuous place that will not impair its strength or serviceability. The marking is to be by low-stress die stamps or by vibrotool engraving.

1.11.2 Reports
Each part or each lot of small parts is to be identified and reported in AB113.

3 Impregnants for Castings and Powder Metal Components

3.1 General
This section covers the requirements for impregnating materials suitable for sealing the voids found in castings or powder metal components which may cause leaking of contained fluids. The impregnating material requirements pertain to the product in bulk form, prior to the impregnation of castings or powder metal components.

3.3 Approval
Impregnating materials intended for use in classed ships are to be approved by ABS. Impregnating materials intended for use in non-classed applications are to be approved by the owner or authorized agent.

3.3.1 Approval Process
The manufacturer is to submit to an ABS Technical Office the following information:
- Identification of the impregnating material
- Description of the manufacturing process
- Procedures for testing and inspection
- Quality procedures and checks
- Previous qualification test data
Upon satisfactory review of the above information, an ABS Surveyor is to carry out a plant survey and witness the manufacturing process. Testing results are to be submitted to support initial approval of the impregnating material. The Surveyor may at his discretion request that testing be carried out in his presence.

3.3.2 Alternate Approval Process

Due consideration will be given to the approval of impregnating materials that have satisfied the 2-13-A1/3 requirements in connection with approval carried out for other organizations. The use in classed ships of products so approved may be restricted.

3.5 Classification of Impregnants

The impregnants covered herein are classified as shown below. Provided all requirements are met, an impregnating material may be classified by more than one designation.

<table>
<thead>
<tr>
<th>Class</th>
<th>Application</th>
<th>Maximum Service Temperature, C (°F)</th>
<th>Pollution Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General</td>
<td>149 (300)</td>
<td>None</td>
</tr>
<tr>
<td>1a</td>
<td>Mortar Shell Casings</td>
<td>149 (300)</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>General</td>
<td>260 (500)</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>Acrylic-Nitrocellulose Lacquer Compatible</td>
<td>149 (300)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

3.7 Impregnant Requirements

3.7.1 Material

Impregnating material meeting the requirements of this guide is to be a nonmetallic resin capable of being cured to a hard, dense structure, and which when cured is to produce a solid seal throughout a casting containing 15 percent porosity.

3.7.2 Recovered Materials

Unless otherwise specified herein, all material covered by this guide is to be new and may be produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. The term “recovered materials” means materials which are recovered from waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials.

3.7.3 Volatility

The impregnating materials are not to contain inert liquids, and are not to react to produce gaseous by-products or liquid by-products, either alone or in contact with any materials present. The volatile content of a class 3 impregnant is to consist of nonphotochemically reactive solvents. A nonphotochemically reactive solvent is any solvent with an aggregate of not more than 20 percent of its total volume composed of the chemical compounds described below or which does not exceed any of the following individual composition limitations, referred to the total volume of solvent:

A combination of hydrocarbons, alcohols, aldehydes, esters, ethers, or ketones having an olefinic or cycloolefinic type of unsaturation: 5 percent.

A combination of aromatic compounds with eight or more carbon atoms to the molecule except ethylbenzene: 8 percent.
A combination of ethylbenzene, keytones having branched hydrocarbon structures, trichlorethylene, or toluene: 20 percent.

3.7.4 Weight Loss
Cured impregnating material is not to exhibit a weight loss exceeding 3 percent. A sample of not less than 5 cm³ (0.3 in³) of the activated impregnant is to be carefully weighed on an analytical balance. The sample is to be cured in accordance with the manufacturers instructions, and subsequently reweighed.

3.7.5 Shrinkage
Cured impregnating material is not to exhibit a change in volume in excess of 10 percent.
A sample of the material is to have its volume determined. The sample is to be cured in accordance with the manufacturers instructions, and subsequently remeasured after cooling to room temperature.

3.7.6 Pot Life
Activated impregnants are to have a pot life of not less than 1 month at the following temperatures. At the end of the one-month test period, an examination for evidence of thickening, curdling or other objectionable property change which would prevent satisfactory use for the impregnation process is to be carried out. Subsequently, the impregnant is to be cured in accordance with 2-13-A1/3.7.8, and meet the requirements.

<table>
<thead>
<tr>
<th>Impregnant Type</th>
<th>Temperature, in °C (°F)</th>
<th>Temperature Variation, in °C (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermocuring</td>
<td>24 (75)</td>
<td>2.8 (5)</td>
</tr>
<tr>
<td>Anaerobic Ion</td>
<td>7 (45)</td>
<td>2.8 (5)</td>
</tr>
</tbody>
</table>

3.7.7 Storage Life
Materials in unopened containers are to be usable and meet manufacturers original specification at the end of one year. Unaltered materials from unopened containers are to be examined at the end of one year and are to meet the curing test requirements and the leakage test requirements.

3.7.8 Curing Test
The impregnant is to be individually tested for suitability with each of the following alloys: aluminum, copper, iron, magnesium and zinc. Each alloy in the form of fine dry chips is to be just covered with activated impregnant for not less than 24 hours and subsequently cured to a hard, firm mass according to the manufacturers instruction. The cured test sample is to be free from visible surface defects, holes, pits, and fissures. Greenish discoloration is not permitted for the copper test sample.

3.7.9 Leakage Test
When tested under pressure, impregnated test specimens are to show no leakage as indicated by a continuous flow of bubbles.

3.7.9(a) Test Specimens The test specimens are to consist of a sintered metal powder cylinder, with the following nominal dimensions as shown in 2-13-A1/Figure 1.

25.4 mm (1.0 in) long
19.0 mm (0.75 in) inside diameter
25.4 mm (1.0 in) outside diameter
The specimens are not to have surfaces altered by operations such as burnishing, coining or sizing. The interconnected voids by volume (porosity) are to be 15 to 25 percent as determined by the method specified in ASTM B328, "Test Method for Density, Oil Content, and Interconnected Porosity of Sintered Powder Metal Structural Parts and Oil-Impregnated Bearings." The alloy composition of the test specimens is to conform to one of the three types as specified in 2-13-A1/Table 1, designated as Type I, Type II, and Type III.

### TABLE 1
Powder Metal Test Specimen Chemical Composition

<table>
<thead>
<tr>
<th>Element</th>
<th>Composition, in percent, maximum unless noted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type I</td>
</tr>
<tr>
<td>Copper</td>
<td>82.0 to 90.0</td>
</tr>
<tr>
<td>Iron</td>
<td>1.0</td>
</tr>
<tr>
<td>Tin</td>
<td>9.5 to 10.5</td>
</tr>
<tr>
<td>Lead</td>
<td>4.0</td>
</tr>
<tr>
<td>Zinc</td>
<td>1.0</td>
</tr>
<tr>
<td>Aluminum</td>
<td>NR</td>
</tr>
<tr>
<td>Carbon (1)</td>
<td>1.75</td>
</tr>
<tr>
<td>Combined Carbon (2)</td>
<td>NR</td>
</tr>
<tr>
<td>Others, Total (3)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Notes**

1. Carbon is commonly in the form of graphite. A maximum of 1.5 percent of another type of solid lubricant may be substituted when specially approved.
2. The combined carbon content may be estimated from metallographic data of the carbon in the iron.
3. Value is calculated by difference from 100 percent.
3.7.9(b) Specimen Preliminary Testing Prior to impregnating, each test specimen is to be pressure tested at 1.4 bar (1.4 kgf/cm\(^2\), 20 psi) for a minimum of 5 minutes or until bubbling occurs to test for leakage. The results of the test are to be recorded. Specimens intended to be subsequently impregnated are to be dried by placing in an oven at 121°C (250°F) for 1 hour.

3.7.9(c) Impregnation Each test specimen is to be impregnated with the impregnating material under evaluation in accordance with 2-13-A1/1 of this guide.

3.7.9(d) Pressure Test Two impregnated test specimens are to be tested and show no leakage at 3.4 bar (3.5 kgf/cm\(^2\), 50 psi). The pressure test apparatus may be made as shown in 2-13-A1/Figure 2. The test specimens are to be placed in the test apparatus, immersed in water and subjected to the air pressure specified in each individual test for a minimum of 3 minutes or until leak occurs. The specimen is to leak or not leak as stated in the individual test.

FIGURE 2
Recommended Pressure Testing Apparatus

3.7.10 Pressure Penetration Test
When tested under pressure, impregnated test specimens with special outside surface preparation are to show no leakage. One impregnated test specimen of each type as prepared for the leakage test is to be machined to remove a minimum of 1.6 mm (0.063 in) of material from the outer diameter. Each specimen is to be subsequently etched by means of a 6N nitric acid solution to remove an additional 0.13 mm (0.005 in) of material from the outer surface. The test specimens so prepared are to be subjected to the pneumatic pressure of the leakage test.

3.7.11 Compatibility
The cured impregnant is not to be attacked by the chemicals listed in 2-13-A1/Table 2. Two impregnated test specimens of each type that have satisfied the leakage test are to be exposed to the media listed in 2-13-A1/Table 2. The test specimens are to be cleaned in a suitable
degreaser for not less than 30 minutes prior to exposure to the stated media. The conditioning
time and temperature are to be as specified in 2-13-A1/Table 2. The test specimens are to be
cleaned in a suitable degreaser after exposure. Subsequently, the test specimens are to be
leakage retested. All of the tests shown in 2-13-A1/Table 2 are to be carried out for each
impregnating material.

**TABLE 2**
Conditioning Tests

<table>
<thead>
<tr>
<th>Media</th>
<th>Media Specification</th>
<th>Time, in hours</th>
<th>Temperature, in °C (°F)</th>
<th>Temperature Variation, in °C (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>NA</td>
<td>336</td>
<td>100 (212)</td>
<td>NA</td>
</tr>
<tr>
<td>Oil</td>
<td>MIL-H-17672</td>
<td>336</td>
<td>99 (210)</td>
<td>2.8 (5)</td>
</tr>
<tr>
<td>Hydrocarbon Fluid</td>
<td>TT-S-735</td>
<td>336</td>
<td>23 (73.4)</td>
<td>2 (3.6)</td>
</tr>
<tr>
<td>Carbon Removal</td>
<td>P-C-111</td>
<td>0.5</td>
<td>23 (73.4)</td>
<td>2 (3.6)</td>
</tr>
<tr>
<td>Lubricating Oil</td>
<td>MIL-L-7808</td>
<td>48</td>
<td>124 (255)</td>
<td>2.8 (5)</td>
</tr>
<tr>
<td>Turbine Fuel</td>
<td>MIL-T-5624</td>
<td>48</td>
<td>23 (73.4)</td>
<td>2 (3.6)</td>
</tr>
<tr>
<td>Ethylene Glycol</td>
<td>MIL-E-9500 (1)</td>
<td>336</td>
<td>149 (300)</td>
<td>2.8 (5)</td>
</tr>
<tr>
<td>Ethylene Glycol</td>
<td>MIL-E-9500 (2)</td>
<td>336</td>
<td>203 (397)</td>
<td>2.8 (5)</td>
</tr>
<tr>
<td>Hydraulic Fluid</td>
<td>MIL-F-17111</td>
<td>336</td>
<td>99 (210)</td>
<td>2.8 (5)</td>
</tr>
<tr>
<td>Fuel</td>
<td>ASTM D910</td>
<td>48</td>
<td>23 (73.4)</td>
<td>2 (3.6)</td>
</tr>
<tr>
<td>Diester Grease</td>
<td>MIL-G-23827</td>
<td>48</td>
<td>23 (73.4)</td>
<td>2 (3.6)</td>
</tr>
<tr>
<td>18% Sulfuric Acid</td>
<td>O-S-809</td>
<td>2</td>
<td>23 (73.4)</td>
<td>2 (3.6)</td>
</tr>
<tr>
<td>Stoddard Solvent</td>
<td>P-D-680</td>
<td>48</td>
<td>23 (73.4)</td>
<td>2 (3.6)</td>
</tr>
<tr>
<td>Ethyl Alcohol</td>
<td>MIL-E463</td>
<td>48</td>
<td>23 (73.4)</td>
<td>2 (3.6)</td>
</tr>
<tr>
<td>Thermal Resistance</td>
<td>NA</td>
<td>336</td>
<td>149 (300)</td>
<td>2.8 (5)</td>
</tr>
<tr>
<td>Thermal Resistance</td>
<td>NA</td>
<td>336</td>
<td>260 (500)</td>
<td>2.8 (5)</td>
</tr>
</tbody>
</table>

**Notes**
1. Exposure for Class 1 impregnant.
2. Exposure for Class 2 impregnant.

3.7.12 Paint Effect
Cured Class 3 impregnant is not to cause paint systems to chip, to peel, or to show loss of
adhesion. Two test specimens of each type are to be impregnated with class 3 impregnating
material, and are to be heated at 149°C (300°F) for 4 hours, air cooled to room temperature, and
subsequently placed in a refrigerated holding area at -54°C ± 2.8°C (-65°F ± 5°F) for not less than
1 hour. Immediately upon removal from refrigeration, the specimen is to be subjected to the
internal pneumatic pressure. The test specimens are to be dried and reimpregnated. The
following lacquer systems are to then be applied to the test specimens in accordance with
MIL-F-18264.

One coat of wash primer in accordance with MIL-C-8514
One coat of lacquer primer in accordance with MIL-P-7962
One coat of acrylonitrilecellulose lacquer in accordance with MIL-L-19537
The test specimens are to be allowed to dry for 48 hours and then tested in accordance with
method 6304 of FED-STD-141.
3.7.13 Reactivity
The reactivity of Class 1a impregnating material with either TNT or Composition B explosive is not to exceed 2.0 ml of gas when tested in accordance with the procedure outlined in Annex A.

3.7.14 Filterable Solids
The impregnant is to contain no filterable solids. A test sample is to be drawn through a Watman No. 5 filter paper or equivalent. The filter paper is to be examined visually during and after the filtration process for evidence of loading by solids.

3.7.15 Weight
The weight per gallon of the resin is to be determined according to FED-STD-141, method 4184.1.

3.7.16 Toxic Materials
The impregnating material is to have no adverse effect on the health of personnel when used for its intended purpose. Conformance is to be determined by a health hazard risk assessment (HHRA) by an organization approved by ABS. Formulation changes in the material require a re-evaluation of the product for toxicity. The manufacturer is to provide sufficient information to permit a toxicological evaluation of the material. As a minimum, the information is to include name, formula and approximate percentage by weight of each ingredient in the product; identification of pyrolysis products; and any other information as may be needed to permit an accurate appraisal of any toxicity problem associated with handling, storage, application, use, removal, disposal, or combustion of the product. The material safety data sheet and a copy of the product label is also to be submitted. The manufacturer is to provide any and all information requested to perform the evaluation; proprietary data, which is clearly marked as such, will be held in the strictest confidence.

3.9 Approval Testing
Approval testing is to be carried out for each class and formulation of impregnating material. The approval testing is to consist of all the testing listed in 2-13-A1/3.7, and all requirements are to be satisfied. The Surveyor may at his discretion request that testing be carried out in his presence.

3.11 Production Testing
Production testing is to be carried out for each lot. A lot is to consist of all impregnant produced in a single production run and offered for delivery at one time.

3.11.1 Impregnating Material
Each lot of impregnating material is to be subjected the following tests.

- Weight Loss
- Shrinkage
- Curing
- Leakage
- Pressure Penetration
- Filterable Solids
- Weight
3.11.2 Impregnating Material Containers

Randomly selected containers filled with the impregnating material are to be examined in accordance with the inspection frequency in 2-13-A1/Table 3 to verify compliance with the requirements of this guide in regard to fill, closure, leakage and marking. Each type container is to be sampled separately when shipment consists of mixed lots. Filled containers are to also be weighed. The volume is to be established by the weight per gallon of the impregnant. Any container in the sample having one or more defects, or underfill, as determined by weight, is to result in the rejection of the entire lot. Rejected lots may be resubmitted for inspection provided all nonconforming containers in the entire lot have been removed or repaired.

In addition to the above tests, one sample (container) is to be cured in accordance with the manufacturers instruction and subsequently visually inspected. The acceptance criteria for the curing test are to be applied.

### TABLE 3
Sampling for Container Inspection

<table>
<thead>
<tr>
<th>Size of Lot, in Containers</th>
<th>Number of Test Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>51</td>
<td>90</td>
</tr>
<tr>
<td>91</td>
<td>150</td>
</tr>
<tr>
<td>151</td>
<td>280</td>
</tr>
<tr>
<td>281</td>
<td>500</td>
</tr>
<tr>
<td>501</td>
<td>1200</td>
</tr>
<tr>
<td>1201</td>
<td>3200</td>
</tr>
<tr>
<td>3201</td>
<td>10000</td>
</tr>
<tr>
<td>10001</td>
<td>35000</td>
</tr>
<tr>
<td>35001</td>
<td>No Limit</td>
</tr>
</tbody>
</table>

3.13 Packaging

The packaging requirements specified herein apply only for direct Government acquisitions.

#### 3.13.1 Packaging Level

Packaging is to be level A or C.

3.13.1(a) Level A, Liquid Materials  Liquid materials are to be packaged in rectangular cans with a screw cap closure not exceeding 3.8 liter (1gallon) capacity, or in closed top style 20 liter (5 gallon) steel drum with screw cap closure.

3.13.1(b) Level A, Powdered and Jelly-Type Material  Powdered or jelly-type materials are to be packaged in round containers with multiple friction top closure not exceeding 3.8 liter (1gallon) capacity, or in 40 liter (5 gallon) round open top style containers with 16 lug closures, or in 20 liter (6 gallon) to 200 liter (55 gallon) open top style metal drums, with bolted ring seal closures and with side seams welded.

3.13.1(c) Level C  Preservation-packaging is to afford protection against deterioration and physical damage. The normal preservation-packaging methods used by the manufacturer may be utilized when such meets the requirements.
3.13.2 General Requirements

General requirements for packaging are to be as follows.

3.13.2(a) Aerobic Thermal Cure Material  Unless otherwise specified, the impregnant, whether furnished in a liquid, jelly or powdered form, is to be packaged in screw top or multiple friction top rectangular cans, steel pails, or metal drums. When required to equal one unit of issue for producing the specific quantity of product, components are to be packaged together as a kit in a unit container.

3.13.2(b) Anaerobic Ion Cure Material  Unless otherwise specified, the impregnant is to be packaged in rectangular screw top low-density polyethylene cartons.

3.15 Markings and Reports

3.15.1 Marking

Each impregnating material container is to be suitably marked by the manufacturer to permit proper identification. Each shipment of containers is to be marked by tagging or other suitable means with the ABS report number.

3.15.2 Reports

Each shipment lot of impregnating material containers is to be identified and reported in AB113.

3.15.3 Safety Data Sheets (SDS)

Safety data sheets are to be included with each shipment of impregnating materials. Copies of the SDS are to be attached to the shipping documents for each destination.

3.15.4 Hazardous Warning Labels

A hazardous warning label must be provided by the manufacturer in accordance with the applicable OSHA requirements (see OSHA Hazard Communication Standard, 29 CFR 1910.1200).

5 Supercession of Military Documents

5.1 Supercession of MIL-STD-276A


5.3 Supercession of MIL-I-17563C


5.3.1 Superseded Specifications

The ABS classes shown below supersede the indicated specification classes and types.

<table>
<thead>
<tr>
<th>Rule Grade</th>
<th>MIL-I-17563C</th>
<th>MIL-I-17563B</th>
<th>MIL-I-6869D</th>
<th>MIL-I-13857</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Class 1</td>
<td>Class 1</td>
<td>Class 1</td>
<td>Type I</td>
</tr>
<tr>
<td>Class 1a</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Type II</td>
</tr>
<tr>
<td>Class 2</td>
<td>Class 2</td>
<td>Class 2</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Class 3</td>
<td>Class 3</td>
<td>Class 3</td>
<td>Class 2</td>
<td>NA</td>
</tr>
<tr>
<td>Class 1, 2, 3</td>
<td>Class 1, 2, 3</td>
<td>Class 4</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
APPENDIX 1 Guide for Impregnation of Castings and Powder Metal Parts
Annex A – Reactivity of Class 1a Impregnating Material

A1. Testing Method

The reactivity test of Class 1a impregnating material with explosives is to be conducted in accordance with method 403.1.2 of MIL-STD-286. The tests are to be conducted at 100°C (212°F) in a constant temperature bath. Specimens having the following composition are to be tested:

- 2.5 grams of impregnated aluminum chips machined from a type III specimen
- 2.5 grams of TNT
- 2.5 grams of Composition B explosive
- 2.5 grams of aluminum chips impregnated with resin mixed with 2.5 grams of TNT, and machined from a type III specimen
- 2.5 grams of aluminum chips impregnated with resin mixed with 2.5 grams of Composition B explosive, and machined from a type III specimen

A2. Calculation

The unit capacity of the capillary and the volume of gas liberated during the test are to be calculated as specified in method 403.1.2 of MIL-STD-286. The reactivity of the impregnant with the explosives is to be calculated as follows:

Reactivity, in ml of gas liberated = \( X - (Y + Z) \)

\[
\begin{align*}
X &= \text{Volume, in milliliters, of gas produced by the 1:1 mixture of 2.5 grams of explosive plus 2.5 grams of impregnated specimen} \\
Y &= \text{Volume, in milliliters, of gas produced by 2.5 grams of impregnated specimen alone.} \\
Z &= \text{Volume, in milliliters, of gas produced by 2.5 grams of explosive alone.}
\end{align*}
\]
Note

1. TNT and Composition B Explosive can be obtained from:
   E.I. DuPont de Nemours, Inc.
   Wilmington, Delaware
   Eastman Kodak Corporation
   Rochester, New York
PART 2

CHAPTER 14 Welding and Fabrication

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PART 2

CHAPTER 14  Welding and Fabrication

SECTION 4  Welding Joint Design

1 Scope

This section contains structural and piping system weld joint designs for U.S. Naval ship construction. These joints are applicable to manual, semiautomatic, automatic arc, and gas welding processes. The welded joint designs shown herein represent standard joint designs used in welded fabrication and are not intended to be all inclusive. Modifications to these joint designs, other than those permitted by this document, are subject to special approval. These requirements are considered suitable for weld design involving military ships, and supersede MIL-STD-22.

3 Supplementary Requirements for Naval Ships

The identification of joint designs for structural, machinery, and pressure vessels are contained in 2-14-4/Figure 1 through 2-14-4/Figure 32. The structural, machinery and pressure vessel joint numbering system is composed of four character groups. By means of the four groups, a unique identification is assigned to each joint design. As an example:

B 2 V : 1

Sequential Number
Fourth character (number) is assigned in sequence 1, 2, 3 etc., to cover distinctive joint differences such as bevel angle, root opening, with backing, without backing, etc.

Period used for separation

Third character (letter) designate configuration joint
S - Square groove
V - Bevel or V-groove
U - U-groove
J - J-groove

Second character (number) designates number of sides
1 - Welded one side
2 - Welded both sides

First character (letter or letters) designates type of joint
B - Butt joint
C - Corner joint
E - Edge joint
L - Lap joint
T - Tee joint
PT - Partial penetration tee joint
The identification of joint designs for piping systems are contained in 2-14-4/Figure 33 through 2-14-4/Figure 70. Joints associated with piping portions of fluid systems are designated P, followed by a number, such as P-6. Joints associated with pressure vessels of fluid systems are designated V, followed by a number, such as V-6.

5 Applicable Documents

5.1 Government Documents

The following specifications, standards and publication form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

- MIL-I-23413 Inserts, Welding Filler Metal, Coiled and Solid Rings
- MIL-STD-1628 Fillet Weld Size, Strength, and Efficiency Determination
- MIL-STD-1689(SH) Fabrication, Welding, and Inspection of Ships Structure
- MIL-STD-2035 Nondestructive Testing Acceptance Criteria
- NAVSEA 0900-LP-000-1000 Fabrication, Welding, and Inspection of Ship Hulls

5.3 Non-Government Documents

The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issue of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation.

AMERICAN WELDING SOCIETY (AWS)

- A2.4 Standard Symbols for Welding, Brazing, and Nondestructive Examination
- A3.0 Standard Welding Terms and Definitions

5.5 Order of Precedence

In the event of a conflict between the text of this document and the reference cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

7 General Requirements

7.1 Welding Symbols and Definitions

Welding symbols and definition of terms used herein are in accordance with AWS A2.4 and AWS A3.0, respectively.
7.3 Special Approval

For the purposes of this document, special approval may be given by the following:

For Government shipyards: The delegated representative of the Shipyard Commander
For commercial shipyards: The delegated representative of the Supervisor of Shipbuilding, Conversion and Repair

Naval Sea Systems Command.
American Bureau of Shipping
The delegated representative of other cognizant Government agencies

7.5 Access

Joints are to be so located, to the maximum extent possible, that the entire weld groove is visible for the welder and that no obstructions impair the accessibility for welding.

7.7 Full Penetration Joints

On full penetration joints welded from both sides, the root of the first weld is to be back-gouged, chipped, or ground to sound metal before welding the second side; however, joints may be welded without such cleaning when qualified processes or techniques (for example, twin-arc, submerged arc, etc.) are employed.

7.9 Reinforcement

Reinforcement of welds is to be in accordance with an approved fabrication document.

7.11 Reinforcing Fillet Welds

Except as specified in 2-14-5/15, the size of the reinforcing fillet, $S$ on structural joints, is to be $\frac{1}{4}T$ (where $T$ is the thickness of the thinner member) but in no case less than 3.2 mm ($\frac{1}{8}$ in.) or greater than 9.5 mm ($\frac{3}{8}$ in.).

7.13 Partial Penetration Structural Tee Joints

Partial penetration structural tee joint dimensions are to be in accordance with 2-14-5/15.

7.15 Included Angle Shift

For joints with U- or V- bevels, the centerline of the included angle may be shifted from the position shown on the joint designs herein, as follows:

<table>
<thead>
<tr>
<th>Included Bevel Angle</th>
<th>Maximum Bevel Angle Shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>in degrees</td>
<td>in degrees</td>
</tr>
<tr>
<td>Less than 30</td>
<td>±5</td>
</tr>
<tr>
<td>30 up to 60</td>
<td>±10</td>
</tr>
<tr>
<td>60 and greater</td>
<td>±20</td>
</tr>
</tbody>
</table>

Bevel angle shifts are permitted, provided the specified minimum total included angle is maintained.
7.17 Thick Material

For material 38 mm (1 1/2 in.) and over in thickness, the joint bevel angles specified by this document need be maintained only for a minimum thickness of 15.9 mm (5/8 in.) to provide accessibility for welding the root, after which the included angle may be reduced to 20 degrees minimum for the remainder of the material thickness.

7.19 Roots with Backing

The maximum allowable root opening of backing-strap or ring-type joints, where only the minimum dimension is specified, is to be 6.4 mm (1/4 in.) above the specified minimum.

7.21 Structural Fillet Weld Size

Fillet weld sizes for structural joints are to be determined in accordance with Section 2-14-5.

7.23 Piping Fillet Weld Size

Fillet weld sizes for piping systems joints are based on the nominal pipe wall thickness \( T \), and are indicated on the applicable joint designs.

7.25 Fillet Weld Minimum Throat

The minimum throat for fillet joints with equal legs is to not be less than 0.7 times the specified fillet size. The minimum throat for fillets with unequal legs is to not be less than 0.7 times the specified short leg.

9 Joint Design Selection

Joint design is to be selected in accordance with the applicable fabrication document (e.g., NAVSEA S9074-AS-GIB-010/278, NAVSEA 0900-LP-000-1000, MIL-STD-1688 (SH), MIL-STD-1689 (SH), ABS Rules for Buildings and Classing Steel Vessels, etc.)
FIGURE 1
Permanent Backing Strap

<table>
<thead>
<tr>
<th>Plate Thickness ($T$) in mm (inches)</th>
<th>$T_1$, min. in mm (inches)</th>
<th>$W$, min. in mm (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up through 3.2 (1/8)</td>
<td>3.2 (1/8)</td>
<td>12.5 (1/2)</td>
</tr>
<tr>
<td>Over 3.2 (1/8) through 8.0 (5/16)</td>
<td>4.8 (3/16)</td>
<td>25.4 (1)</td>
</tr>
<tr>
<td>Over 8.0 (5/16)</td>
<td>6.4 (1/4)</td>
<td>38 (1-1/2)</td>
</tr>
</tbody>
</table>

Notes:
1. $S = T/2$, but in no case less than 3.2 mm (1/8 in.) or greater than 6.4 mm (1/4 in.) The welds may be on either edge of the strap or within the weld groove.
2. Intermittent fillet welds or tack welds may be used unless otherwise specified.
3. When shapes are used instead of a backing strap, all dimensions and notes are to apply.
4. Butt joints in permanent backing straps are to be welded but need not comply with NDT requirements applicable to the welded joint itself.
FIGURE 2
Butt Joints, Square
B1S.1, B2S.1, B1S.2

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Dimension Y in mm (inches)</th>
<th>Dimension T in mm (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1S.1</td>
<td>0 To 0.8 (1/32)</td>
<td>1.6 (1/16)</td>
</tr>
<tr>
<td>B2S.1</td>
<td>0 To T</td>
<td>6.4 (1/4)</td>
</tr>
<tr>
<td>B1S.2</td>
<td>T min.</td>
<td>4.8 (3/16)</td>
</tr>
</tbody>
</table>

Notes:
1 Joints welded from one side without a backing are not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 3
Butt Joints, Welded on Backing
B1V.1, B1V.2, B1V.3, B1V.4, B1V.5, B1V.6, B1V.7

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Angle X min or range where indicated (degree)</th>
<th>Dim Y mm (in.)</th>
<th>Dim T mm (in.)</th>
<th>Welding Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1V.1</td>
<td>45</td>
<td>4.8 (3/16)</td>
<td></td>
<td>All</td>
</tr>
<tr>
<td>B1V.2</td>
<td>35</td>
<td>6.4 (1/4)</td>
<td></td>
<td>All</td>
</tr>
<tr>
<td>B1V.3</td>
<td>20</td>
<td>9.5 (3/8)</td>
<td></td>
<td>Flat, vert, over</td>
</tr>
<tr>
<td>B1V.4</td>
<td>0 - 25</td>
<td>6.4 (1/4)</td>
<td></td>
<td>All</td>
</tr>
<tr>
<td>B1V.5</td>
<td>45</td>
<td>6.4 (1/4)</td>
<td></td>
<td>Flat, vert, over</td>
</tr>
<tr>
<td>B1V.6</td>
<td>25</td>
<td>9.5 (3/8)</td>
<td></td>
<td>All</td>
</tr>
<tr>
<td>B1V.7</td>
<td>35</td>
<td>9.5 (3/8)</td>
<td></td>
<td>All</td>
</tr>
</tbody>
</table>

NOTES:
1. Ceramic or other nonmetallic backing may be used subject to prior approval.
2. The use of B1V.4 requires prior approval.
FIGURE 4
Butt Joint, Single-V and Single Bevel
B2V.1, B2(S)V.2

B2V.1

25.4 mm (1 in.) max. 0 TO 4.8 mm (3\(\frac{3}{16}\))

SINGLE-V

B2(S)V.2

25.4 mm (1 in.) max. 0 TO 4.8 mm (3\(\frac{3}{16}\))

SINGLE BEVEL
FIGURE 5
Butt Joints, Double-V and Double Bevel
B2V.3, B2(S)V.4

B2V.3

\[
T = 6.4 \text{ mm } \left( \frac{1}{4}'' \right) \text{ Min } \quad 0 \text{ TO } 4.8 \text{ mm } \left( \frac{3}{16}'' \right) \quad 0 \text{ TO } 4.8 \text{ mm } \left( \frac{3}{16}'' \right)
\]

DOUBLE-V

B2(S)V.4

\[
T = 6.4 \text{ mm } \left( \frac{1}{4}'' \right) \text{ Min } \quad 0 \text{ TO } 4.8 \text{ mm } \left( \frac{3}{16}'' \right) \quad 0 \text{ TO } 4.8 \text{ mm } \left( \frac{3}{16}'' \right)
\]

DOUBLE BEVEL
FIGURE 6
Butt Joints, Single-U and Single-J

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Angle X, min. in degrees</th>
<th>Dimension T, min. in mm (inches)</th>
<th>Welding Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2U.1</td>
<td>35</td>
<td>19 (3/4)</td>
<td>All</td>
</tr>
<tr>
<td>B2U.2</td>
<td>20</td>
<td>19 (3/4)</td>
<td>Flat, Vertical, Overhead</td>
</tr>
<tr>
<td>B2U.3</td>
<td>12</td>
<td>19 (3/4)</td>
<td>Flat</td>
</tr>
<tr>
<td>B2J.1</td>
<td>25</td>
<td>19 (3/4)</td>
<td>Flat, Vertical, Overhead</td>
</tr>
<tr>
<td>B2J.2</td>
<td>35</td>
<td>19 (3/4)</td>
<td>All</td>
</tr>
</tbody>
</table>
FIGURE 7
Butt Joints, Double-U and Double-J

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Angle X, min. in degrees</th>
<th>Dimension T, min. in mm (inches)</th>
<th>Welding Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2U.4</td>
<td>35</td>
<td>38 (1-1/2)</td>
<td>All</td>
</tr>
<tr>
<td>B2U.5</td>
<td>20</td>
<td>38 (1-1/2)</td>
<td>Flat, Vertical, Overhead</td>
</tr>
<tr>
<td>B2J.3</td>
<td>25</td>
<td>38 (1-1/2)</td>
<td>Flat, Vertical, Overhead</td>
</tr>
<tr>
<td>B1J.4</td>
<td>35</td>
<td>38 (1-1/2)</td>
<td>All</td>
</tr>
</tbody>
</table>
Note:

1. Joints welded from one side are not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 9
Corner Joints, Outside Single-V
C1V.1, C2V.1

Note:
1 Joints welded from one side are not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 10
Corner Joints, Outside Single Bevel
C1V.2, C1V.3

Note:
1 Joints welded from one side are not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 11
Corner Joints, Fillet Reinforced, Outside Single Bevel
C2V.2, C2V.3

C2V.2

C2V.3
FIGURE 12
Corner Joints, Fillet Reinforced, Inside Single Bevel
C1V.4, C2V.4

C1V.4 (SEE NOTE 1)

WELDED ONE SIDE

C2V.4

WELDED BOTH SIDES

Note:
1 Joints welded from one side are not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 13
Corner Joints, Fillet Welded, Outside Square
C1S.2, C2S.2

C1S.2 (SEE NOTE)

SINGLE

C2S.2

DOUBLE

Note:
1 Joints welded from one side are not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 14
Corner Joints, Fillet Reinforced, Double Bevel
C2V.5, C2V.6

C2V.5

C2V.6
FIGURE 15
Corner Joints, Single-U
C1U.1, C2U.1

C1U.1 (SEE NOTE 1)

4.8 mm $\frac{3}{16}$" Min

1.6 mm $\frac{1}{16}$" TO 4.8 mm $\frac{3}{16}$" $T = 19$ mm $\frac{3}{4}$" Min

0 TO 4.8 mm $\frac{3}{16}$"

WELDED ONE SIDE

C2U.1

4.8 mm $\frac{3}{16}$" Min

$1.6$ mm $\frac{1}{16}$" TO 4.8 mm $\frac{3}{16}$" $T = 19$ mm $\frac{3}{4}$" Min

0 TO 4.8 mm $\frac{3}{16}$"

FILLET REINFORCED

Note:

1 Joints welded from one side are not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 16
Corner Joints, Welded One Side, Outside Single-J
C1J.1, C1J.2, C1J.3, C1J.4

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Angle X, min. in degrees</th>
<th>Dimension T, min. in mm (inches)</th>
<th>Welding Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1J.1</td>
<td>25</td>
<td>19 (3/4)</td>
<td>Flat, Vertical, Overhead</td>
</tr>
<tr>
<td>C1J.3</td>
<td>25</td>
<td>19 (3/4)</td>
<td>Flat, Vertical, Overhead</td>
</tr>
<tr>
<td>C1J.2</td>
<td>35</td>
<td>19 (3/4)</td>
<td>All</td>
</tr>
<tr>
<td>C1J.4</td>
<td>35</td>
<td>19 (3/4)</td>
<td>All</td>
</tr>
</tbody>
</table>

Note:
1 Joints welded from one side are not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 17

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Angle X, min. in degrees</th>
<th>Dimension T, min. in mm (inches)</th>
<th>Welding Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2J.1</td>
<td>25</td>
<td>19 (3/4)</td>
<td>Flat, Vertical, Overhead</td>
</tr>
<tr>
<td>C2J.3</td>
<td>25</td>
<td>19 (3/4)</td>
<td>Flat, Vertical, Overhead</td>
</tr>
<tr>
<td>C2J.2</td>
<td>35</td>
<td>19 (3/4)</td>
<td>All</td>
</tr>
<tr>
<td>C2J.4</td>
<td>35</td>
<td>19 (3/4)</td>
<td>All</td>
</tr>
</tbody>
</table>
FIGURE 18
Corner Joints, Welded One Side, Single Bevel
C1V.5, C1V.6, C1V.7, C1V.8, C1V.9, C1V.10, C1V.11, C1V.12

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Angle X, min. in degrees</th>
<th>Dimension Y, min in mm (inches)</th>
<th>Welding Position</th>
<th>Dimension T</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1V.5</td>
<td>45</td>
<td>6.4 (1/4)</td>
<td>All</td>
<td>Unlimited</td>
</tr>
<tr>
<td>C1V.8</td>
<td>45</td>
<td>6.4 (1/4)</td>
<td>All</td>
<td>Unlimited</td>
</tr>
<tr>
<td>C1V.11</td>
<td>45</td>
<td>6.4 (1/4)</td>
<td>All</td>
<td>Unlimited</td>
</tr>
<tr>
<td>C1V.6</td>
<td>35</td>
<td>9.5 (3/8)</td>
<td>All</td>
<td>Unlimited</td>
</tr>
<tr>
<td>C1V.9</td>
<td>35</td>
<td>9.5 (3/8)</td>
<td>All</td>
<td>Unlimited</td>
</tr>
<tr>
<td>C1V.12</td>
<td>35</td>
<td>9.5 (3/8)</td>
<td>All</td>
<td>Unlimited</td>
</tr>
<tr>
<td>C1V.7</td>
<td>25</td>
<td>9.5 (3/8)</td>
<td>Flat, Vertical, Overhead</td>
<td>Unlimited</td>
</tr>
<tr>
<td>C1V.10</td>
<td>25</td>
<td>9.5 (3/8)</td>
<td>Flat, Vertical, Overhead</td>
<td>Unlimited</td>
</tr>
</tbody>
</table>

Note:
1 Backing may be removed and the joint welded on both sides. If the joint is not welded on both sides, the joint is not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 19
Corner Joint, Welded One Side and Both Sides, Inside Single-J
C1J.5, C2J.5

C1J.5 (SEE NOTE 1)

Note:
1 Joints welded from one side are not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 20
Corner Joint, Fillet Reinforced, Double-J
C2J.6

C2J.6

0 TO 4.8 mm (\(\frac{3}{16}\))

38 mm (\(\frac{1}{2}\)) Min

12.5 mm (\(\frac{1}{2}\)) R Min

1.6 mm (\(\frac{1}{16}\)) TO 4.8 mm (\(\frac{3}{16}\))

35° MIN

35° MIN

DOUBLE-J CORNER JOINT
FILLET REINFORCED
FIGURE 21
Tee Joint, Partial Penetration
PT1S.1

Note:
1 Where the root gap, Y, is greater than 1.6 mm (1/16 in.) as a normal condition, S, the fillet weld leg length, is to be increased by an amount equal to the excess of the opening above 1.6 mm (1/16 in.).
FIGURE 22
Tee Joints, Partial Penetration
PT2S.1, PT2S.2, PT2S.3

Notes:
1. Where the root gap, $Y$, is greater than 1.6 mm (1/16 in.) as a normal condition, $S$, the fillet weld leg length, is to be increased by an amount equal to the excess of the opening above 1.6 mm (1/16 in.).
2. $L$ minimum equals 8 times $S$, but in no case less than 38 mm (1-1/2 in.).
3. $L$ maximum equals 24 times the thickness of the thinner member, but in no case more than 150 mm (6 in.).
4. $C$ maximum equals 48 times the thickness of the thinner member, but in no case more than 300 mm (12 in.).
5. The specific length of the fillet is to be the length of the weld at full size. Crater and taper ends are not to be included when measuring the dimension, $L$.
6. Fillet sizes are to be determined in accordance with the requirements of the applicable fabrication document.
FIGURE 23
Tee Joint (High Efficiency), Fillet Reinforced,
Double Bevel, Partial Penetration
PT2J.1, PT2V.1

Notes:
1. When the calculated land dimension, Z, is not greater than 4.8 mm (3/16 in), a full penetration weld is to be used.
2. Alternate methods of determining a depth of bevel, B, and corresponding size of the reinforcing fillet leg length, S, may be used provided each such joint is individually sketched or checked to ensure that the required effective width of the weld, D, will be obtained. In no case, however, is the reinforcing fillet to be smaller than T/2 or 9.5 mm (3/8 in.), whichever is less.
FIGURE 24
Tee Joint, Fillet Reinforced, Double Bevel, Partial Penetration
PT2J.2, PT2V.2

Notes:
1 For use when the root width, Z, is 12.5 mm (1/2 in.) or greater.
2 The fillet weld leg length, S, is to be T/2 or 9.5 mm (3/8 in.), whichever is less.
FIGURE 24A
Tee Joint, Fillet Reinforced, Partial Penetration, No Backgouging Required
PT2V.3, PT2V.4, PT2V.5

Notes:
1. $B_1$ is not to exceed $2B_2$.
2. $S_B$ is equal to $\frac{1}{2}$ times $T_B$.
3. The fillet weld leg length, $S$, is to be $T/2$ or $9.5$ mm (3/8 in.), whichever is less.

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FIGURE 25
Tee Joint, Fillet Reinforced, Single Bevel
T2V.3, T2V.1

**Note:**

1. Joints welded from one side are not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
### FIGURE 26
Tee Joint, Fillet Reinforced
T2V.2, T1V.1, T1V.2

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Angle X, min. in degrees</th>
<th>Dimension Y, min. in mm (inches)</th>
<th>Dimension T</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1V.1</td>
<td>45</td>
<td>6.4 (1/4)</td>
<td>Unlimited</td>
</tr>
<tr>
<td>T2V.2</td>
<td>35</td>
<td>9.5 (3/8)</td>
<td>Unlimited</td>
</tr>
</tbody>
</table>

**Note:**
1. Backing may be removed and the joint welded on both sides. If the joint is not welded on both sides, the joint is not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 27
Tee Joint, Fillet Reinforced, Single-J
T1J.1, T2J.1

T1J.1 (SEE NOTE 1)

19 mm \(\frac{3}{4}\) Min
1.6 mm \(\frac{1}{16}\) TO 4.8 mm \(\frac{3}{16}\)
0 TO 4.8 mm \(\frac{3}{16}\)
12.5 mm \(\frac{5}{8}\) R Min

WELDED ONE SIDE

T2J.1

19 mm \(\frac{3}{4}\) Min
1.6 mm \(\frac{1}{16}\) TO 4.8 mm \(\frac{3}{16}\)
0 TO 4.8 mm \(\frac{3}{16}\)
12.5 mm \(\frac{5}{8}\) R Min

WELDED BOTH SIDES

Note:
1 Joints welded from one side are not to be used when the root of the weld is subject to a bending tension stress equivalent to one-half the yield strength of the base metal or greater.
FIGURE 28
Tee Joint, Fillet Reinforced, Double-J
T2J.2

T2J.2

DOUBLE-J TEE JOINT,
FILLET REINFORCED
FIGURE 29
Lap Joint, Double Fillet Welded
L2S.1

Note:
1 The size of fillet welds is to be governed by the design requirements.
FIGURE 30
Lap Joint
L1V.1, L1S.1, L1S.2, L1V.2

Note:
1. When T is less than 12.5 mm (1/2 in.), the slot is to be beveled to a 45-degree included angle.
**FIGURE 31**
Edge Joint  
E1S.1, E1V.1, E1U.1, E1U.2

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Angle $X$, min. in degrees</th>
<th>Welding Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1U.1</td>
<td>45</td>
<td>All</td>
</tr>
<tr>
<td>E1U.2</td>
<td>20</td>
<td>Flat, Vertical, Overhead</td>
</tr>
</tbody>
</table>

**Note:**  
1. This joint is not to be used when the root of the weld is subject to bending tension.
FIGURE 32
Butt Welding Plates of Unequal Thickness

Note:
Limits for differences in plate thickness without beveling.

<table>
<thead>
<tr>
<th>Thin Plate Thickness</th>
<th>Thickness Difference, max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>in mm (inch)</td>
<td>in mm (inch)</td>
</tr>
<tr>
<td>Less than 12.5 (1/2)</td>
<td>3.2 (1/8)</td>
</tr>
<tr>
<td>Over 12.5 (1/2) up to 25.4 (1)</td>
<td>4.8 (3/16)</td>
</tr>
<tr>
<td>Over 25.4 (1)</td>
<td>6.4 (1/4)</td>
</tr>
</tbody>
</table>

The transition between members of unequal thickness, greater than those shown above are to require chamfering of the thicker member down to the thickness of the thinner member. For submarines, the taper is to be 4:1 minimum. For surface ships, the taper is to be 2:1 minimum.
FIGURE 33
Butt Joint, Square
P-1

3.2 mm (\(\frac{1}{8}\)) Max

0 TO 1.6 mm (\(\frac{1}{16}\))
FIGURE 34
Butt Joint, V-Groove
P-2
FIGURE 35
Butt Joint, Welded on Permanent Backing Ring

P-3

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Y (Root Opening)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 NPS and under</td>
<td>4.8 (3/16)</td>
</tr>
<tr>
<td>Over 3 NPS</td>
<td>6.4 (1/4)</td>
</tr>
</tbody>
</table>
FIGURE 36
Butt Joint, Welded on Permanent, Integral Backing Ring, V-Groove
P-4

TD SHALL BE EQUAL TO OR GREATER THAN THE MINIMUM REQUIRED WALL THICKNESS

X = 7/16 TO 9/16
Y = 3/16 TO 5/16
FIGURE 37
Butt Joint, Welded on Removable Backing Ring, V-Groove
P-5

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Y (Root Opening), min. in mm (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 NPS and under</td>
<td>4.8 (3/16)</td>
</tr>
<tr>
<td>Over 3 NPS</td>
<td>6.4 (1/4)</td>
</tr>
</tbody>
</table>
FIGURE 38
Butt Joint, Welded on Permanent Backing Ring
U-Groove
P-6
FIGURE 39
Butt Joint, Welded on Removable Backing Ring
U-Groove
P-7

4.8 mm (3/16) R Min

45° MIN.

1.2 mm (3/64) ± 0.4 mm (1/64)

BACKING RING AND WELD
SHALL BE REMOVED FLUSH WITH INSIDE OF PIPE.
FIGURE 40
Butt Joint, Welded on Flared-Type Backing Ring
V-Groove
P-8

BACKING RING AND FIT-UP SHALL BE IN ACCORDANCE WITH 2-14-4/FIGURE 63
FIGURE 41
Butt Joint, Welded on Both Sides, Square
P-9

<table>
<thead>
<tr>
<th>NPS Pipe Size</th>
<th>L (Maximum) in mm (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2</td>
<td>100 (4)</td>
</tr>
<tr>
<td>3</td>
<td>125 (5)</td>
</tr>
<tr>
<td>3-1/2</td>
<td>150 (6)</td>
</tr>
<tr>
<td>4</td>
<td>200 (8)</td>
</tr>
<tr>
<td>5</td>
<td>250 (10)</td>
</tr>
<tr>
<td>6</td>
<td>300 (12)</td>
</tr>
<tr>
<td>8</td>
<td>400 (16)</td>
</tr>
<tr>
<td>10</td>
<td>500 (20)</td>
</tr>
<tr>
<td>12</td>
<td>600 (24)</td>
</tr>
</tbody>
</table>
FIGURE 42
Butt Joint, Welded on Both Sides, V-Groove
P-10

<table>
<thead>
<tr>
<th>NPS Pipe Size</th>
<th>L (Maximum) in mm (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2</td>
<td>100 (4)</td>
</tr>
<tr>
<td>3</td>
<td>125 (5)</td>
</tr>
<tr>
<td>3-1/2</td>
<td>150 (6)</td>
</tr>
<tr>
<td>4</td>
<td>200 (8)</td>
</tr>
<tr>
<td>5</td>
<td>250 (10)</td>
</tr>
<tr>
<td>6</td>
<td>300 (12)</td>
</tr>
<tr>
<td>8</td>
<td>400 (16)</td>
</tr>
<tr>
<td>10</td>
<td>500 (20)</td>
</tr>
<tr>
<td>12</td>
<td>600 (24)</td>
</tr>
</tbody>
</table>
FIGURE 43
Butt Joint, Welded on Both Sides, Double V-Groove
P-11

<table>
<thead>
<tr>
<th>NPS Pipe Size</th>
<th>L (Maximum) in mm (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2</td>
<td>100 (4)</td>
</tr>
<tr>
<td>3</td>
<td>125 (5)</td>
</tr>
<tr>
<td>3-1/2</td>
<td>150 (6)</td>
</tr>
<tr>
<td>4</td>
<td>200 (8)</td>
</tr>
<tr>
<td>5</td>
<td>250 (10)</td>
</tr>
<tr>
<td>6</td>
<td>300 (12)</td>
</tr>
<tr>
<td>8</td>
<td>400 (16)</td>
</tr>
<tr>
<td>10</td>
<td>500 (20)</td>
</tr>
<tr>
<td>12</td>
<td>600 (24)</td>
</tr>
</tbody>
</table>
FIGURE 44
Butt Joint, Automatic Welded One Side, V-Groove
P-12
FIGURE 45
Fillet Welded, Slip-On Coupling
P-13

NOTES:
1. L-min shall be as follows: 1 inch for less than 3/4 NPS, 1-1/2 inch for over 3/4 inch for 3 NPS, 2 inch for over 3 NPS.
2. Up to 22-degree bevel may be used.
3. Maximum socket thickness shall be in accordance with the applicable fitting or component drawing.
4. Joint is acceptable for joining pipe to pipe only and shall not be used for welding to fittings (elles, tees, etc.) unless approved by NAVSEA.
FIGURE 46
Socket, Fillet Welded
P-14

NOTES:
1. Up to 22-degree bevel may be used.
2. Wall thickness (W) and minimum socket depth (L) shall be in accordance with the applicable specification for the fittings.
3. For repairs where the weldment and the pipe must be removed, the existing fitting, with reduced socket depth, may be reused under the following conditions:
   (a) The pipe and gap clearance shall be held to 1/16 inch maximum.
   (b) If the diametrical clearance between the pipe and the fitting is 0.025 inch or less, the L-dimension may be reduced by 50 percent of the specified dimension.
   (c) If the diametrical clearance is greater than 0.025 inch but is within 0.065 inch, the L-dimension may be reduced by 25 percent of the specified dimension.
4. The provisions of note 3 do not apply if the diametrical clearance exceeds 0.065 inch.
5. The provisions of note 3 do not apply to systems classified under "SUBSAFE." For SUBSAFE systems, fittings with reduced socket depth shall not be used without specific approval by NAVSEA.
FIGURE 47
Socket Flange, Fillet Welded
P-15

NOTES:
1. Up through 22-degree bevel may be used.
2. Flange thickness and minimum socket depth (L) shall be in accordance with the 
   applicable specification for the flange.
3. Seal weld required when used for salt water and other corrosive fluids; base 
   material is not resistant to crevice corrosion.
4. For repairs where the weldment and the pipe must be removed, the existing 
   fitting, with reduced socket depth, may be reused under the following conditions:
   (a) The pipe and gap clearance shall be held to 1/16 inch maximum.
   (b) If the diametrical clearance between the pipe and the fitting is 0.025 inch or 
       less, the L-dimension may be reduced by 50 percent of the specified 
       dimension.
   (c) If the diametrical clearance is greater than 0.025 inch but is within 
       0.065 inch, the L-dimension may be reduced by 25 percent of the specified 
       dimension.
5. The provisions of note 3 do not apply if the diametrical clearance exceeds 
   0.065 inch.
6. The provisions of note 3 do not apply to systems classified under "SUBSAFE." For 
   SUBSAFE systems, fittings with reduced socket depth shall not be used without 
   specific approval by NAVSEA.
FIGURE 48
Fillet Welded, Slip-On Flange, Fillet Reinforced, Single Bevel
P-16

NOTES:
1. Dimension D to be as follows:

<table>
<thead>
<tr>
<th>Pipe Size (NPS)</th>
<th>Dim D (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through 2</td>
<td>3/16</td>
</tr>
<tr>
<td>2-1/2 through 7</td>
<td>1/4</td>
</tr>
<tr>
<td>8 through 16</td>
<td>5/16</td>
</tr>
</tbody>
</table>

2. Final machined surface shall have a maximum surface roughness of 125 Rₐ.
FIGURE 49
Structural Sleeve for Piping Penetration, Fillet Welded
P-17

NOTES:
1. The design of the sleeve shall be as specified on the applicable sleeve drawing.
2. Maximum diametrical clearance shall be as follows:
   1/16 inch - for 1/4-NPS through 3-1/2 NPS
   1/8 inch - for 4-inch NPS through 8-NPS
   3/16 inch - above 8-NPS
3. The applicable installation drawing shall specify whether one or both ends of the sleeve shall be welded to the pipe.
FIGURE 50
Double Fillet Welded Slip-On Flange
P-42

NOTES:
1. This joint shall not be used with butterfly valves, spiral-wound gaskets, or flanged joints in oil systems.
2. T x 1-3/4T (minimum) (but the short leg shall not be less than 3/16 inch).
FIGURE 51
Branch Connection, Internal Fillet Welded
P-60

(T TO BE THICKNESS OF THINNEST JOINT MEMBER)

1/8" CLEARANCE MAX (DIAMETRICAL)

45° MIN
FIGURE 52
Branch Connection, External Fillet Welded
P-61
NOTE:

1. \( S = \frac{1}{2}T \) or \( \frac{3}{16} \) inch, whichever is less. Where additional reinforcement is required, "S" shall be as specified by the design.
FIGURE 54
Branch Connection, Welded on Both Sides
External Fillet Reinforced, Single Bevel
P-63

<table>
<thead>
<tr>
<th>NPS</th>
<th>Up to 12</th>
<th>12 to 24</th>
<th>24 and over</th>
</tr>
</thead>
<tbody>
<tr>
<td>L max</td>
<td>I.D.</td>
<td>1-1/2 x I.D.</td>
<td>Unlimited</td>
</tr>
</tbody>
</table>

NOTE:
1. $S = 1/2T$ or 3/16 inch, whichever is less. Where additional reinforcement is required, "$S" shall be as specified by the design.
FIGURE 55
Branch Connection, Welded on Removable Backing Ring
External Fillet Reinforced, Single Bevel
P-64

NOTES:
1. Root openings (Y) for use with backing rings: pipe sizes 3 NPS or less, 3/16 inch min.; pipe sizes over 3 NPS, 1/4 inch min.
2. \( S = \frac{1}{2}T \) or 3/16 inch, whichever is less. Where additional reinforcement is required, S shall be as specified by design.
FIGURE 56
Branch Connection, Welded on Removable Backing Ring
Internal Fillet Reinforced, Single Bevel
P-66

NOTES:
1. Root openings (Y) for use with backing rings: pipe sizes 3 NPS or less, 3/16 inch min.; pipe sizes over 3 NPS, 1/4 inch min.
2. S = 1/2T or 3/16 inch, whichever is less. Where additional reinforcement is required, S shall be as specified by design.
FIGURE 57
Integrally Reinforced Branch Connection
Welded on One Side, Single Bevel
P-67

Note:
1 Pressure and temperature combination are to be in accordance with the rating of the outlet.
FIGURE 58
Integrally Reinforced Fitting, Branch Connection
Welded on One Side or Both Sides, Single Bevel
P-68

Note:
1 Pressure and temperature combination are to be in accordance with the rating of the outlet.
FIGURE 59
Branch Connection with Pilot
Fillet Reinforced, Single Bevel
P-70

NOTES:
1. Root openings (Y) shall conform to the following: pipe sizes 3 NPS or less; 3/16 inch minimum; pipe sizes over 3 NPS, 1/4 inch minimum.
2. For bosses designed as integrally reinforced branch fittings, size of fillet S shall be 1/2T or 3/16 inch, whichever is less.
FIGURE 60
Branch Connection with Plug
Fillet Reinforced, Single Bevel
P-71

NOTES:
1. Root openings (Y) shall conform to the following: pipe sizes 3 NPS or less; 3/16 inch minimum; pipe sizes over 3 NPS, 1/4 inch minimum.
2. For bosses designed as integrally reinforced branch fittings, size of fillet S shall be 1/2T or 3/16 inch, whichever is less.
FIGURE 61
Branch Connection without Pilot
Fillet Reinforced, Single Bevel
P-72

NOTES:
1. Root openings (Y) shall conform to the following: pipe sizes 3 NPS or less; 3/16 inch minimum; pipe sizes over 3 NPS, 1/4 inch minimum.
2. For bosses designed as integrally reinforced branch fittings, size of fillet(s) shall be 1/2T or 3/16 inch, whichever is less.
3. Diameter of attachment (D) shall be 3/16 inch less than the final bore for 1-NPS and smaller branch pipe; 1/4 inch less than the final bore for branch pipe over 1-NPS.
### FIGURE 62
Consumable Insert Butt Joint, V-Groove and U-Groove
P-73, P-74, P-75, P-76, P-77

<table>
<thead>
<tr>
<th>Joint No.</th>
<th>Dim A (inches)</th>
<th>Dim B (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-73</td>
<td>0.10 ± 0.005</td>
<td>0.030 ± 0.005</td>
</tr>
<tr>
<td>P-74</td>
<td>0.10 ± 0.005</td>
<td>0.030 ± 0.005</td>
</tr>
<tr>
<td>P-75</td>
<td>0.10 ± 0.005</td>
<td>0.031 max</td>
</tr>
<tr>
<td>P-76</td>
<td>0.10 ± 0.005</td>
<td>0.031 max</td>
</tr>
<tr>
<td>P-77</td>
<td>0.10 ± 0.005</td>
<td>0.031 max</td>
</tr>
</tbody>
</table>

Notes:
- See Notes 1 through 8
- See Notes 3 + 8
- Dim C (inches) 0.031 max
- Dim D (inches) 40 ± 5/6
- Diff in Dia (inches) 25 ± 3/8
- Dim E (inches) 40 ± 5/6
- Diff in Dia (inches) 25 ± 3/8
- Dim F (inches) 40 ± 2/12
FIGURE 62N
Consumable Insert Butt Joint, V-Groove and U-Groove
Figure Notes

Notes to figure 62:

1. Consumable insert dimensions shall be in accordance with MIL-I-23413.
2. Use of insert rings shall be verified by procedure approval for the specific application.
3. For pipe to be welded in the vertical axis position, θ on the low side of the joint may be as follows, provided the total included angle is 2 times the angle θ specified in the table:
   (a) 30 degrees ± 3 degrees for P-73 and P-75.
   (b) 8 degrees ± 3 degrees for P-74 and P-76.
4. Consumable inserts of geometries different from those shown herein or in MIL-I-23413 may be used following welding procedure approval, by an authorized agent as identified in 3.2.
5. The depth of counterbore A may be obtained by machining, expanding, or forming and shall be 3/8 inch minimum or T-minimum whichever is greater, except that on elbows, A shall be limited to a depth that will not reduce the wall thickness below the minimum allowable value. In no case shall A be less than 1/8 inch.
6. Center of radius shall be located so that the plane of the root face will extend not more than 0.015 inch from the nominal position shown. (See insert sketch for joint type P-74.)
7. For joints of nickel-copper (S-42) and nickel-chromium-iron (S-43) materials dimensions B may be changed to 1/16 inch ± 1/64 inch for joint P-74.
8. For joints of nickel-copper materials dimension B may be changed to 47-1/2 degrees ± 2-1/2 degrees for joint P-73.
FIGURE 63
Backing Rings for Welded Pipe Joints

Removable backing ring

Permanent backing rings

(a) Flat type

(b) Flared type

See Note 5

<table>
<thead>
<tr>
<th>Ring type</th>
<th>Dim.</th>
<th>2&quot; IPS or less</th>
<th>over 2&quot; IPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>1/8&quot; + 1/32&quot;</td>
<td>3/16&quot; max.</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>3/4&quot; + 1/32&quot;</td>
<td>1&quot; + 1/32&quot;</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>1/16&quot; approx.</td>
<td>1/16&quot; - 1/32&quot;</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>3/8&quot; approx.</td>
<td>45° chamfer</td>
<td>3/16&quot; + 1/32&quot;</td>
</tr>
<tr>
<td>Flared</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>1/8&quot; + 1/32&quot;</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>3/4&quot; + 1/32&quot;</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>1/32&quot; approx.</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>9/32&quot; approx</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>
FIGURE 63N
Backing Rings for Welded Pipe Joints
Figure Notes

Notes to figure 63:

1. Rings may be solid or split type. For class P-1 piping, permanent split-type rings, if used, shall be welded after fitting and before final insertion in the pipe. (When split-type rings are welded, defects that can be identified as being in the backing ring butt weld shall not be cause for rejection.) For class P-2 piping, backing ring butts need not be welded.

2. Backing rings may be furnished with spacers as follows:

   (a) A minimum of three spacers shall be located around the outer surface of the backing ring to maintain a minimum root opening.
   (b) No portion of the ring other than the spacers shall project beyond the outer surface of the backing ring.
   (c) Removable spacers shall not require, or result, in removal of material from the backing ring for a depth of more than one-half the thickness of the ring.
   (d) When used, nonremovable spacers shall be constructed to permit complete fusion of the spacers into the backing ring and the welding groove without causing weld defects. A spacer having a cross-sectional area greater than 0.125 square inch and a height of more than one-half the thickness of the ring shall not be permitted. (Push-out-type spacers shall show blank dots on radiograph.)

3. Backing rings may be tack welded inside or outside.

4. Backing rings shall not have a diametrical clearance of more than 0.045 inch for pipe sizes 2 inch IPS and smaller and 0.065 inch for pipe sizes 2-1/2 inch IPS and larger.

5. The depth of counterbore may be obtained by machining, expanding, or forming; and shall be 1/2 inch (minimum) or T (minimum), whichever is larger, to ensure proper pipe inside diameter in way of joint. Counterbore for elbows shall be limited to a depth that will not reduce wall thickness below design minimum.

6. Pipe tapers less than 4:1 are acceptable provided they meet the requirements of approved ANSI fittings or applicable drawings.
FIGURE 63A
Bell End Fitting Socket Weld Joint

NOTES:
1. Minimum thickness (W) in all areas after expansion is equal to the minimum pipe purchase wall thickness.
2. Minimum expansion radius (R) is four times the expansion thickness.
3. Minimum insertion depth (L) shall be in accordance with the applicable fitting specification. Minimum insertion depth may be reduced to 0.75 L if diametrical clearance is less than 0.025 inch.
4. Fillet weld leg shall extend to the top of the required expansion thickness.
5. The use of this joint shall require NAVSEA approval.
6. Unless otherwise approved by NAVSEA.
FIGURE 64
Root Connections
V-4, V-5, V-6
FIGURE 65
Nozzle Joints
V-7, V-8
FIGURE 66
Nozzle Joints
V-9, V-11, V-12

INSIDE DIAMETER $D_n$ IS THE DIAMETER BEFORE WELDING. AFTER WELDING THE JOINT SHALL BE FINISHED BY MACHINING OR DRILLING THE INSIDE WALL TO DIAMETER $D_n$. 

V-9

V-11

V-12
FIGURE 67
Nozzle Joints
V-14, V-15

V-14

V-15

STEEL RING

SURFACE FINISHED AND DRILLED TO SUIT CONNECTION

FILL WITH WELD METAL INSIDE RING

45° MIN

EQUIPMENT

BUILT UP FLANGE PAD FOR FERROUS EQUIPMENT
FIGURE 68
Root Connections
V-21, V-22, V-23, V-24, V-25, V-26
FIGURE 69
Outlet Connections, Fillet Reinforced, Single-J V-27
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Structural Tank Nozzle to Pipe, Fillet Welded
V-28
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<th>Page</th>
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<td>221</td>
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</tr>
<tr>
<td></td>
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<td>220</td>
</tr>
</tbody>
</table>
PART 2

CHAPTER 14 Welding and Fabrication

SECTION 5 Alternative Requirements for Fillet Weld Size

1 Scope

These requirements are considered suitable for fillet weld design involving military ships, and supersede MIL-STD-1628. Where requested and approved by ABS in accordance with 3-2-19/17, the sizing for fillet welds is to comply with these requirements.

3 General

3.1 Approach

The approach contained herein is applicable to the sizing of double continuous fillet welds and double continuous partial penetration Tee welds in ship structure. The method may be used to size welds at the intersection of continuous members and intercostal members.

3.3 Methodology

The engineering methodology and calculation in these requirements is based upon the design of weld size by means of analyzing the strength of the base metal in way of the weld and analyzing the strength of the weld metal. The analysis entails calculating and comparing the following strengths under both longitudinal loading and transverse loading:

- Heat affected zone of continuous member
- Heat affected zone of intercostal member
- Weld metal throat

The final weld sizing criterion is that which is appropriate for the weaker member. This method is not intended to furnish strength values for use in determining design or allowable working loads based on yield strength or allowable working stresses.

5 Terms, Definitions, and Symbols

5.1 General

The terms and definitions of AWS A3.0 apply to this document.
5.3 Symbols

\[ B \]
Base leg or depth of bevel, inches.

\[ C_F \]
Computation factor

\[ D \]
Effective width of the weld in shear, inches

\[ E \]
Efficiency of joint

\[ F_1 \]
Longitudinal force on welds, pounds

\[ F_2 \]
Fillet weld strength per linear inch, pounds/inch

\[ HAZB_i \]
Heat Affected Zone Boundary of intercostal member (length = 1.1 \times S).

\[ HAZB_c \]
Heat affected Zone Boundary of continuous member (length = 1.1 \times S for case III and length = S for case VI).

\[ L \]
Length of welded joint, inches

\[ R \]
Ultimate tensile strength of weaker member, pounds per square inch (psi).

\[ R_1 \]
Ultimate tensile strength of intercostal member, pounds per square inch (psi).

\[ R_2 \]
Longitudinal shear strength of weld metal, psi.

\[ R_3 \]
Ultimate shear strength of intercostal member, psi.

\[ R_4 \]
Transverse shear strength of weld metal, psi.

\[ R_5 \]
Ultimate tensile strength of continuous member, psi.

\[ R_6 \]
Ultimate shear strength of continuous member, psi.

\[ S \]
Fillet weld size, inches

\[ T \]
Thickness of weaker member (\( T_C \) or \( T_I \)), inches

\[ T_C \]
Thickness of continuous member, inches.

\[ T_I \]
Thickness of intercostal member, inches.

\[ Z \]
Land width (to nearest \( \frac{1}{16} \)), inches.

7 General Requirements

7.1 Joint efficiency

Joint efficiency is to be based on the strength of the weaker member being joined and the loading direction governing weld sizing.

7.3 Joint Strength

The strength of continuous double fillet welded joints are to be based on the longitudinal and transverse strengths of the base metal-filler metal combinations.

7.5 Reduced Weld Size

Where it can be shown from a design standpoint that the thickness of the weaker member joined is greater than that required to provide the necessary strength, the fillet weld size may be reduced accordingly to provide a weld joint efficiency based on the actual required weaker member thickness.
7.7 Fabrication Applicability

The applicable fabrication document is to specify the following:

Acceptability of the filler metal and base metal combinations.
Minimum required joint efficiencies.
Allowable joint design requirements.
Any specific weld joint dimensions or restrictions.

7.9 Service Applicability

Service conditions where the welds are not anticipated to deteriorate due to environmental actions are to be demonstrated for consideration of approval for classification purposes. The intended service is to be considered for the following:

Criticality of the welds to the service performance.
Fatigue loading of the welds
Corrosion rates of the welds
Service history of welds under renewal

9 Detail Requirements

9.1 Weaker member

Continuous double fillet weld sizes for a given efficiency are based upon the load carrying capacities of the weaker member and the shear strengths of the filler metal. The weaker member, the intercostal member ($T_I$) or the continuous member ($T_C$), must be determined separately for the longitudinal loading direction and for the transverse direction. When the continuous member is weaker than the intercostal member and a third member provides back-up to ensure adequate transfer of loads, the intercostal member is to be considered the weaker member.

9.1.1 Longitudinal Loading

For loading in the longitudinal direction, the strength of the intercostal member is equal to the product of the thickness times the ultimate shear strength ($T_I \times R_3$), and the strength of the continuous member is equal to two (2) times the product of the thickness times the ultimate shear strength ($2 \times T_C \times R_6$). The lower strength value establishes the weaker member in the longitudinal direction.

9.1.2 Transverse Loading

For loading in the transverse direction, the strength of the intercostal member is equal to the product of the thickness times the ultimate tensile strength ($T_I \times R_1$), and the strength of the continuous member is equal to two (2) times the product of the thickness times the ultimate shear strength ($2 \times T_C \times R_6$). The lower strength value establishes the weaker member in the transverse direction.

9.3 Base Metal Strength

The base metal strengths are shown in 2-14-5/Table 1, which lists the ultimate tensile and shear strengths. The values given in 2-14-5/Table 1 are common minimum plate values for each type of material represented. Certain material specifications may have differing minimum values.
TABLE 1
Base Metal Strength Values

<table>
<thead>
<tr>
<th>Base Material Type (1)</th>
<th>Minimum Ultimate Tensile Strength (psi) (R₃ or R₆) (2), (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quenched and tempered alloy steel (HY-130)</td>
<td>137,000</td>
</tr>
<tr>
<td>Quenched and tempered alloy steel (HY-100)</td>
<td>114,000</td>
</tr>
<tr>
<td>High Strength Low Alloy Steel (HSLA-100)</td>
<td>114,000</td>
</tr>
<tr>
<td>Quenched and tempered alloy steel (HY-80)</td>
<td>96,000</td>
</tr>
<tr>
<td>High Strength Low Alloy Steel (HSLA-80)</td>
<td>96,000</td>
</tr>
<tr>
<td>Special treatment steel (STS)</td>
<td>105,000</td>
</tr>
<tr>
<td>Higher strength steel (HS)</td>
<td>75,000</td>
</tr>
<tr>
<td>Ordinary strength steel (OS)</td>
<td>60,000</td>
</tr>
<tr>
<td>Austenitic stainless steel (SS)</td>
<td>75,000</td>
</tr>
<tr>
<td>Nickel-copper alloy (NiCu)</td>
<td>70,000</td>
</tr>
<tr>
<td>Copper-nickel alloy (CuNi)</td>
<td>45,000</td>
</tr>
<tr>
<td>Aluminum alloy 5456</td>
<td>45,000</td>
</tr>
<tr>
<td>Aluminum alloy 5454</td>
<td>36,000</td>
</tr>
<tr>
<td>Aluminum alloy 5086</td>
<td>38,000</td>
</tr>
<tr>
<td>Aluminum 5083</td>
<td>40,000</td>
</tr>
<tr>
<td>Aluminum 5052</td>
<td>25,000</td>
</tr>
<tr>
<td>Nickel-Chromium-iron alloy (NiCrFe)</td>
<td>80,000</td>
</tr>
<tr>
<td>Nickel-Chromium-Molybdenum-Columbium (NiCrMoCb)</td>
<td>110,000</td>
</tr>
</tbody>
</table>

Notes

1 Base material specifications shall be in accordance with the applicable fabrication document.
2 Unless otherwise specially approved and based on actual test data, base material shear strength values shall be determined as follows:

   For aluminum alloys:
   \[ R₃ = 0.60 \times R₁ \]
   \[ R₆ = 0.60 \times R₅ \]

   For steels (i.e., OS, HS, HY-80/100/130, HSLA-80/100, STS):
   \[ R₃ = 0.75 \times R₁ \]
   \[ R₆ = 0.75 \times R₅ \]

   For other materials:
   \[ R₃ = 0.67 \times R₁ \]
   \[ R₆ = 0.67 \times R₅ \]

3 The most common minimum ultimate tensile strength used in material specifications has been used for the minimum tensile strength. In the case of quenched and tempered alloy steels, the tensile strength has been based on a statistical analysis of 38 test certificates to develop a relationship between tensile strength (TS) and yield strength (YS).

   \[ TS = 1.20 \ \text{YS} \text{ for HY-80} \]
   \[ TS = 1.14 \ \text{YS} \text{ for HY-100} \]
   \[ TS = 1.05 \ \text{YS} \text{ for HY-130} \]
9.5 Filler Metal Strength

The filler metal strengths are shown in 2-14-5/Table 2, which lists the ultimate tensile strength, average longitudinal shear strength and transverse shear strength. 2-14-5/Table 2 also lists filler metal types by applicable specification having physical properties and chemical compositions sufficiently close to those listed that they can be considered equivalent for weld sizing purposes. Filler metal types not covered by this document, but which are approved for use by the applicable fabrication document, are to be tested in accordance with 2-14-5/13.

<table>
<thead>
<tr>
<th>Filler Metal Type for Weld Sizing Calculations</th>
<th>Equivalent Filler Metal Types for Weld Sizing Calculations</th>
<th>Applicable Specification(s)</th>
<th>Minimum Ultimate Tensile Strength (ksi) (1)</th>
<th>Average Longitudinal Shear Strength (ksi) (R_s)</th>
<th>Average Transverse Shear Strength (ksi) (R_t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIL-12018-M2</td>
<td>MIL-12018-M2</td>
<td>MIL-E-22200.10</td>
<td>120</td>
<td>82</td>
<td>110</td>
</tr>
<tr>
<td>MIL-11018-M</td>
<td>MIL-11018-M</td>
<td>MIL-E-22200/1</td>
<td>110</td>
<td>79</td>
<td>105</td>
</tr>
<tr>
<td>MIL-10018-M</td>
<td>MIL-10018-M</td>
<td>MIL-E-22200/1</td>
<td>100</td>
<td>72</td>
<td>99</td>
</tr>
<tr>
<td>MIL-9018-M</td>
<td>MIL-9018-M</td>
<td>MIL-E-22200/1</td>
<td>90</td>
<td>69</td>
<td>91</td>
</tr>
<tr>
<td>MIL-80XX-C3</td>
<td>MIL-8015-C3(5)</td>
<td>MIL-E-22200(6)(1)</td>
<td>80</td>
<td>62</td>
<td>2</td>
</tr>
<tr>
<td>MIL-70XX</td>
<td>MIL-7015(5)</td>
<td>MIL-E-22200/1</td>
<td>70</td>
<td>54</td>
<td>2</td>
</tr>
<tr>
<td>MIL-60XX</td>
<td>MIL-6010(5)</td>
<td>QQ-E-450(5)</td>
<td>60</td>
<td>49</td>
<td>2</td>
</tr>
<tr>
<td>MIL-309XX</td>
<td>MIL-308-15</td>
<td>MIL-E-22200/2</td>
<td>80</td>
<td>58</td>
<td>2</td>
</tr>
</tbody>
</table>

TABLE 2
Filler Metal Strength Values
<table>
<thead>
<tr>
<th>Filler Metal Type for Weld Sizing Calculations</th>
<th>Equivalent Filler Metal Types for Weld Sizing Calculations</th>
<th>Applicable Specification(s)</th>
<th>Minimum Ultimate Tensile Strength (ksi) (1)</th>
<th>Average Longitudinal Shear Strength (ksi) ($R_{L}$)</th>
<th>Average Transverse Shear Strength (ksi) ($R_{T}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E410NiMo</td>
<td>E410NiMo</td>
<td>AWS A5.4</td>
<td>110</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>MIL-8N12</td>
<td>MIL-8N12, MIL-8N12H</td>
<td>MIL-E-22200/3, MIL-E-22200/3, MIL-E-22200/3</td>
<td>80</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>MIL-9N10</td>
<td>MIL-9N10</td>
<td>MIL-E-22200/3, MIL-E-22200/3</td>
<td>70</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>MIL-CuNi (70-30)</td>
<td>MIL-CuNi (70-30)</td>
<td>MIL-E-22200/4, MIL-E-22200/4</td>
<td>50</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

**BARE ELECTRODES**

| MIL-140S-1                                     | MIL-140S-1                                           | MIL-3-24355, MIL-E-23765/2 | 140                                         | 101                                              |                                               |
| MIL-120S-1                                     | MIL-120S-1                                           | MIL-E-23765/2               | 120                                         | 87                                              |                                               |
| MIL-100S-1                                     | MIL-100S-1                                           | MIL-E-23765/2               | 100                                         | 83                                              | 99                                            |
| ER80S-B2L                                      | ER80S-B2L, MIL-80S-1                                 | MIL-E-23765/2, AWS A5.28    | 80                                          | 56                                              |                                               |
| MIL-70S-1                                      | MIL-70S-1, MIL-70S-2, MIL-70S-3                       | MIL-E-23765/1, MIL-E-23765/1, MIL-E-23765/1 | 70                                          | 59                                              |                                               |
| MIL-B88                                        | MIL-B88(5)                                           | MIL-E-19822(5)              | 100                                         | 80                                              |                                               |
| MIL-CuNiA1                                     | MIL-CuNiA1                                           | MIL-E-23765/5               | 85                                          | 46                                              |                                               |
| MIL-E82                                        | MIL-EN82, MIL-EN82H                                  | MIL-E-21562, MIL-E-21562    | 80                                          | 55                                              |                                               |
| MIL-EN82H                                      | MIL-EN82H, MIL-EN82H                                 | MIL-E-21562, MIL-E-21562    | 80                                          | 69                                              |                                               |
| MIL-316L-15                                    | MIL-308L, MIL-316L                                  | MIL-E-19933, MIL-E-19933, MIL-E-19933 | 75                                          | 61                                              |                                               |
| MIL-EN60                                       | MIL-EN60, MIL-RN60                                   | MIL-E-21562, MIL-E-21562    | 70                                          | 53                                              |                                               |
| MIL-EN61                                       | MIL-EN61, MIL-RN61                                   | MIL-E-21562, MIL-E-21562    | 60                                          | 58                                              |                                               |
| MIL-CuNi (70-30)                               | MIL-CuNi (70-30)                                    | MIL-E-23765/3, MIL-E-23765/3 | 50                                          | 45                                              |                                               |
| MIL-CuSi                                       | MIL-CuSi                                             | MIL-E-23765/3               | 50                                          | 18                                              |                                               |
| MIL-71T-1M                                     | MIL-71T-1M                                           | MIL-E-24403/1               | 70                                          | 64                                              |                                               |
| MIL-71T-1-HY                                   | MIL-71T-1-HY                                        | MIL-E-24403/1               | 70                                          | 68                                              |                                               |
| MIL-101-TC/TM                                  | MIL-101TC, MIL-101TM                                 | MIL-E-24403/2, MIL-E-24403/2 | 100                                         | 74                                              | 103                                           |
| MIL-5356                                       | MIL-5356(5), ER5356                                  | MIL-E-16053(5), AWS A5.10   | 35                                          | 22                                              | 29                                            |
### Filler Metal Type for Weld Sizing Calculations

<table>
<thead>
<tr>
<th>Filler Metal Type for Weld Sizing Calculations</th>
<th>Equivalent Filler Metal Types for Weld Sizing Calculations</th>
<th>Applicable Specification(s)</th>
<th>Minimum Ultimate Tensile Strength (ksi)</th>
<th>Average Longitudinal Shear Strength (ksi) ($R_{l}$)</th>
<th>Average Transverse Shear Strength (ksi) ($R_{t}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIL-5556</td>
<td>MIL-5556(5) ER5556</td>
<td>MIL-E-16053(5) AWS A5.10</td>
<td>42</td>
<td>24</td>
<td>31</td>
</tr>
<tr>
<td>ER4043</td>
<td>ER4043</td>
<td>AWS A5.10</td>
<td>24</td>
<td>13</td>
<td>(2)</td>
</tr>
<tr>
<td>ER1100</td>
<td>ER1100</td>
<td>AW A5.10</td>
<td>11</td>
<td>6</td>
<td>(2)</td>
</tr>
<tr>
<td>ERTi-6A1-4V</td>
<td>ERTi-5 ERTi-6A1-4V(7)</td>
<td>AWS A5.16 AWS A5.16(7)</td>
<td>146</td>
<td>(6)</td>
<td>(2)</td>
</tr>
<tr>
<td>ERTi-1</td>
<td>ERTi-1</td>
<td>AWS A5.16</td>
<td>60</td>
<td>(6)</td>
<td>(2)</td>
</tr>
<tr>
<td>ERTi-2</td>
<td>ERTi-2</td>
<td>AWS A5.16</td>
<td>58</td>
<td>(6)</td>
<td>(2)</td>
</tr>
<tr>
<td>ERTi-3</td>
<td>ERTi-3</td>
<td>AWS A5.16</td>
<td>82</td>
<td>(6)</td>
<td>(2)</td>
</tr>
<tr>
<td>MI-1N12</td>
<td>MIL-EN25 MIL-RN625</td>
<td>MIL-E-21562 MIL-E-21562</td>
<td>110</td>
<td>77</td>
<td>(2)</td>
</tr>
</tbody>
</table>

#### Notes

1. Value specified may not be a specification requirement.
2. $R_{l} = 1.33 R_{2}$ where test values are not available.
3. $R_{2} = 0.6 x$ minimum ultimate tensile strength where test values are not available.
4. $R_{2} = 0.5 x$ minimum ultimate tensile strength where test values are not available.
5. This is a canceled specification or electrode that is included for information.
6. Actual longitudinal shear strength test values are not available. Estimated values (based on a percent of ultimate tensile strength) may be used when approved.
7. This filler metal type is applicable to a superseded specification issue.

### 11 Calculation of Fillet Weld Strength, Computation Factors, Fillet Weld Size and Efficiencies

#### 11.1 Fillet Weld Strength

Calculation of continuous double fillet weld longitudinal strength per linear inch ($F_{2}$), and the overall load carrying capacity ($F_{1}$) is to be accomplished using the following formulas:

\[
F_{2} = 1.414 S R_{2} \quad \text{(rounded to nearest 1,000 psi)}
\]

\[
F_{1} = F_{2} L \quad \text{(rounded to nearest 5,000 lbs)}
\]

#### 11.3 Calculation of Computation Factors

Formulas for determining computation factors ($S/T$) for a given base metal and filler metal combination are shown in 2-14-5/Table 3. 2-14-5/Figure 1 illustrates a continuous double fillet weld. 2-14-5/Figure 2 shows the load directions and weld failure areas. The following four steps are to be followed to determine the governing factor that is to be used for weld sizing purposes:

Step 1 Determine the weaker member for loading in the longitudinal and transverse direction (see 2-14-5/9.1).

Step 2 Calculate the largest computation factor based on the appropriate formulas for the weaker member in the longitudinal direction.
Step 3 Calculate the largest computation factor based on the appropriate formulas for the weaker member in the transverse direction.

Step 4 Select the larger value of the two computation factors, from Steps 2 and 3 above. The governing computation factor and weaker member thickness are to be used to determine the fillet weld size for a given joint efficiency.

### TABLE 3
**Formulas for Computation Factors**

<table>
<thead>
<tr>
<th>Load Direction</th>
<th>Failure Region</th>
<th>Case</th>
<th>Intercostal Member</th>
<th>Continuous Member</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal</td>
<td>Weld throat 45 degree plane</td>
<td>I</td>
<td>$S = \frac{R_3}{T_I}$ 1.414$R_2$</td>
<td>$S = \frac{R_6}{T_c} 0.707R_2$</td>
</tr>
<tr>
<td></td>
<td>HAZB$_B$ (Intercostal member)</td>
<td>II</td>
<td>$S = \frac{T_I}{0.454}$</td>
<td>$S = \frac{R_6}{T_c} 1.1R_3$</td>
</tr>
<tr>
<td></td>
<td>HAZB$_C$ (Continuous member)</td>
<td>III</td>
<td>$S = \frac{R_3}{T_I} 2.2R_6$</td>
<td>$S = \frac{S}{T_c} 0.909$</td>
</tr>
<tr>
<td>Transverse</td>
<td>Weld throat 45 degree plane</td>
<td>IV</td>
<td>$S = \frac{R_1}{T_I} 1.414R_4$</td>
<td>$S = \frac{R_6}{T_c} 0.707R_4$</td>
</tr>
<tr>
<td></td>
<td>HAZB$_B$ (Intercostal member)</td>
<td>V</td>
<td>$S = \frac{R_3}{T_I} 2.2R_3$</td>
<td>$S = \frac{R_6}{T_c} 1.1R_3$</td>
</tr>
<tr>
<td></td>
<td>HAZB$_B$ (Continuous member)</td>
<td>VI</td>
<td>$S = \frac{R_3}{T_I} 2.0R_5$</td>
<td>$S = \frac{R_6}{T_c} R_5$</td>
</tr>
</tbody>
</table>

**Notes**

1. For definition of symbols, see 2-14-5/5.3.
2. Computation factors shall be rounded off to the nearest 0.05.
FIGURE 1
Double Fillet Weld Joint Design

TRANSVERSE DIRECTION

LONGITUDINAL DIRECTION IS PERPENDICULAR TO PLANE X-Y

INTERCOSTAL MEMBER

FILLET WELD EACH SIDE

45° WELD THROAT

CONTINUOUS MEMBER
FIGURE 2
Weld Loading Directions and Failure Areas
11.5 Calculation of Fillet Weld Size

The fillet weld size is to be calculated by the following formula:

\[ S = e T C_F \] (rounded up to the next larger 1/16 inch.)

11.7 Calculation of Fillet Weld Efficiency

The efficiency of continuous double fillet welds is to be calculated using the following formula:

\[ e = \frac{S}{TC_F} \] (rounded to nearest 0.05 or 5 percent)

13 Development of Shear Data

For filler metals not listed in 2-14-5/Table 2, fillet weld shear strength data is to be obtained by performing four longitudinal fillet weld tests in accordance with the following procedure:

- The tests are to be conducted in accordance with AWS B4.0.
- The tests are to include two specimens of each fillet size (1/4-inch and 3/8-inch).
- Test specimens with the same fillet size are to be welded with a different heat of filler metal.
- The average actual throat of the fractured fillet weld test specimen is to be measured and used to calculate the shear strength.
- The shear strength values for the four test specimens are to be averaged and rounded-off to the nearest thousand.

15 Partial Penetration Groove Tee Welds

Partial penetration groove tee welds designed to these requirements require special approval. Additional joint configuration requirements, such as minimum bevel angle and minimum land width, \( Z \), are to be in accordance with the applicable fabrication document or weld joint design standards. Alternate methods of determining the depth of bevel, \( B \), and corresponding reinforcing fillet size, \( S \), may be used when specially approved.

15.1 Weld Dimensions

Partial penetration groove tee weld dimensions, as shown in 2-14-5/Figure 3, are to be computed as specified herein. The structurally weaker member for partial penetration groove tee welds is to be that member which has the lowest product of thickness times ultimate strength.
FIGURE 3
Double Partial Penetration Groove Tee Weld Joint Design

Double – Bevel Tee Joint

Double – J Tee Joint
Part 2  Supplementary Requirements for Naval Vessels
Chapter 14  Welding and Fabrication
Section 5  Alternative Requirements for Fillet Weld Size

15.3  Effective Width

The effective width of the weld in shear, \( D \), is to be computed using the following equation:

\[
D = \frac{eTR}{2R_2} \quad \text{(rounded to nearest 0.001)}
\]

15.5  Depth of Bevel

There are two equations for the base leg or depth of bevel, \( B \).

15.5.1  When \( D \) is not greater than 0.707 inch

When \( D \) is not greater than 0.707 inch, the equation for \( B \) is to be:

\[
B = \frac{D}{1.414} \quad \text{(rounded to next larger 1/16 inch)}
\]

\[
S = B, \quad S \geq \frac{1}{4} \text{ inch}
\]

15.5.2  When \( D \) is greater than 0.707 inch

When \( D \) is greater than 0.707 inch, the equation for \( B \) is to be:

\[
B = (D^2 - 0.25)^{0.5} \quad \text{(rounded to next larger 1/16 inch)}
\]

\[
S \geq \frac{1}{2} \text{ inch}
\]

15.7  Land Width

The land width, \( Z \), is to be calculated using the following equation:

\[
Z = T_I - 2B
\]

17  References

The following documents of the issue in effect on the date of the solicitation form a part of this standard to the extent specified herein. Canceled specifications noted herein are retained for informational purposes and to assist in the selection of equivalent filler metal types for weld sizing determination.

Federal and Military Specifications

- QQ-E-450  Electrodes, Welding, Covered: Mild Steel (Canceled).
- MIL-E-16053  Electrodes, Welding, Bare, Aluminum Alloys (Canceled).
- MIL-E-18193  Electrodes, Welding, Carbon Steel and Alloy Steel, Bare, Coiled (Canceled).
- MIL-E-19822  Electrodes, Welding, Bare, High-Yield Steel (Canceled).
- MIL-E-19933  Electrodes and Rods - Welding, Bare, Chromium and Chromium-Nickel Steels.
- MIL-E-21562  Electrodes and Rods - Welding, Bare, Nickel Alloy.
- MIL-E-22200/2  Electrodes, Welding, Covered (Austenitic Chromium-Nickel Steel).
- MIL-E-22200/3  Electrodes, Welding, Covered: Nickel Base Alloy; and Cobalt Base Alloy.
- MIL-E-22200/4  Electrodes, Welding, Covered, Copper-Nickel Alloy.
- MIL-E-22200/6  Electrodes, Welding, Mineral Covered, Low-Hydrogen, Medium and High Tensile Steel (Canceled).
- MIL-E22200/7  Electrodes, Welding, Covered, Molybdenum Alloy Steel Application (Canceled).
### MIL-E-22200/8

### MIL-E-22200/9

### MIL-E-22200/10

### MIL-E-23765/1
Electrodes and Rods - Welding, Bare, Solid and Alloyed Cored, Ordinary Strength and Low Alloy Steel.

### MIL-E-23765/2
Electrodes and Rods - Welding, Bare, Solid and Alloyed Cored, Low Alloy Steel.

### MIL-E-23765/3
Electrodes and Rods - Welding, Bare, Solid Copper Alloy.

### MIL-E-23765/4
Electrodes, Welding, Bare, Solid; and Fluxes, Submerged Arc Welding, Carbon and Low Alloy Steels.

### MIL-E-24403/1
Electrodes, Welding, Flux Cored, Ordinary Strength and Low alloy Steel.

### MIL-E-24403/2
Electrodes - Welding, Flux cored, Low-Alloy Steel.

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**American Welding Society (AWS)**

A3.0 Terms and Definitions

A5.1 Carbon Steel Electrodes for Shielded Metal Arc Welding, Specification for.

A5.4 Stainless Steel Electrodes for Shielded Metal Arc welding, Specification for.

A5.5 Low Alloy Steel Covered Arc Welding Electrodes, Specification for.

A5.10 Bare Aluminum and Aluminum Alloy Welding Electrodes and Rods, Specification for.

A5.16 Titanium and Titanium Alloy Welding Electrodes and Rods, Specification for.

A5.28 Low Alloy Steel Filler Metals for Gas Shielded Arc Welding, Specification for.

B4.0 Standard Method for Mechanical Testing of Welds.