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MILITARY STANDARD

FABRICATION, WELDING AND INSPECTION OF HY-80/100 SUBMARINE APPLICATIONS

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FOREWARD

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this standard should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

CONTENTS

CONTENTS - continued

CONTENTS - continued

CONTENTS - continued

CONTENTS - continued

CONTENTS - continued

CONTENTS - continued

CONTENTS - continued

CONTENTS - continued

CONTENTS - continued

CONTENTS - continued

CONTENTS - continued

TABLES

CONTENTS - continued

TABLES - continued

FIGURES

If MBL > 10, (a single digit principal digit), apply / point type to the

CONTENTS - continued

FIGURES - continued

APPENDICES

1. SCOPE

1.1 Scope. This standard contains minimum requirements for shipbuilding practices, standards for materials, weld joint design, workmanship, welding inspection, and record requirements for combatant submarines and non-combatant submersibles constructed of HY-80/100 material. Requirements for HY-130 submarine applications are contained in MIL-STD-1681. Requirements for non-HY steel submarine applications are contained in MIL-STD-1689.

1.2 This contains both mandatory requirements and guidance information. The mandatory requirements indicated by the words "shall" or "is required" are designed to serve as standards applicable to materials, workmanship, inspection, and quality control. Guidance information is indicated either by the words "should" or "may". Such information represents the latest technical guidance to assure quality but is not mandatory.

1.3 Reference in this document to a particular paragraph or section number shall include all applicable subparagraphs under that paragraph or section number. For example, the reference to 6.6 shall include 6.6.1, 6.6.2, 6.6.2.1 and 6.6.3.

1.4 Requirements subject to Naval Sea Systems Command (NAVSEA) approval. Any requirements contained in this standard specifically requiring NAVSEA approval shall be forwarded to Naval Sea Systems Command, Metals Division, SEA 5142, Washington, DC 20362-5101.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks 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 (see 17.2).

SPECIFICATIONS

MILITARY

MIL-S-16216	-	Steel Plate, Alloy, Structural, High Yield Strength (HY-80 and HY-100).
MIL-E-19933	-	Electrodes and Rods - Welding, Bare Chromium and Chromium-Nickel Steels.
MIL-E-21562	-	Electrodes and Rods - Welding, Bare, Nickel Alloy.
MIL-S-21952	-	Steel (HY-80 and HY-100) Bars, Alloy.
MIL-E-22200	-	Electrodes, Welding, Covered: General Specification for.
MIL-E-22200/1	-	Electrodes, Welding, Mineral Covered, Iron-Powder, Low-Hydrogen Medium and High Tensile Steel, As Welded or Stress-Relieved Weld Application.
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-22200/10	-	Electrodes, Welding, Mineral Covered, Iron-Powder, Low-Hydrogen Medium, High Tensile and Higher-Strength Low Alloy Steels.
MIL-S-22664	-	Steel Structural Shapes, Alloy, High Yield Strength (HY-80 and HY-100).
MIL-S-22698	-	Steel Plate, Shapes and Bars, Weldable Ordinary Strength and Higher Strength: Structural.
MIL-S-23008	-	Steel Castings, Alloy, High Yield Strength (HY-80 and HY-100).
MIL-S-23009	-	Steel Forgings, Alloy, High Yield Strength (HY-80 and HY-100).
MIL-E-23765	-	Electrodes and Rods - Welding, Bare, Solid and Alloyed Cored, General Specification for.
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-24403 - Electrodes - Welding, Flux Cored, General Specification for.
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.
MIL-S-24451 - Steel Heat Treated Heads, Alloy Structural, High Yield Strength (HY-80 and HY-100).

STANDARDS

MILITARY

MIL-STD-22 - Welded Joint Design.
MIL-STD-248 - Welding and Brazing Procedure and Performance Qualification.
MIL-STD-271 - Nondestructive Testing Methods.
MIL-STD-1628 - Fillet Weld Size, Strength, and Efficiency Determination.
MIL-STD-1681 - Fabrication, Welding, and Inspection of HY-130 Submarine Applications.
MIL-STD-1689 - Fabrication, Welding, and Inspection of Ships Structure.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

PUBLICATIONS

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

0900-LP-003-8000 - Surface Inspection Acceptance Standards for Metals.
0900-LP-003-9000 - Radiographic Standards for Production and Repair Welds.

0900-LP-006-3010 - Ultrasonic Inspection Procedure and Acceptance Standards for Hull Structure Production and Repair Welds.
0900-LP-999-9000 - Surface Finish of Flame or Arc Cut Material, Acceptance Standards.

(Application for copies should be addressed to the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues 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 (see 17.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

E 186 - Standard Reference Radiographs for Heavy-Walled (2 to 4-1/2-in) (51 to 114-mm) Steel Castings. (DoD adopted)
E 280 - Standard Reference Radiographs for Heavy-Walled (4-1/2 to 12-in) 114 to 305-mm) Steel Castings. (DoD adopted)
E 446 - Standard Reference Radiographs for Steel Castings up to 2-in (51 mm) in thickness. (DoD adopted)

(Application for copies should be addressed to American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

AMERICAN WELDING SOCIETY (AWS)

A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination. (DoD adopted)
A3.0 - Standard Welding Terms and Definitions Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting. (DoD adopted)
B4.0 - Standard Methods for Mechanical Testing of Welds. (DoD adopted)

(Applications for copies should be addressed to the American Welding Society, Inc., 550 NW LeJeune Road, P.O. Box 351040, Miami, FL 33135.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These

documents also may be available in or through libraries or other informational services.)

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

3. DEFINITIONS

3.1 General. Except as noted herein, welding nomenclature and definitions shall conform to AWS A2.4 and AWS A3.0.

3.2 Acceptable. Acceptable, as used herein, complies with or conforms to the applicable standard or specification.

3.3 Activity. Activity is the physical plant of an organization performing work to which this document is applicable.

3.4 Approval (approved). Approval or approved, as used herein, is the item under consideration which requires acceptance by NAVSEA, or its authorized representative. Approval or approved shall be by NAVSEA authorized representatives unless NAVSEA approval is specified.

3.5 Arc strikes. An arc strike is any inadvertent heat affected zone or change in the contour of the finished weld or adjacent base metal resulting from an arc or heat generated by the passage of electrical current between the surface of the finished weld or base metal and a current source such as a welding electrode or magnetic particle (MT) prod.

3.6 Backgouge. Backgouge is the preparation of the second side of full penetration welds welded from both sides to the extent necessary to permit proper deposition of weld metal.

3.7 Bulkheads.

3.7.1 Closure Bulkhead. Closure bulkhead is the hull end bulkhead designed to withstand collapse depth pressure.

3.7.2 Containment bulkhead. Containment bulkhead is a transverse bulkhead within the pressure hull envelope which functions to contain within the compartment damage resulting from a design basis casualty within that compartment other than a watertight integrity casualty. Containment bulkheads are considered pressure hull support structures for design and inspection requirements.

3.7.3 Holding bulkhead. Holding bulkhead is a transverse watertight bulkhead within the pressure hull envelope which forms one boundary of an escape compartment and is designed to maintain watertight integrity up to the depth prescribed in the ship's building specification. Holding bulkheads are considered pressure hull support structure for design and inspection requirements.

3.7.4 Structural bulkhead. Structural bulkhead is a complete or partial watertight or nonwatertight bulkhead which supports the pressure hull or non-pressure hull.

3.8 Buildup. Buildup is defined under weld buildup (see 3.38.7.1).

3.9 Circularity. Circularity is the degree of deviation of a transverse section of the hull from a true circle.

3.10 Coamings. Coamings are compensation material surrounding holes in structure which extend through or on one side only of the hole. They are usually connected by a corner, groove tee, or fillet weld and may provide all or partial compensation for the hole.

3.11 Control surfaces. Control surfaces are those portions of submarine structure external to the hull designed to provide steering, diving or stabilization capabilities, such as rudders, stabilizers, and diving planes.

3.12 Corner crack. Corner crack is a crack occurring in weld metal in way of a temporary access snipe, a drain or a vent opening, or at the intersection of three members.

3.13 Fabrication. The term fabrication covers construction, alteration, modification, or repair operations involved in the building of submarines.

3.14 Foundation. Foundation is a base or support used to hold a component or part of a component or system. For example, machinery bed plates and mounting brackets are foundations.

3.15 Heat. Heat is a quantity of metal that was molten simultaneously in the same container or process just preceding solidification.

3.16 Heat soak. Application of heat to a weld joint to promote hydrogen removal.

3.16.1 Interlayer heat soak. Heat applied to a weld joint after deposition of each layer of weld material.

3.16.2 Intraweld heat soak. Heat applied to a weld joint at specified intervals during welding of the joint.

3.17 Higher strength steel. Higher strength steel (HSS) shall be in accordance with MIL-S-22698.

3.18 High yield strength steel. High yield strength steel (HY) is steel with the minimum yield strength specified.

3.18.1 HY-80/100 steel. HY-80 and HY-100 steel is steel in accordance with MIL-S-16216, MIL-S-23008, MIL-S-23009, MIL-S-21952, MIL-S-22664 and MIL-S-24451 for plate, castings, forgings, bars, shapes and heads, respectively.

3.19 Inserts. Inserts are those structural reinforcements welded into the pressure hull envelope or other structure by some type of butt joint.

Inserts reinforce the structure at openings or areas of high stress and may be of the same or greater thickness than the surrounding structure.

3.20 Inspector. Inspector is the contractor, naval shipyard or other Government agency employee qualified as required by this standard to accept or reject materials or workmanship based on specified test results.

3.21 Liners. Liners are structural reinforcements around a hole in plates welded by some type of tee or corner joint.

3.22 Load. Load is a quantity of steel from the same heat that is heat treated in the same furnace or oven at the same time. (A load and a heat may not be identical quantities of steel.)

3.23 NAVSEA authorized representative. NAVSEA authorized representative is any Government representative specifically authorized to approve equipment, material, or procedures within the scope of this document for NAVSEA. These are as follows:

a. For naval shipyards: The delegated representative of the Shipyard Commander.

b. For commercial shipyards: The delegated representative of the Supervisor of Shipbuilding, Conversion and Repair (SUPSHIP).

3.24 Ordinary strength steel. Ordinary strength steel (OSS) shall be in accordance with MIL-S-22698.

3.25 Patches. Patches are plates installed to replace deleted inserts or penetrations, to correct discrepant, damaged or defective materials, or to correct errors in construction.

3.26 Penetrations. Penetrations are those items such as pipe, sleeves, or trunks welded into the submarine structure by some type of groove tee, corner, or fillet weld. Penetrations pass through and extend beyond one or both sides of the structure.

3.27 Plates (plating).

3.27.1 Access plates. Access plates are sections of plating which are removed for access, installations or removal of equipment, and are later reinstalled. Access plates do not involve cutting of pressure hull frames.

3.27.2 Small access plates. Small access plates are sections of plating removed and later reinstalled having a maximum diameter of 24 inches.

3.27.3 Closure plates. Closure plates are those plates left off or removed for access, wherein at least one transverse frame is cut.

3.27.4 Tank plating. Tank plating is tank boundary plating.

3.28 Record of accomplishment. A record which provides objective evidence of completion, inspection of welds and accountability of fabrication requiring inspection by this document. Records shall identify the ship, applicable drawing, identification of the fabrication completed (drawing, assembly, piecemark, etc.), and type of inspection involved. Signature shall represent certification of only that portion of the structure inspected at the time.

3.29 Re-entrant angle. Re-entrant angle is the angle formed between the base plate and the toe of the weld (see figure 1).

3.30 Shape. Shape, as used herein, is one piece of hot-rolled or extruded material other than flat plate, strip, tube or bar, having a cross-section in the shape of a Tee, L angle, Zee, Channel, I or H.

3.31 Structure. Submarine structure is categorized by function (see figure 2).

3.31.1 HY-80/100 submarine structure. HY-80/100 submarine structure is all HY-80/100 structure associated with submarine fabrication.

3.31.2 Non-pressure hull structure. Non-pressure hull structure is a structure which is not designed to withstand collapse depth pressure. This includes such items as low (soft) and intermediate pressure tanks, non-support structure, and foundations.

3.31.3 Non-support structure. Non-support structure is all structures not otherwise specifically categorized. This includes, but is not limited to, free flooding structure, decks, deck stanchions, control surfaces, and fairwaters.

3.31.4 Pressure hull envelope. Pressure hull envelope is all structural material in boundaries maintaining watertight integrity at collapse depth. This includes such items as pressure hull plating, sea chests, trunks, hatches, missile tubes, closure bulkheads, inserts, penetrations, sonar spheres, access plates, and hard tank plating.

3.31.5 Pressure hull structure. Pressure hull structure is all structures whose function is to withstand collapse depth pressure, including the pressure hull envelope and supporting structure.

3.31.6 Support structure. Support structure is all structures whose function is to contribute to the ability of the pressure hull envelope to withstand collapse depth pressure, but does not itself form part of the watertight boundary under normal operations. This includes items such as pressure hull frames, hard tank framing, transverse structural floors acting as frames, holding bulkheads, and that portion of any internal or external bulkhead functioning as a frame.

a. When transverse floors and bulkheads act as frames, only the first 18 inches off the pressure hull plating measured normal to the ship's axis from the surface to which the floor or bulkhead is attached is to be considered as pressure hull framing (i.e., support structure), unless otherwise specified.

b. When frames have nominal depth greater than 18 inches and transition into floors and bulkheads, only the nominal depth of the frame in way of floors or bulkheads is to be considered as pressure hull framing, unless otherwise specified.

3.31.7 Containment structure. A containment structure is all compartment structures, not covered by other structural categories, whose function is to contain, within portions of a compartment, damage resulting from a design basis casualty with that compartment, other than a watertight integrity casualty.

3.32 Snipe. Snipe is a small temporary or permanent opening in an abutting member to permit the deposition of a sound weld in a joint passing beneath the abutting member. A temporary snipe is closed by welding or a patch plate depending on its size. A permanent snipe is left open for use as a vent or drain hole.

3.33 Tanks.

3.33.1 Hard tanks. Hard tanks are tanks designed to withstand pressure equal to or greater than ship test pressure (test depth).

3.33.2 Intermediate pressure tanks. Intermediate pressure tanks are tanks designed to withstand pressure greater than 125 pounds per square inch but less than ship test pressure (test depth).

3.33.3 Low pressure tanks (soft tanks). Low pressure tanks or soft tanks are those tanks designed to withstand pressures of 125 pounds per square inch and less.

3.34 Tilting bracket. Tilting bracket is a plate or shape fitted to a load carrying member to stabilize the member from going out of plane.

3.35 Web stiffener. Web stiffener is a plate fitted to a load carrying member web to preclude web failure by buckling.

3.36 Cold forming. Cold forming is a forming operation performed on material below 500 degrees Fahrenheit.

3.37 Hot forming. Hot forming is a forming operation performed on material in a temperature range between 1600 and 2150 degrees Fahrenheit.

3.38 Welds.

3.38.1 Attachment weld. Attachment weld is any weld attaching an OSS or HSS member to HY-80/100 submarine structure where all of the following conditions are met (see figure 3 for examples):

a. Application involves: pipe hangers, cable hangers, ventilation hangers, attachments supporting items such as instruments or electrical equipment where the total static weight of the instruments or electrical equipment is 1 ton (2240 pounds) or less, or lifting pads designed to carry 1 ton (2240 pounds) or less.

b. A normal cross section through the attaching member does not exceed 2-1/2 inches nominal design length in any direction.

c. Except for solid round bar, the thickness of the attaching member does not exceed 1/2 inch.

d. For solid round bar, the maximum design weld throat does not exceed 1/2 inch.

3.38.2 Block weld. Block weld is an increment of a continuous multiple pass weld that is completely, or partially built up in cross-section before adjacent lengths of weld are deposited.

3.38.3 Completed weld. Completion occurs when all weld metal has been deposited, preheat is removed, weld has cooled to ambient temperature and the weld has been VT inspected, accepted, and is ready for other nondestructive test (NDT) inspections.

3.38.4 Finished weld. Finished weld is a weld which has received all required final inspections and has been accepted.

3.38.5 Foundation weld. Foundation weld is a weld used to fabricate a foundation or to attach it to the submarine.

3.38.6 Tank weld. A 100 percent efficient full or partial penetration weld in tank boundary plating (such as floor to tank top, side to shell, butts and seams) or to either side of tank boundary plating where the member involved is being used primarily as tank boundary plate stiffener. It does not include frame to hull welds internal to the tank, backup structures, foundation welds, pressure hull butt and seam welds, or attachment welds (see figure 4).

3.38.7 Weld surfacing.

3.38.7.1 Weld buildup. Weld buildup is the deposition of filler metal to restore base material or weld surface dimensions or to interpose a layer of

metal on the material surface of the joint prior to joining the material members together.

3.38.7.2 Weld cladding (defined in AWS A3.0) (see figure 5). For purposes of inspection, cladding deposited for O-ring or gasket seating surfaces is further subdivided to the categories of:

a. Inboard surface (non-pressure, dry side).

b. Outboard surface (pressure, wet side).

c. Seating or seal area surface.

3.39 Weld contour. Weld contour is the surface profile of a weld in the as-deposited condition or after preparation to meet workmanship or NDT requirements.

3.40 Weld contouring. Weld contouring is the deliberate shaping of weld surfaces for hydrodynamic or fatigue considerations, or as otherwise permitted in this standard.

3.41 Weld pass. Weld pass is a single longitudinal progression of a welding bead along a joint or weld deposit for the length of one block or more, which may consist of more than one start or stop.

4. QUALIFICATION REQUIREMENTS

4.1 Scope. This section covers the requirements necessary for the qualification of welding procedures, welders and welding operators, nondestructive test (NDT) procedures, NDT personnel, NDT equipment, workmanship inspection procedures, and workmanship inspection personnel for HY-80/100 submarine construction.

4.2 General requirements. The purpose of these qualification requirements is to insure that qualified procedures are used with adequate equipment by properly trained personnel. It shall be the responsibility of the activity to insure that only qualified personnel, procedures and NDT equipment are used for fabrication and inspection to comply with this standard.

4.3 Welding procedure qualification. Procedures for welding covered by this standard shall be qualified in accordance with MIL-STD-248.

4.3.1 Special qualification requirements.

4.3.1.1 Gas metal arc short circuiting transfer process qualification. Use of the gas metal arc short circuiting transfer process is not permitted for welds in submarine structure except as permitted in section 13.

4.4 Welder performance qualification. Prior to performing any production welding of HY-80/100, personnel shall be qualified in accordance with MIL-STD-248. Welding operator qualification is not required for operators of stud welding equipment.

4.5 NDT procedure qualification.

4.5.1 Radiographic (RT) inspection. Qualification of RT inspection procedures, including film processing procedures, shall be in accordance with MIL-STD-271, except as modified by section 15. Records of procedure qualification shall be as specified in section 5.

4.5.2 Magnetic particle (MT) inspection. MT inspection shall be performed in accordance with MIL-STD-271, except as modified by section 15. Each activity shall certify that the procedure used is in accordance with these requirements.

4.5.3 Liquid penetrant (PT) inspection. PT inspection shall be performed in accordance with MIL-STD-271, except as modified by section 15. Each activity shall certify that the procedure used is in accordance with these requirements.

4.5.4 Ultrasonic (UT) inspection. Qualification of UT inspection procedures shall be made in accordance with MIL-STD-271. Records of UT procedure qualification shall be as specified in section 5. Qualification of UT inspection procedures for castings shall consist of the development of

inspection procedures, calibration standards, and acceptance standards by the user activity, and applications of these shall be subject to NAVSEA approval.

4.5.5 Visual (VT) inspection. VT inspection shall be performed in accordance with MIL-STD-271, except as modified by section 15. Each activity shall certify that the procedure used is in accordance with these requirements.

4.5.6 Eddy current (ET) inspection. Qualification of ET procedures shall be in accordance with MIL-STD-271. Applications and record requirements shall be approved by NAVSEA.

4.5.7 Other NDT. NDT procedures, techniques, equipment, and materials not specified in this standard may be used, provided the procedure and performance qualification is approved by NAVSEA.

4.6 Qualification of NDT personnel. NDT personnel shall be qualified and certified in accordance with MIL-STD-271.

4.7 NDT equipment qualification. All NDT equipment, when used by qualified NDT operators employing approved procedures, shall detect flaws within the limits specified in section 7. For weld inspection, UT inspection equipment shall meet the requirements of MIL-STD-271.

4.8 Vision tests. Personnel, as specified in 4.4 except tack, spot and stud welders, and 4.6 shall be required to pass an annual vision test. The test shall be conducted by a trained technician using standard test methods for determining visual acuity. The standard of acceptance for the vision test shall be natural or corrected near-distance acuity such that the individual is capable of reading J1 letters on the standard Jaeger type chart for near vision. Other equivalent visual tests may be substituted for the Jaeger chart. Personnel as specified in 4.6 shall be required to pass a vision test in accordance with MIL-STD-271. Glasses or other corrective aids used to pass the vision tests shall be used when performing production work.

4.9 Workmanship inspection requirements.

4.9.1 Workmanship procedures. Each activity shall develop written procedures to provide for documentation of the quality and completeness of workmanship for HY-80/100 structure as required by section 6. These procedures shall specify, as a minimum, the following:

a. Actions required to ensure conformance to all drawing, specification and contract requirements, including actions to ensure inspections of structure are complete prior to the structure being made inaccessible for inspection.

b. The organizational elements responsible to certify specific workmanship attributes.

c. Signatures certifying workmanship inspections shall be based on personal observation.

d. Detailed documentation requirements ensuring records are maintained as required by section 5.

4.9.2 Qualification of workmanship inspection personnel. All personnel performing workmanship inspections required by section 6 shall be formally trained to use a written workmanship procedure in accordance with a documented program.

5. RECORD REQUIREMENTS

5.1 Scope. This section describes the records required for HY-80/100 submarine structure fabrication.

5.2 General. Each activity shall have written procedures which assign responsibility and provide accountability for performing work and inspections as required by this standard. Records are required only to the extent specified herein.

5.3 Records.

5.3.1 General requirements. The quality control system shall include the preparation and maintenance of written records. Records shall contain, as a minimum, the information noted herein and shall be developed in accordance with section 17. Vendor inspection or mill certificate records will fulfill the requirements of this section for that portion of the required information contained therein.

5.3.1.1 Welding procedure qualification. These records shall comply with MIL-STD-248.

5.3.1.2 Welder and welding operator qualification. These records shall comply with MIL-STD-248.

5.3.1.3 NDT procedure qualification. These records shall comply with MIL-STD-271.

5.3.1.4 NDT personnel qualification. These records shall comply with MIL-STD-271.

5.3.1.5 Workmanship personnel qualification. Workmanship personnel qualification records shall include the following information:

a. Workmanship inspector identification (name, clock number or social security number).

b. Method of workmanship inspection and procedure trained in.

c. Dates of training.

d. Signature certifying that the workmanship inspector has satisfactorily completed the required training, and is qualified to perform the method of workmanship inspection that the inspector has been trained in.

5.3.2 Welding traceability.

5.3.2.1 Welding electrode control inspection. Records of receipt inspection required by section 8 shall contain the following:

a. Manufacturer's certification and test results for compliance with the applicable military specification referenced in section 2.

b. Records of receipt inspection verification of electrode conformance as required by section 8.

c. Records of moisture content of electrodes in use as required in section 10 (laboratory test results).

d. Date of inspection and signature of inspectors.

5.3.2.2 Welding in-process monitoring. Records of in-process monitoring, as required by section 6, shall contain the following attributes as applicable at the time monitoring is performed:

a. Base material identification.

b. Welding process being used.

c. Filler metal type identification.

d. Heat input (satisfactory or unsatisfactory).

e. Preheat/interpass temperature of the joint being welded (satisfactory or unsatisfactory).

f. Location on ship or assembly where welding is being performed.

g. Type of weld; original or repair.

h. Date of inspection and signature of inspector making check.

i. Record of corrective actions taken in case of discrepancy.

j. Joint preparation (satisfactory or unsatisfactory).

k. Joint configuration and fit-up (satisfactory or unsatisfactory).

l. Root cleaning and contour (satisfactory or unsatisfactory).

m. Slag removal (satisfactory or unsatisfactory).

n. Welder identification and qualification.

o. Repair excavation contour (satisfactory or unsatisfactory).

p. Heat soak (satisfactory or unsatisfactory).

5.3.2.3 MT inspection of welds. Records of inspections required in 6.5 shall include the following:

a. Type of MT test (e.g., prod or yoke).

b. Weld location (assembly and joint identification).

c. Type of weld (e.g., tee, butt, or fillet).

d. Approximate length of weld inspected.

e. Length and number of rejectable indications found.

f. Approximate location of rejectable indications found, if any.

g. Type of rejectable indications (transverse, longitudinal or corner).

h. Date of original inspection.

i. Date of repair and reinspection (if required) and results.

j. Signature of inspectors.

5.3.2.4 PT inspection of welds. Records for inspections required in 6.6 shall contain the following:

a. Type of penetrant used (section 15).

b. Weld location (ship, assembly, and joint identification).

c. Type of weld (e.g., butt, tee, fillet or clad).

d. Type of rejectable indications.

e. Surface condition (e.g., as-machined, as-welded, ground).

f. Date of original inspection.

g. Date of repairs and reinspection (if required) and results.

h. Signature of inspectors.

5.3.2.5 RT inspection of welds. Records for inspections required in 6.7 shall comply with MIL-STD-271 and contain the following:

a. Date of radiography.

b. Location of weld radiographed (positive identification system).

c. Thickness of material.

d. Energy source (isotope type, size of source or KVP and amperage of x-ray).

e. Surface condition (e.g., as-machined, as-welded, ground).

f. Type of film, screens, source-to-film distance, and exposure time.

g. Flaws (note acceptable slag, porosity, or other discontinuities).

h. Disposition (satisfactory or unsatisfactory).

i. Date and signature of film interpreter.

5.3.2.6 UT inspection of welds. Records of inspections required in 6.8 shall be as specified in MIL-STD-271.

5.3.2.7 VT inspection of welds. Records of inspections required in 6.4 shall include the following:

a. Reference to the written procedures controlling the inspection.

b. The organizational element responsible.

c. Signatures certifying VT of welds. This certification shall be based on personal observation.

d. The location, assembly, types of welds, weld joint identification (when applicable), VT results, repairs for acceptance and re-VT (when applicable), and items a., b. and c. above shall be documented by a record of accomplishment.

5.3.3 Material traceability.

5.3.3.1 Plate quality inspection. These records shall contain the following:

a. Ship or hull number.

b. UT soundness findings.

c. UT gauge measurements.

d. Micrometer edge thickness measurements.

e. Brinell hardness, chemistry, and mechanical properties as required by applicable base material specification.

f. Record of VT with notation on the size and location of defects to be repaired or which have been repaired.

g. Location of plate in submarine pressure hull envelope, as follows:

(1) Hull plating.
(2) All components which are fabricated from plate and which are welded into and become an integral part of the pressure hull envelope. This includes inserts, penetrations, and patches.
(3) Hard tank plating.

h. Heat, load, and slab number (mill source).

i. Date of inspection and signature of inspectors.

5.3.3.2 Bars and rolled or extruded shapes inspection. These records shall include the following:

a. Ship or hull number.

b. Heat, load, and slab number (mill source).

c. Record of VT with notation of the size and location of defects to be repaired or which have been repaired.

d. Brinell hardness, chemistry and mechanical properties as required by applicable base material specification.

e. Dimensions (shapes only).

f. Soundness (UT and MT where applicable).

g. Location, when part of pressure hull envelope.

h. Date of inspection and signature of inspectors.

5.3.3.3 Castings and forgings inspection. These records shall include the following:

a. Ship or hull number.

b. Heat, casting serial number (must be unique identification).

c. Soundness (RT, MT, and UT, as applicable).

d. Brinell hardness and test coupon results (including chemical and mechanical properties as required by the applicable base material specification).

e. Record of VT with notation of the size and location of defects to be repaired or which have been repaired.

f. Dimensional inspection.

g. Location, size and orientation of repairs (as specified in section 16 for castings).

h. Location of all cast or forged components which are welded into and become an integral part of the pressure hull envelope.

i. Date of inspection and signature of inspectors.

5.3.3.4 MT and PT material inspection. These records shall include the following:

a. Method of MT or type of penetrant used, as applicable.

b. Part designation (drawing piece number, purchase and item number, serial number or other).

c. Type of material (casting, bar, forging, plate and other).

d. Number and length of defects found.

e. Date of original inspection.

f. Date of final repair and inspection.

g. Signature of inspectors.

5.3.3.5 RT casting inspection. These records shall include the following:

a. Date of radiography.

b. A sketch showing the location of all nominal and special weld repairs (with positive reference point for symmetrical shapes).

c. Location of casting being radiographed with positive shooting sketch identification.

d. Thickness of material.

e. Energy source (isotope type, size of source or KVP and amperage of x-ray).

f. Surface condition (e.g., as-machined, repair welded, ground, as cast).

g. Type of film, screens, source-to-film distance, and exposure time.

h. Flaws (note acceptable slag, porosity, or other discontinuities).

i. Disposition (satisfactory or unsatisfactory).

j. Date and signature of film interpreter.

5.3.3.6 UT material inspection. These records shall include the following:

a. Part designation (drawing piece number, purchase and item number, serial number or other).

b. Type of material (casting, bar, forging, plate or other).

c. Approved procedure identification.

d. Instrument manufacturer and model number.

e. Transducer size and type.

f. Search beam angle.

g. Frequency used for test.

h. Couplant.

i. Reference calibration standards.

j. Observations and acceptance/rejection evaluation (for rejectable defects in complex parts, a sketch showing the size and location of the defect is required).

k. Acceptance standard used (when other than specified in this document).

l. Dates of original inspection, final repair and inspection.

m. Signature of inspectors.

5.3.4 Workmanship inspection. Workmanship inspections required in section 6 shall be documented by use of a record of accomplishment or detailed records.

5.3.4.1 Circularity inspection. Circularity measurements shall be made as required by 12.6 in a format similar to figures 6, 7 and 8 (see 17.3 and appendix A). Records of training and certification shall be kept for personnel responsible for taking final acceptance circularity measurements.

5.3.4.2 Pressure hull frame dimensions inspection. These records, as required by 12.6, shall contain the following in a format similar to figure 9:

a. Ship or hull number.

b. Frame number.

c. Dimensions, including web and flange tilt, flange width and unbalance, and frame depth.

d. Station number.

e. Distance between frames.

5.3.5 Record instructions.

5.3.5.1 Records shall be marked "N/A" for sections not applicable to the particular job or a vertical arrow drawn through similar items.

5.3.5.2 Each activity shall be responsible for the records, including RT films, on materials or components furnished by sub-contractors.

5.3.6 Maintenance of records. All required records shall be maintained by the activity and be available to the NAVSEA representative throughout the life of the contract and for 3 years after delivery of the submarine. At the expiration of the record's retention period, all records shall be made available to NAVSEA or its authorized representative by written notification. If no disposition is authorized within 6 months, the records may be destroyed.

6. INSPECTION REQUIREMENTS

6.1 Scope. This section contains the requirements for inspection of fabrication and workmanship of materials and welds in or to HY-80/100 submarine structure. Where more than one inspection category applies, the most restrictive category's requirements shall be used. Records are required for all inspections specified herein, unless otherwise indicated. Record requirements are provided in section 5.

6.1.1 General. Inspection shall be made when the material or weld or both is accessible for inspection to the degree necessary to confirm the material or weld or both is acceptable.

6.2 Material inspection. HY-80/100 plate, forgings, castings, bars, and extruded shapes employed in submarine structure shall be receipt inspected in accordance with section 8.

6.3 Workmanship inspection.

6.3.1 In-process monitoring of HY-80/100 welding. In-process monitoring of welding shall be accomplished to ensure compliance with welding procedures, and related drawing requirements. In-process monitoring shall be accomplished in accordance with a written procedure as specified in section 4. Corrective action shall be taken upon detection of discrepancies and such action shall be recorded as specified in section 5.

6.3.2 Inspection of workmanship. All structures in the process of fabrication and completed shall be inspected in accordance with written procedures as specified in section 4 to ensure compliance and completeness with detailed working drawings and this document. This inspection shall include the following:

a. Weld joint design, weld joint preparation, flame and arc cut surfaces, plate edges for laminations, and joint fit-up in accordance with sections 11 and 14.

b. Tack welds in accordance with section 13.

c. Weld repairs for excavation contours, and full penetration welds for root cleaning and contour in accordance with section 14.

d. HY-80/100 base material surfaces, after completion of fabrication, for arc strikes, weld spatter, fabrication scars, and removal of temporary attachments in accordance with section 14.

e. Pressure hull and main ballast tank plating, welded plate in free flood areas, and structural bulkheads for plate and shape alignment, and fairness in accordance with section 12 and drawings.

f. Specified geometrical tapers of structural material and welds in accordance with section 11 and drawings.

g. Snipes in accordance with section 13.

h. Penetrations and intersecting butt welds in the pressure hull envelope for weld build-up in accordance with section 13.

i. Underwater exterior surfaces in accordance with drawings.

j. Pressure hull frames for frame dimensional tolerances, flange curvature, spacing and butt alignment in accordance with section 12.

k. Hull circularity of submarines in accordance with section 12.

l. Structural castings, forgings, and shaped inserts for specified dimensions, surface conditions, and identification markings in accordance with section 16 and drawings.

m. Hard tank and main ballast tank frames for dimensional tolerances and spacing in accordance with drawings.

n. Pressure hull penetration bore diameters in accordance with drawings.

6.4 VT inspection. All completed welds shall be VT inspected in accordance with 15.7 to ensure completeness and compliance with detailed working drawings and sections 7, 13 and 14. This inspection shall include:

a. Weld size adequacy for type of joint (B, T, PT, C, L) specified, and shape of fillet weld face.

b. Weld surface uniformity for smoothness or sharp irregularities and acceptability for other NDT when required.

c. Weld surface cleanliness and physical defects such as cracks, burn through, melt through, oxidation and slag, slag craters, porosity, pits, arc strikes, gouges (fabrication damage), spatter, end-melt and corner-melt.

d. Weld contour for re-entrant angles, unfused bead overlap and undercut.

e. Welds in or to weight handling fittings or fixtures after proof load testing.

f. Seal-off and wrap-around welding.

g. Contour grinding.

6.4.1 VT inspection of base materials. VT inspection of HY-80/100 plate, rolled or extruded shapes, castings, forgings, bars and formed material shall be in accordance with sections 8 and 16.

6.5 MT inspection.

6.5.1 General. MT inspection requirements are specified in tables I and II. MT inspection shall be performed in accordance with 15.4. Areas inspected shall comply with the acceptance standards in section 7. PT inspection shall be substituted for MT inspection where MT inspection is impracticable. Use of alternate inspection methods shall require approval. Either DC prod or AC yoke may be used.

TABLE I. MT inspection requirements.

Inspection category	Time of inspection	Notes
I. Pressure hull structure		
A. Pressure hull envelope.		
(1) Full penetration butt, corner and groove tee weld in pressure hull envelope. Partial penetration tee welds in pressure hull envelope. Full penetration tee weld to the pressure hull envelope, except as noted below in categories (2) and (4).	Final inspection shall be made no sooner than the same shift 7 days (160 hours minimum) after the weld is completed and has cooled to ambient temperature.	1/ 2/ 3/ 4/ 5/ 6/
(2) Full penetration tee welds to the pressure hull envelope where the tee member is less than or equal to 1/4T or 1/2 inch, whichever is less (where T is thickness of pressure hull envelope in way of the attachment).	Final inspection shall be made no sooner than 24 hours after the weld is completed and has cooled to ambient temperature.	1/ 2/ 4/ 5/

See footnotes at end of table.

TABLE I. MT inspection requirements. - continued

Inspection category	Time of inspection	Notes
(3) Hard tank welds.		
(a) Full or partial penetration tee welds on non-pressure surface.	If final inspection is made prior to the first hydrostatic test, the time of inspection shall be in accordance with requirement of category I.A.(1), (2) or (4) of this table, as applicable. If final inspection is made after the first hydrostatic test, the requirements of category I.A.(3)(b) of this table apply.	1/ 2/ 7/
(b) All other welds.	Inspect the hard tank welds in accordance with 6.5.5.	1/
(4) Partial penetration welds to pressure hull envelope and partial or full penetration tee welds of internal frames to pressure hull envelope.	Final inspection shall be made no sooner than 24 hours after the weld is completed and has cooled to ambient temperature.	1/ 2/ 4/ 5/
(5) Repair of holes.		
(a) Depth of repair is 3/4T or less (where T is thickness of base material involved).	Final inspection shall be made no sooner than 24 hours after the weld is completed and has cooled to ambient temperature.	1/ 5/ 8/
(b) Depth of repair is greater than 3/4T (where T is thickness of base material involved).	Final inspection shall be made no sooner than the same shift 7 days (160 hours minimum) after the weld is completed and has cooled to ambient temperature.	1/ 5/
(6) Hot formed welds.	After heat treatment.	1/ 5/ 8/
(7) Cold formed full penetration welds in or to the pressure hull envelope.	Final inspection shall be made no sooner than the same shift 7 days (160 hours minimum after the weld is completed and has cooled to ambient temperature, after forming.	1/ 2/ 3/ 4/ 5/ 8/

See footnotes at end of table.

TABLE I. MT inspection requirements. - continued

Inspection category	Time of inspection	Notes
(8) Ground areas where arc strikes, fabrication scars, weld defects, and areas where attachments are removed and repair welding is not required.	After removal and after the surface has been prepared as required in 14.6.	9/ 10/
(9) Weld repair of fabrication scars, arc strikes and areas where attachments are removed and repair by welding is required.	Final inspection shall be made no sooner than 24 hours after the weld is completed and has cooled to ambient temperature. The surface shall be prepared as required by 14.6.	1/ 9/
(10) Areas where automatically timed arc welded studs over 3/8 inch in diameter have been used and removed.	After removal and after the surface has been prepared as required in 14.6.	9/
(11) Root area of full penetration butt, corner, and groove tee welds after backgouging; weld repair excavation sites.	After removal of any slag, scale, or surface roughness which would interfere with interpretation of indications.	9/
(12) That portion of prepared surfaces not subsequently covered by welding.	After final surface preparations.	5/ 9/
B. Support structure.		
(1) Full or partial penetration butt, corner and tee welds in or to support structure.	Final inspection shall be made no sooner than 24 hours after the weld is completed and has cooled to ambient temperature.	1/ 5/ 8/
(2) Repair of holes.		
(a) Depth of repair is 3/4T or less (where T is thickness of base material involved).	Final inspection shall be made after the weld is completed and has cooled to ambient temperature.	1/ 5/ 8/

See footnotes at end of table.

TABLE I. MT inspection requirements. - continued

Inspection category	Time of inspection	Notes
(b) Depth of repair is greater than 3/4T (where T) is thickness of base material involved).	Final inspection shall be made no sooner than 24 hours after the weld is completed and has cooled to ambient temperature.	1/ 5/ 8/
(3) Hot formed welds.	After heat treatment.	1/ 5/ 8/
(4) Cold formed welds.	Final inspection shall be made no sooner than 24 hours after the weld is completed and has cooled to ambient temperature, after forming.	1/ 5/ 8/
(5) Ground areas where arc strikes, fabrications scars, weld defects and areas where attachments are removed and repair by welding is not required.	After removal and after surface has been prepared as required in 14.6.	9/ 10/
(6) Weld repair of fabrication scars, arc strikes and areas where attachments are removed and repair by welding is required.	After repair welding and after the surface has been prepared as required in 14.6.	1/ 9/
(7) Areas where automatically timed arc welded studs over 3/8 inch in diameter have been used and removed.	After removal and after the surface has been prepared as required in 14.6.	9/
(8) Root area of full penetration butt, corner, and groove tee welds after backgouging; weld repair excavation sites.	After removal of any slag, scale or surface roughness which would interfere with interpretation of indications.	9/
(9) That portion of prepared surfaces not subsequently covered by welding.	Inspection not required.	N/A

See footnotes at end of table.

TABLE I. MT inspection requirements. - continued

Inspection category	Time of inspection	Notes
II. Containment structure and containment bulkheads		
A. Inspection requirements for containment structure and containment bulkheads shall be as specified for support structure (category I.B.).		
III. Non-pressure hull structure		
A. Intermediate pressure tanks.		
(1) Full or partial penetration butt, corner, and tee welds in or to intermediate tank structure.	Final inspection shall be made no sooner than 24 hours after the weld is completed and has cooled to ambient temperature.	1/ 5/ 8/
(2) Repair of holes.	Final inspection shall be made after the weld is completed and has cooled to ambient temperature.	1/ 8/
(3) Hot formed welds.	After heat treatment.	1/ 8/
(4) Cold formed full penetration welds in or to intermediate pressure tank.	Final inspection shall be made no sooner than 24 hours after the weld is completed and has cooled to ambient temperature after forming.	1/ 5/ 8/
(5) Ground areas where arc strikes, fabrication scars, weld defects, and areas where attachments are removed, and repair by welding is not required.	After removal and after the surface has been prepared as required by 14.6.	9/ 10/
(6) Weld repair of fabrication scars, arc strikes and areas where attachments are removed and repair by welding is required.	After repair welding and after the surface has been prepared as required in 14.6.	1/ 9/

See footnotes at end of table.

TABLE I. MT inspection requirements. - continued

Inspection category	Time of inspection	Notes
(7) Areas where automatically timed arc welded studs over 3/8 inch in diameter have been used and removed.	After removal and after the surface has been prepared as required in 14.6.	9/
(8) Root area of full penetration butt, corner and groove tee welds after backgouging; weld repair excavation sites.	After removal of any slag, scale, or surface roughness which would interfere with interpretation of indications.	9/
(9) That portion of prepared surfaces not subsequently covered by welding.	Inspection not required.	N/A
B. Low pressure (soft) tanks.		
(1) Full or partial penetration butt, corner and tee welds in or to low pressure (soft) tanks.	Final inspection shall be made after the weld is completed and has cooled to ambient temperature.	1/ 8/
(2) Repair of holes.	Inspection not required.	N/A
(3) Hot formed welds.	After heat treatment.	1/ 8/
(4) Cold formed full penetration welds in or to low pressure tanks.	Final inspection shall be made after the weld is completed and has cooled to ambient temperature, after forming.	1/ 5/ 8/
(5) Ground areas where arc strikes, fabrication scars, weld defects, and areas where attachments are removed and repair by welding is not required.	Inspection not required except those defects that were detected by MT inspection and subsequently removed by grinding shall be reinspected by MT after grinding.	9/
(6) Weld repair of fabrication scars, arc strikes and areas where attachments are removed and repair by welding is required.	Inspection not required except those defects that were detected by MT inspection and subsequently repair welded shall be reinspected by MT after repair welding.	1/ 9/

See footnotes at end of table.

TABLE I. MT inspection requirements. - continued

Inspection category	Time of inspection	Notes
(7) Areas where automatically timed arc welded studs over 3/8 inch in diameter have been used and removed.	Inspection not required.	N/A
(8) Root area of full penetration butt, corner, and groove tee welds after backgouging; weld repair excavation sites.	Inspection not required.	N/A
(9) That portion of prepared surfaces not subsequently covered by welding.	Inspection not required.	N/A
C. Foundations.		
(1) Full or partial penetration butt, corner and tee welds in or to foundations.	Final inspection shall be made after the weld is completed and has cooled to ambient temperature.	1/ 8/
(2) Repair of holes.	Inspection not required.	N/A
(3) Hot formed welds.	After heat treatment.	1/ 8/
(4) Cold formed full penetration welds in or to foundations.	Final inspection shall be made after the weld is completed and has cooled to ambient temperature after forming.	1/ 5/ 8/
(5) Ground areas where arc strikes, fabrication scars, weld defects, and areas where attachments are removed and repair by welding is not required.	Inspection not required except those defects that were detected by MT inspection and subsequently removed by grinding shall be reinspected by MT after grinding.	9/
(6) Weld repair of fabrication scars, arc strikes and areas where attachments are removed and repair by welding is required.	Inspection not required except those defects that were detected by MT inspection and subsequently repair welded shall be reinspected by MT after repair welding.	1/ 9/

See footnotes at end of table.

TABLE I. MT inspection requirements. - continued

Inspection category	Time of inspection	Notes
(7) Areas where automatically timed arc welded studs over 3/8 inch in diameter have been used and removed.	Inspection not required.	N/A
(8) Root area of full penetration butt, corner, and groove tee welds after backgouging; weld repair excavation sites.	Inspection not required.	N/A
(9) That portion of prepared surfaces not subsequently covered by welding.	Inspection not required.	N/A
D. Non-support structure.		
(1) Full or partial penetration butt, corner, and tee welds in or to non-support structure.	Inspection not required.	N/A
(2) Repair of holes.	Inspection not required.	N/A
(3) Hot formed welds.	Inspection not required.	N/A
(4) Cold formed full penetration welds in or to non-support structure.	Inspection not required.	N/A
(5) Ground areas where arc strikes, fabrication scars, weld defects, and areas where attachments are removed and repair by welding is not required.	Inspection not required.	N/A
(6) Outside surfaces of welds in or to completed rudders and planes and welds to the hub of rudders and planes. Other interior welds of rudders and planes do not require inspection.	Final inspection shall be made no sooner than 24 hours after the weld is completed and has cooled to ambient temperature.	1/ 8/

See footnotes at end of table.

TABLE I. MT inspection requirements. - continued

Inspection category	Time of inspection	Notes
(7) Areas where automatically timed arc welded studs over 3/8 inch in diameter have been used and removed.	Inspection not required.	N/A
(8) Weld repair of fabrication scars, arc strikes and areas where attachments are removed and repair by welding is required.	Inspection not required.	N/A
(9) Root area of full penetration butt, corner, and groove tee welds after backgouging; weld repair excavation sites.	Inspection not required.	N/A
(10) That portion of prepared surfaces not subsequently covered by welding.	Inspection not required.	N/A

See footnotes at end of table.

NOTES TO TABLE I

1/ If weld repairs are necessary, the repaired area shall be reinspected as required for the original weld.

2/ Extent of inspection of repairs made to welds referenced to this note is based on the depth of repair, as measured from the plate surface, and as follows:

Depth of repair (T equals thickness of thinner member being repaired)	Inspection (see figures 10 and 11)
a) Less than or equal to 1/3T	Inspect the weld repair and a minimum of 6 inches beyond each end of the repair on the repair face.
b) Greater than 1/3T to and including 2/3T	Perform the inspection in (a) above for both the repair and opposite face.
c) Greater than 2/3T	Perform the inspection in (b) above. In addition perform the inspection required by 3/ below.

The expansion inspection on a full penetration hull butt weld in the pressure hull envelope need only be extended to an intersecting full penetration weld to the pressure hull, when the intersecting member is 1/4 the hull thickness or greater, and falls within the 6 inch requirement.

The weld surfaces in 6.5.2.a. and b. are not subject to the expansion inspection requirements above.

3/ All previously inspected full penetration welds in or to pressure hull envelope that are within 6 inches of:

a) Newly installed full penetration welds in the pressure hull envelope, or
b) Weld repairs in the pressure hull envelope which exceed a total excavation depth of 2/3T (see 2/) shall be reinspected for a distance within 6 inches of the new or repair weld except reinspection is not required if the previously inspected weld:

(1) has been heat treated (that is, quenched and tempered) as part of the base material.
(2) was previously contour ground in accordance with section 14 and MT inspected.

(3) is in a member that is not contiguous to the new weld (that is, is in an intersecting or attached member) (see figure 11 for illustration of requirements).

4/ When full penetration tee welds other than attachment welds are made to the pressure hull envelope, all previously inspected full penetration welds in or to the pressure hull envelope (as noted below) shall be reinspected to the following extent:

Tee member thickness (T represents thickness of the pressure hull at the attachment site)	Extent of reinspection
Less than or equal to 1/2T for HY-80/100	Reinspection not required
Greater than 1/2T for HY-80/100	Reinspect all other full penetration welds in or to the pressure hull envelope within 3 inches toe-to-toe distance of the attachment weld, except reinspection is not required if the previously inspected weld was previously contour ground in accordance with section 14 and MT inspected in accordance with 6.5.

5/ Final inspection shall be performed after forming or straightening operations.

6/ Surface areas of butt welds which are to be subsequently covered by faying pads, shall be final MT inspected (after being ground as necessary for fitting of the faying pads).

7/ Contour grind all hard tank welds except butt welds (see figure 4).

8/ Detailed records of the MT inspections covered by this item are not required. A record of accomplishment of the inspections grouped by category of item and hull area or location shall be maintained. Surveillance of accomplishment is required and shall be conducted in accordance with a written procedure.

9/ No detailed records of accomplishment are required. A formal procedure for accomplishing these inspections must be established and available for review.

10/ For arc strikes, nicks, gouges and fabrication scars which do not require weld repair, PT or 5X VT inspection may be substituted for MT.

TABLE II. MT inspection requirements applicable to HY-80/100 base material, mill defects and forming.

Inspection category	Time of inspection	Notes
(1) Repairs of base material defects.	If repair welding is required, the area to be repaired shall be MT inspected prior to welding. Final inspection shall be made no sooner than 24 hours after the weld is completed and has cooled to ambient temperature. If repair welding is not required, final inspection shall be made after the defect is removed.	1/ 2/ 3/ 4/
(2) Tension surface of base material that is cold formed in excess of 12 percent total elongation.	After forming.	1/ 2/ 3/ 5/
(3) Tension surface of base material that is hot formed in excess of 15 percent total elongation.	After forming and the material has reached ambient temperature.	1/ 2/ 3/ 5/

NOTES TO TABLE II

1/ Inspection shall include the entire surface of the repair or area involved.

2/ Lamellar indications in the base materials shall be evaluated in accordance with section 7. Repairs shall be in accordance with section 13.

3/ Detailed records of the MT inspection covered by this table are not required. A record of accomplishment of the inspections grouped by category item, hull area or location shall be maintained. Surveillance of accomplishment is required and shall be conducted in accordance with a written procedure.

4/ For arc strikes, nicks, gouges and fabrication scars which do not require weld repair, PT or 5X VT inspection may be substituted for MT.

5/ If repairs are necessary, the inspection requirements of category (1) apply.

6.5.2 Exemptions (to tables I and II).

a. Inspection is not required for areas where capacitor discharge stud or resistance spot welds, 1/4 inch or less stud or spot diameter and arc stud welds, 3/8 inch and less stud diameter, have been removed, nor for permanent automatically-timed or permanent resistance welds.

b. Weld surface areas which are to be subsequently covered by other partial or full penetration welds do not require final MT inspection, for example, surface areas of longitudinal butt welds under frame webs and their associated welds, surface areas of frame and stiffener connections covered by intercostal welds (for material 1-1/8 inch and over, see 6.5.3).

c. Inspection is not required for arc strike removal sites, fabrication scars, nicks and gouges prior to repair welding.

d. Inspection is not required for prepared surfaces that will be covered by weld metal or prepared surfaces for bolts, studs, or for pipe, mechanical, or electrical penetration holes less than 4 inches in diameter.

e. Inspection is not required for twin arc tack welds that are a minimum of 6 inches long and blend smoothly into adjacent base material.

f. Inspection is not required of the backgouged surfaces of root passes or repair weld excavation sites if the weld will subsequently be either RT or UT inspected.

g. Inspection is not required for attachment welds to non-pressure hull structure (see 3.38.1).

6.5.3 Loss of preheat inspection. For HY-80/100 base material 1-1/8 inch and over when welding with ferritic electrodes, MT inspection of the weld is required when preheat drops below the temperature specified in 13.6.4.4.

6.5.4 Hard tanks. The inspection sequence for hard tanks is specified in 6.5.5. If subsequent work is performed which involves the penetration of the tank plating of a hard tank that has successfully passed hydrostatic and final MT tests as specified in table I, the new welds shall be contour ground or peened and ground, if required by section 14, and the tank retested hydrostatically and inspected. (MT inspection after hydrostatic testing may be limited to the additional welding; plus, in the event that the new weld is a full penetration weld through the tank plating, the previously inspected full penetration welding in or to the tank plating within 6 inches of the toe of the new weld). This reinspection shall also include 6 inches (measured from the tank plating) of any butt weld in attached members falling within

this area. Backup structure, as identified on figure 4 shall be inspected as specified in table I.

6.5.5 Sequence of MT inspection for hard tanks. MT inspection of hard tanks shall be in the following sequence:

a. Contour grind all hard tank welds, except butt welds (see figure 4).

b. Hydrostatic test.

c. MT inspect 100 percent of all hard tank welds:

(1) If no cracks are found, the tank is acceptable.

(2) If cracks are found, repair in accordance with sections 13 and 14.

d. Hydrostatic test.

e. MT inspect all weld repairs in accordance with the requirements of footnote 2/ to table I:

(1) If no cracks are found, the tank is acceptable.

(2) If cracks are found, repair in accordance with sections 13 and 14; repeat steps 6.5.5.d. and e. until the weld repairs and associated expansion areas are crack-free.

6.5.5.1 Welds under category I.A.(3)(a) of table I, which have passed final inspection are exempt from the MT inspection of 6.5.5.c. See 6.5.4 for reinspection requirements when an accepted hard tank is penetrated by a new full penetration weld. Records of inspection shall be maintained as required by section 5. For hull surveillance inspection, the inspection sequence for the required welds shall be in accordance with 6.5.5.c. through e. The MT inspection of 6.5.5.c. is limited to the required welds only. Final MT inspection shall be performed after all machining or grinding is completed.

6.5.6 Penetrations or hull liners. Welds of penetrations or hull liners greater than 4 inches in diameter which can not be RT inspected in accordance with 6.7.1 or UT volumetrically inspected in accordance with 6.8.4 shall be MT inspected after deposition of each layer, or 3/8 inch thickness, which ever is greater.

6.6 PT inspection.

6.6.1 General. Inspection shall be performed in accordance with section 15. All areas shall comply with the acceptance standards of section 7.

6.6.2 Non-ferrous or austenitic welding. Non-ferrous or austenitic stainless steel welds that penetrate the pressure hull envelope shall have the final weld and backgouged surface (if backgouging is required) PT inspected. If the final weld is to be subsequently UT or RT inspected, PT of the backgouged surfaces is not required. In addition, all weld clad O-ring or gasket seating surfaces to pressure hull envelope shall be PT inspected.

6.6.2.1 Repairs. Weld repair excavations of non-ferrous or austenitic welds do not require PT inspection prior to repair welding.

6.6.3 Final inspection. Final inspection shall be performed in the final surface condition.

6.7 RT inspection.

6.7.1 General. RT inspection requirements are specified in table III. RT inspection shall be performed in accordance with section 15 and interpreted to the acceptance standards of section 7.

TABLE III. RT inspection (applicable to completed welds in or to HY-80/100.

Inspection category	Sequence of inspection	Notes
I. Pressure hull structure		
A. Pressure hull envelope.		
(1) Butt welds in the pressure hull envelope.	Final inspection shall be made no sooner than 8 hours after the weld is completed and the preheat source has been de-energized.	1/ 2/ 3/ 4/ 5/
(2) Other full penetration welds through the pressure hull including penetrations (more than 4 inches in diameter) and liners wherein the projection does not exceed the limits of figure 12.	Final inspection shall be made no sooner than 8 hours after the weld is completed and the preheat source has been de-energized.	2/ 3/ 4/ 5/ 6/

See footnotes at end of table.

of a feature type. (3) Feature type - designation

TABLE III. RT inspection (applicable to completed welds in or to HY-80/100. - continued

Inspection category	Sequence of inspection	Notes
(3) Weld repair of holes or gouges in the pressure hull envelope which exceed 1/3 of the base material in depth.	Final inspection shall be made no sooner than 8 hours after the weld is completed and the preheat source has been de-energized.	1/ 2/ 3/ 5/ 7/
(4) Full penetration butt welds which have been hot formed as in 9.2.6.2.	Final inspection shall be made after forming no sooner than 8 hours after the welds have cooled to ambient temperature.	1/ 2/ 3/ 5/
B. Support structure.		
(1) Butt welds in holding bulkheads.	Final inspection shall be made no sooner than 8 hours after the weld is completed and the preheat source has been de-energized.	1/ 2/ 3/ 4/ 5/ 8/
(2) Butt welds in flanges of pressure hull frames.	Final inspection shall be made no sooner than 8 hours after the weld is completed and the preheat source has been de-energized.	1/ 2/ 3/ 4/ 5/
(3) Butt welds in unflanged pressure hull frames to the extent shown on figure 13.	Final inspection shall be made no sooner than 8 hours after the weld is completed and the preheat source has been de-energized.	1/ 2/ 3/ 4/ 5/
(4) Full penetration butt welds which have been hot formed as specified in 9.2.6.2.	Final inspection shall be made no sooner than 8 hours after the weld is completed and the preheat source has been de-energized.	1/ 2/ 3/ 5/
II. Containment structure and containment bulkheads		
A. Butt welds in the boundary plating of containment structure and containment bulkheads.		

See footnotes at end of table.

TABLE III. RT inspection (applicable to completed welds in or to HY-80/100. - continued

Inspection category	Sequence of inspection	Notes
III. Non-pressure hull structure		
A. Intermediate pressure tanks.		
(1) Butt welds in tank plating.	Final inspection shall be made no sooner than 8 hours after the weld is completed and the preheat source has been de-energized.	1/ 2/ 3/ 4/ 5/

FOOTNOTES TO TABLE III.

1/ The degree of inspection shall be 100 percent unless otherwise specified.

2/ (a) When repair welding is required as a result of RT inspection, the repaired area shall be re-radiographed for the length of the repair plus 3 inches on each end of the repair. When an intersecting full penetration weld to the pressure hull, that is 1/4 the hull thickness or greater, falls within the 3 inch expansion requirement, the RT inspection of the repair of a full penetration hull butt weld in the pressure hull envelope need only extend to the intersecting weld.

(b) Re-RT of welds previously accepted by RT is not required when the depth of repair of a defect which is MT or VT detected does not exceed two layers or half the thickness of the thinnest member joined, whichever is less.

3/ When additional weld is deposited on the surface of RT accepted welds, re-RT is not required provided the additional weld deposit does not exceed two layers. Subsequent weld overlay or buildup for corrosion or dimensional control which covers previously accepted welding is not subject to the two layer limitation, and re-RT of the previously accepted welding is not required.

4/ UT inspection may be substituted for RT inspection for butt welds in flanges and unflanged webs, and shall be substituted for those portions of butt welds which are obscured from RT inspection by frame webs, attaching webs, or structural bulkheads other than containment bulkheads. (See figure 13.)

5/ Grinding or machining, within the limits of section 14, of welds previously accepted by RT or UT shall not require reinspection by RT or UT.

6/ The degree of inspection shall be 100 percent except as shown on figure 12.

7/ Bolt holes which are weld repaired and will be re-drilled within 1/2D, where D is the bolt hole diameter, of the initial location (centerline to centerline) of the bolt hole do not require RT.

8/ UT inspection may be substituted for the RT inspection of butt welds used in the installation of access plates in holding bulkheads. Containment bulkheads are excluded from this substitution.

6.8 UT inspection.

6.8.1 General. UT inspection shall be performed in accordance with section 15 and interpreted to the acceptance standards of section 7.

6.8.2 Welds. UT volumetric inspection of welds, performed in accordance with MIL-STD-271, shall be substituted for RT when the required RT cannot be performed to the requirements of this document. Grinding or machining within the limits of section 14 of welds accepted by UT shall not require reinspection by UT. If substitution of UT for RT involves a weld repair requiring expansion of inspection in accordance with footnote 2/ to table III, UT may also be used for the expansion areas.

6.8.3 Tee welds. Full penetration tee joints welded from both sides to the pressure hull envelope simultaneously (twin arc) or which are not root cleaned and inspected as required by table I (unless exempted by 6.5.2) shall be UT inspected for full penetration in accordance with MIL-STD-271.

6.8.4 Penetrations or hull liners. Welds of penetrations greater than 4 inches in diameter or liners which project through the pressure hull more than 1 inch at any point in the circumference or weld length shall be UT volumetrically inspected if the joint is accessible, and of a configuration suitable for ultrasonic inspection, provided the design angle does not exceed the requirements of footnote 3/, figure 12.

6.8.5 Approval. Applications of UT as a substitute for MT or PT shall be subject to approval. Applications of UT as a substitute for RT other than as specified in 6.8.2, table III or figure 12 shall be subject to NAVSEA approval.

6.9 Stud welding inspection. Stud welding inspection requirements shall be in accordance with section 13.

6.10 Electrode moisture determinations. Electrode moisture inspection requirements shall be in accordance with section 10.

6.11 Castings. Castings which have satisfactorily passed receipt inspection requirements shall be considered as wrought material as specified in 16.2.1, except for MT acceptance, where the standards of section 7 for castings shall be acceptable. Where PT is used for the inspection of weld overlay cladding, any defects found in the base metal shall be evaluated for acceptance to the MT criteria of section 7 for castings.

7. INSPECTION ACCEPTANCE STANDARDS

7.1 Scope. This section contains the inspection acceptance standards (including visual inspection) which apply to submarine structure for the detection of surface and internal discontinuities in HY-80/100 base materials and welds in or to HY-80/100. Discontinuities that exceed the limits set forth herein shall be repaired in accordance with the requirements of this standard.

7.2 General. Acceptance standards are contained for the following:

a. Visual inspection of completed welds (VT).
b. Magnetic particle inspection (MT).
c. Radiographic inspection (RT).
d. Ultrasonic inspection (UT).
e. Liquid penetrant inspection (PT).

Ships structure fabricated in accordance with this standard shall comply with all applicable drawings, specifications and standards. Personnel responsible for evaluation of all NDT results shall be certified in accordance with section 4.

7.3 VT inspection of base materials. VT acceptance standards shall be in accordance with section 8.

7.4 VT inspection of completed welds. Completed welds inspected in accordance with 6.4 shall comply to the acceptance criteria detailed herein.

7.4.1 Weld inspection zone. The area to be inspected shall include the weld face and 1/2 inch of base material on each side of the weld. Areas beyond this weld zone shall be controlled by the workmanship requirements of section 14.

7.4.2 Cleanliness. Welds inspected for final acceptance shall be free of slag, paint (except as allowed by section 15) and spatter in excess of 1/8 inch length or diameter.

7.4.3 Weld surface uniformity. The weld surface shall be free of sharp irregularities between beads and shall fair into the base material at the weld edges without undercut or overlap (rollover) in excess of the requirements of this standard. Surface roughness, burn through, oxidation and crater pits shall not exceed the acceptance criteria of NAVSEA 0900-LP-003-8000. Weld surfaces shall be prepared for NDT as required by section 15.

7.4.4 Shape of fillet weld face. Fillet and fillet reinforced welds shall be essentially flat (-1/16 inch +3/16 inch of a line drawn toe-to-toe). Weld concavity is acceptable provided the minimum throat thickness is at least equal to the minimum specified leg size multiplied by 0.7 (see figure 1). Excessive roughness at weld edges and re-entrant angles less than 90 degrees as shown in figure 1 shall be corrected.

7.4.5 Arc strikes. Arc strikes shall be repaired in accordance with 14.6.2.

7.4.6 Cracks. All cracks shall be removed.

7.4.7 Porosity. Only pores greater than 1/32 inch in length or diameter shall be evaluated. No single pore shall be greater than 3/32 inch in length or diameter. The sum of pore diameters in any two inch length of weld shall not exceed 1/8 inch.

7.4.8 Undercut, end-melt and corner-melt. Depth of undercut and grinding shall be measured from the unground plate surface adjacent to the weld area (see figure 14 for gauges). End-melt and corner-melt shown in figure 15 and undercut shall meet the requirements of table IV.

TABLE IV. Undercut, end-melt and corner-melt.

			Maximum depth/length after grinding	
Condition	Base metal thickness (inches)	Maximum depth as-welded condition (inches)	Depth (inch)	Length restriction
Undercut	Less than 1/2 1/2 and larger	1/32 1/32	1/32 1/32 1/16	None None 1/
End-melt 2/	1/4 and less only	1/32	1/16	Only at ends of a member, figure 15.
Corner-melt	Any thickness	1/32	1/16	Only at the corners of a member, figure 15.

1/ The accumulated length does not exceed either 15 percent of the joint length or 12 inches in any 36-inch length of welding, whichever is less.
2/ For base material greater than 1/4 inch, undercut requirements apply.

7.4.9 Weld size.

7.4.9.1 Groove-tee and fillet welds. Groove-tee fillet reinforced welds and fillet welds shall be at least equal to the size specified on the drawing (except as allowed by 7.4.10). When fillet size must be increased due to excessive gap between members at the time of fit-up, the required weld size shall be increased as required by 14.2.4.

7.4.9.2 Butt welds. Butt weld surfaces shall not be below the adjacent plate surfaces, except localized weld surface indication areas and weld toes, unground or corrected by grinding, that do not exceed the depth limitations for undercut of 7.4.8. The as-deposited surfaces at the weld edge shall be satisfactory, provided they do not form a re-entrant angle less than 90 degrees with the base plate due to excessive convexity and rollover. Butt welds ground for hydrodynamic purposes shall not extend more than 1/16 inch above the adjacent plate surfaces. In the case of butt welds joining plates of unequal thickness, the weld shall taper gradually, approximately four to one, from the beveled edge of the thicker plate surface to the thinner plate. No point of the finished tapered butt weld surface shall be below a line from the edges of the weld joint preparation except for allowable undercut. Otherwise butt weld reinforcement shall not require a maximum height limitation provided all other requirements of this section are met.

7.4.10 Seal-off and wrap-around welding. Fillet and fillet reinforced partial penetration welds shall be sealed off with weld at the end(s) of members (flatbars, angles, channels and tees) to form a closed loop where surfaces are to be wetted. Members which will not be wetted shall be sealed off when practical. When specified by a weld all-around symbol, the minimum weld reinforcement size shall be maintained (wrap-around) at the end(s) of attached members. When the member is located per tolerances and the full size fillet weld (wrap-around) is not obtainable, the maximum size obtainable shall be considered acceptable provided the above seal-off requirement in wetted areas is maintained.

7.4.11 Contour grinding. When required, contour ground welds shall comply with the requirements of 14.4, and figure 16. Contour grinding of fillet or partial penetration welds shall not be performed unless required by the ships specifications or drawings, or 14.4 in which cases, fillet size requirements shall be maintained after contouring.

7.4.12 Nicks, gouges, and other fabrication scars. Nicks, gouges, and other fabrication scars in the weld inspection zone shall not exceed 1/32 inch in depth and 12 inches in length for materials less the 1/2 inch thick; and, provided the fabrication scar blends smoothly into the material, 1/16 inch in depth and 12 inches in length for materials equal to or greater than 1/2 inch thick.

7.4.13 Other NDT. Welds that comply to the requirements set forth above are considered acceptable for any other NDT.

7.5 MT inspection.

7.5.1 Welds. All welds and 1/2 inch of adjacent base material shall be inspected, when specified. Indications less than 1/16 inch shall be disregarded. The following conditions shall be cause for rejection:

a. Relevant linear indications greater than 1/8 inch in length.

b. Two or more relevant linear indications separated by less than 1 inch.

c. Four or more relevant linear indications in any 4 inches of weld length.

7.5.1.1 Nonrelevant indications. Indications believed to be nonrelevant shall be investigated for relevancy in accordance with MIL-STD-271.

7.5.2 Castings. All accessible casting surfaces shall be inspected. Indications less than 1/8 inch shall not be evaluated. The following conditions shall be cause for rejection:

a. Relevant linear indications greater than 1/4 inch in length.

b. Two or more relevant linear indications separated by less than 1 inch.

Indications which do not meet this criteria may be removed by grinding without repair welding provided the minimum design thickness is not violated. Weld repairs and 1/2 inch of adjacent base material shall meet the requirements of 7.5.1.

7.5.3 Flame, arc-cut or machined plate edges and tapers. When inspected as required in section 6, all indications in excess of the following shall be cause for rejection. Repair may be accomplished in accordance with sections 13 and 14.

a. Any single linear indication lying approximately parallel to the surface whose length exceeds 2 inches.

b. Linear indications lying approximately parallel to the surface whose accumulated length exceeds 4 inches in the least favorable 6-inch length.

c. Any linear indication normal to the major surfaces of the material.

d. Laminations visually disclosed on exposed plate edge which are not included in a weld joint shall be excavated and welded as specified in section 14.

7.5.4 Formed material. When inspected as required by section 6, the surfaces of hot or cold formed material shall be free of linear indications in excess of 1/8 inch. Welds, temporary weld sites or areas of welded surface repair on hot formed material, which were welded prior to heat treatment, shall meet the requirements of 7.5.1.

7.5.5 Forgings and bars. When required to be MT inspected by section 8 or by applicable specifications, the inspected surfaces of forgings and bars shall be free of linear or linearly disposed indications in excess of 1/8 inch. Welds and heat affected zones in forgings and bars shall meet the requirements of 7.5.1.

7.6 RT inspection.

7.6.1 Welds. Radiographs of welds shall be interpreted to the class II standards of NAVSEA 0900-LP-003-9000 (section II does not apply).

7.6.1.1 Inadvertent radiography. Inadvertent radiography shall be dispositioned in accordance with NAVSEA 0900-LP-003-9000.

7.6.2 Castings.

7.6.2.1 Base materials. When radiographed as required by section 8, casting radiographs shall meet the acceptance criteria indicated in table V. After castings have been released for fabrication, i.e., the casting has met the base material specification requirements including repair of base material defects, the inspection requirements of section 6 and acceptance standards of section 7 apply except:

a. Rejectable MT indications found after machining or fabrication/ installation welding need only be removed to the following extent:

(1) Until the indication length is reduced to 1/4 inch or less for depths of excavation up to and including 3/8 inch.

(2) Until the indication length is reduced to 1/2 inch or less for depths of excavation greater than 3/8 inch and up to and including one inch.

Depths of excavation need not exceed one inch regardless of indication length provided the area has previously passed, or passes, RT or UT inspection requirements.

b. Rejectable linear PT indications shown to be associated with the casting need not be removed if VT inspection verifies the indication to be less than or equal to 1/4 inch in length. Linear indications at the toe of the weld shall be evaluated to the respective weld class for the weld involved. Where the linear indication exceeds 1/4 inch in length, removal shall be as

established in a. above. Rounded indications, up to and including 5/16 inch diameter, shall not be cause for rejection.

c. Rejectable RT or UT indications associated with fabrication or installation welds need not be removed if it is established that the indications are contained within the casting. Comparison to the radiographs of the casting of the area involved is an acceptable method for assessment of the indications.

Inspection requirements, including extent and type of inspection to be performed for weld repair, shall be based upon the intended use of the casting, e.g., pressure hull envelope, support structure. For those castings which fulfill multiple functions, e.g., portions of the casting act as pressure hull envelope and other portions act as support structure, the inspection requirements for the applicable usage location applies.

TABLE V. RT acceptance criteria for castings.

Thickness (inches)	ASTM 1/ Standard	Shrinkage	Porosity	Inclusion	Hot tears or cracks	Inserts or chaplets
Less than 1	E 446	CA 2 CB 2 CC 2 CD 2	A2	B2	None	None
1 to 2	E 446	CA 3 CB 3 CC 3 CD 3	A3	B3	None	None
Over 2 to 4-1/2	E 186	C (Type 1) Level 3 C (Type 2) Level 3 C (Type 3) Level 3	A3	B3	None	None
Over 4-1/2 to 12	E 280	C (Type 1) Level 2 C (Type 2) Level 2 C (Type 3) Level 3	A3	B3	None	None

1/ Evaluation of radiographs for acceptance shall be in accordance with the applicable ASTM standard.

7.6.2.2 Weld repair. Weld repairs in castings shall be interpreted to the class III standards of NAVSEA 0900-LP-003-9000 (section II does not apply). Indications appearing in the weld repair that are determined to be in the casting and acceptable to the casting standard shall not be rejected. RT prior to repair (for comparison) or UT after repair may be used for such determinations. In applying the standards of this section to casting weld repair, the surface area of the casting repair shall be adjusted to the weld surface area illustrated in the strip porosity charts, with the maximum repair depth determining which chart is used. Interpolation may be employed for thicknesses not shown and extrapolation for thicknesses beyond 4 inches. Porosity, slag, lack of fusion or incomplete penetration may be judged in this manner, that is, by considering the repair area as a series of adjacent strips of weld, if the extent of repair necessitates it, to allow comparison with the porosity illustrations and the slag, lack of fusion, and incomplete penetration charts.

7.6.3 RT indications of surface imperfections. When weld spatter and arc strikes in excess of the requirements set forth in this standard are overlooked during VT and are shown as RT indications in the weld area, not interfering with interpretation, the affected area need not be re-radiographed but should be cleared and the action noted in the RT records. When doubt exists as to the acceptability of RT indication of weld spatter, arc strikes, grinding marks, surface roughness or handling marks, a VT inspection shall be made to the area in question. Final acceptance or rejection shall be based on the results of such VT inspection and notation of this action shall be made on the RT record.

7.7 UT inspection.

7.7.1 Materials. Materials shall meet the UT inspection acceptance standards of the applicable base material specification.

7.7.1.1 Weld repairs in castings. Weld repairs in castings that would require RT in accordance with section 16, but cannot be RT inspected due to configuration or obstructions may be UT inspected for acceptance. The weld surface shall be ground flush and inspected in accordance with the original base material specification. In addition, a volume extending 1/2 inch from the weld toes and equal to the depth of excavation shall be inspected in accordance with NAVSEA 0900-LP-006-3010, class II requirements. The design material thickness (DMT) shall be based on the depth of excavation.

7.7.2 Welds. Acceptance standards for butt and corner welds inspected by the UT method, as specified in section 6, shall be in accordance with the class I requirements of NAVSEA 0900-LP-006-3010. Acceptance standards for tee welds inspected by the UT method, as specified in section 6, shall be in accordance with the requirements of NAVSEA 0900-LP-006-3010. In cases where volumetric UT inspection of tee welds is required, acceptance standards shall be in accordance with the class III requirements for full penetration butt and corner welds of NAVSEA 0900-LP-006-3010. NAVSEA approval is required to use

UT in lieu of specified RT except for those applications permitted by section 6. UT inspection of expansion areas required by footnote 2/ to table III (when UT is substituted for RT) shall meet the above requirements.

7.8 PT inspection.

7.8.1 Welded joints. Weld joints shall be evaluated in accordance with class 2 criteria of NAVSEA 0900-LP-003-8000.

7.8.2 Weld cladding. Weld cladding shall be evaluated in accordance with NAVSEA 0900-LP-003-8000 as follows (see figure 5):

a. Inboard surfaces - class 3.

b. Seating or seal area - class 1.

c. Outboard surfaces - class 2.

8. RECEIPT INSPECTION OF MATERIALS

8.1 Scope. This section contains the requirements of the receipt inspection of HY-80/100 plates, bars, shapes, castings, forgings, and filler materials used in welding submarine structures. Other required NDT shall be as required by the acquisition specification.

8.2 Documentation. Documentation showing compliance with the requirements herein shall be part of the inspection records maintained as required by section 5.

8.2.1 Responsibility. The receiving activity shall be responsible to verify that the inspections required in this section are performed and documented. Certified test results for all HY-80/100 materials, including filler metals, showing chemical and mechanical properties as determined by the contractor, shall be obtained and reviewed for compliance with the applicable material specification. The receiving activity shall verify that each manufacturer of material received has successfully completed and has a NAVSEA approval letter for the first article test requirements for the type (plate, casting, etc.) and the specific grade (HY-80 or HY-100) of material.

8.2.2 Contractor inspection. Where the required inspection is performed by the contractor or by other subcontracted representative prior to receipt, the receipt inspection by the receiving activity shall consist of checking the required documentation against the material received for compliance with the applicable material specification.

8.2.3 Receiving activity inspection. Where the required inspection has not been made prior to receipt, the receiving activity shall perform and record the inspection required by the acquisition document as well as the inspections specified in this document.

8.3 Surface cleaning and preservation. Prior to inspection, the materials shall have been cleaned by an approved pickling procedure or by blasting.

8.3.1 Wrought HY-80/100 materials. Plates, bars, shapes, and forgings shall be free of mill scale and extraneous matter in accordance with the applicable material specifications. When pickling is used, heavy scale shall be broken by flame descaling or other suitable means. The pickling time shall be limited as necessary to prevent surface pitting. Excessive quantities of nickel smut produces in pickling solution shall be removed. This requirement applies only to finished items.

8.3.2 Cast HY-80/100 materials. Cast materials shall have been cleaned by abrasive blasting or mechanical processes in accordance with the applicable material specification. Scale, fins, sand, and excessive rough spots shall be removed by mechanical means, unless removed prior to quenching and tempering.

8.3.3 Priming. After cleaning, priming of HY-80/100 materials shall be accomplished in accordance with the applicable material specification.

8.4 HY-80/100 plate material. Records, as required by section 5, shall be maintained for each plate or section of plate used in pressure hull structure that is inspected for the following in accordance with the applicable base material specification MIL-S-16216.

8.4.1 Surface defects. After the plate has been cleaned and primed, VT inspection shall be made of both surfaces for surface defects.

8.4.2 Dimensions. Micrometer edge or UT gauging for thickness shall be used.

8.4.3 Soundness. Material over 1/2 inch in thickness for pressure hull structure shall be UT inspected for soundness.

8.4.4 Identification. Plate materials shall be identified.

8.4.5 Hardness. Plates 1/2 inch and greater in thickness shall have hardness measurements taken at a minimum of two points, at diagonal corners. These measurements shall fall within the range of 200-260 Brinell hardness numbers (BHN) for HY-80 and 230-290 BHN for HY-100.

8.5 HY-80/100 rolled or extruded shapes. Records of inspection, as required by section 5, shall be maintained for shapes used in pressure hull structure inspected for the following in accordance with the applicable base metal specification MIL-S-22664.

8.5.1 Surface defects. All surfaces of shapes shall be VT inspected for surface defects. Unacceptable surface conditions shall be repaired as specified in 8.10.2. Shapes which are flame or arc cut shall have the cut surfaces VT inspected. If defects over 1/4 inch long are found, MT inspection shall be performed on all cut surfaces on the involved material. These cut surfaces shall meet the MT standards of section 7.

8.5.2 Dimensions. Shapes shall comply with the specification requirements for dimensions, squareness, straightness, camber, and freedom from twist. This inspection shall be performed prior to fabrication.

8.5.3 Soundness. Structural shapes with web thickness over 1/2 inch used in pressure hull structure shall be UT inspected to the acceptance standards of section 7.

8.5.4 Identification. Shapes shall be identified.

8.5.5 Hardness. Shapes shall have hardness measurements made at each end. These measurements shall fall within the range of 200-260 BHN for HY-80 and 230-290 BHN for HY-100.

8.6 HY-80/100 bars. Records of inspection, as required by section 5, shall be maintained for bars used in pressure hull structure inspected for the following in accordance with the base material specification MIL-S-21952.

8.6.1 Surface defects. Bars shall be VT inspected for surface defects. Bars which are flame or arc cut shall have the cut surfaces VT inspected. If defects over 1/4 inch long are found, MT inspection shall be performed on all cut surfaces on the involved material. These cut surfaces shall meet the MT acceptance standard of section 7.

8.6.2 Dimensions. Bars shall comply with the inspection requirements.

8.6.3 Identification. Bars shall be identified.

8.6.4 Hardness. Bars shall have hardness measurements made at each end. These measurements shall fall within the range of 200-260 BHN for HY-80 and 230-290 BHN for HY-100.

8.7 Cast HY-80/100 material. Records, as required by section 5, including location of nominal and special weld repairs performed in accordance with section 16, shall be maintained for all HY-80/100 castings.

8.7.1 Surface defects. HY-80/100 castings shall be VT inspected for compliance with MIL-S-23008 for initial inspection, and section 16 for weld repairs.

8.7.2 Dimensions. Dimensions shall be checked for acceptability to acquisition specifications.

8.7.3 Soundness. Castings shall have been MT and RT inspected to and approved procedure as required by MIL-S-23008. All NDT results, including radiographs, together with records of nominal and special weld repairs performed, shall be obtained by the receiving activity and reviewed for compliance with 7.6.2, and the applicable specification. Areas exhibiting unacceptable soundness or surface defects shall be repaired in accordance with section 16. The following HY-80/100 castings require RT inspection to the extent specified. UT inspection may be used in lieu of RT where geometry would not yield satisfactory RT results or where casting thickness is beyond practical RT limits.

8.7.3.1 Shooting sketch. Castings forming part of the pressure hull envelope shall receive 100 percent RT inspection in accordance with a radiograph standard shooting sketch.

8.7.3.2 Castings other than those forming part of the pressure hull envelope.

8.7.3.2.1 Those areas which by failure would prevent normal propulsion, steering, or diving shall receive at least 75 percent RT inspection.

8.7.3.2.2 Those areas designed to be stressed in excess of 2/3 of yield strength, when yield is the basis for design, shall receive at least 75 percent RT inspection.

8.7.3.2.3 Those areas serving as support structure shall receive at least 75 percent RT inspection.

8.7.4 Hardness. Castings shall have hardness measurements made at area of minimum and maximum thickness. These measurements shall fall within the range of 200-260 BHN for HY-80 and 230-290 BHN for HY-100.

8.8 HY-80/100 formed materials. Records of contractor repairs performed in accordance with section 13, together with certified mechanical test and RT results, shall be maintained as required by section 5 for all HY-80/100 formed material.

8.8.1 Surface and soundness. Formed materials shall have been inspected as required by section 9 to the applicable requirements of this section for plate material surface inspection and soundness. Certified test results and radiographs of welds in formed material shall be obtained by the receiving activity and reviewed for compliance with this document and applicable specifications.

8.9 HY-80/100 forgings. Records of inspection, as required by section 5 for the following items, shall be maintained for forgings used in pressure hull structure inspected in accordance with base material specification.

8.9.1 Surface defects. Forgings shall be VT inspected for compliance with MIL-S-23009.

8.9.2 Dimensions. Dimensions shall be checked for acceptability to acquisition specification.

8.9.3 Soundness. Forgings shall have been MT and, when specified, UT inspected as required by MIL-S-23009.

8.9.4 Identification. Forgings shall be identified.

8.9.5 Hardness. Forgings shall have hardness measurements made at area of minimum and maximum thickness. These measurements shall fall within the range of 200-260 BHN for HY-80 and 230-290 BHN for HY-100.

8.10 Grinding and welding repairs. Repairs of unacceptable surface conditions disclosed during VT inspection of HY-80/100 material surfaces shall be accomplished in accordance with the following requirements.

8.10.1 Weld repairs of mill defects on plate surfaces. Surface roughness in excess of that permitted in the base material specification, and which cannot be repaired by grinding, shall be weld repaired in accordance

with the base material specification. Welding requirements for these repairs shall be in accordance with section 13.

8.10.2 Shape surface repairs. Surface tears, scores, seams, scabs, blisters, laps, snakes, and scale in excess of the base material specification shall be removed by grinding provided the thickness is not reduced below that allowed by the base material specification.

8.10.2.1 Weld repairs. At the time of shape surface inspection, surface imperfections of sufficient depth to reduce the shape material below that permitted in the base material specification, and which cannot be repaired by grinding, shall be weld repaired in accordance with the base material specifications. Welding requirements for these repairs shall be in accordance with section 13.

8.10.3 Forging surface repairs. Grinding shall be employed to remove unacceptable surface defects within the limitations of the base material specification.

8.10.3.1 Weld repairs. Weld repairs of base metal surface defects of forgings are prohibited unless specifically approved by NAVSEA. Approved weld repairs shall be accomplished in accordance with the requirements of section 13. Weld buildup to correct machining errors shall be accomplished in accordance with the requirements of section 13.

8.11 Welding filler materials. Records of inspection required by section 5 shall be maintained for all electrodes listed in section 10. Welding wire, electrodes (bare and coated) and submerged arc flux shall be accepted for chemistry, mechanical properties and electrode coating moisture content based on inspection and test at the point of manufacture or by the receiving activity for compliance to the applicable material specification. Where testing is done by the manufacturer, a certified copy of the test results shall be obtained by the receiving activity and reviewed for compliance with the applicable material specification.

8.11.1 Ferritic filler material verification. The chemistry of ferritic welding wire and electrodes (bare and coated) and submerged arc flux shall be verified by the receiving activity in the following manner.

8.11.1.1 Manual shielded metal arc electrodes. Chemical analysis shall be made from coated electrode weld deposits as specified in MIL-E-22200. The sampling plan for selection of samples for deposition of chemical analysis pad shall be in accordance with table VI. Each lot of ferritic manual shielded metal arc electrodes shall be as identified by the contractor with lot definition as specified in MIL-E-22200, level B.

TABLE VI. Electrode sampling plan.

Level I	Each lot of material submitted by a single contractor shall be sampled. Upon obtaining five consecutive acceptable sample lots, sampling shall be made at level II.
Level II 1/	One lot selected at random from each five lots submitted by a contractor shall be sampled. Upon obtaining ten consecutive acceptable sample lots, sampling shall be made at level III.
Level III 1/	One lot selected at random from each ten lots submitted by a contractor shall be sampled. Upon obtaining 15 consecutive acceptable sample lots, sampling shall be made at level IV.
Level IV 1/	One lot selected at random from each 20 lots submitted by a contractor shall be sampled.

1/ If an unacceptable sample lot is obtained at level II, III or IV, sampling level shall revert to the next lower (more restrictive) level until satisfactory performance is demonstrated by conformance with the requirements at that level.

8.11.1.2 Gas metal arc spooled bare wire. Chemical analysis shall be made from gas metal arc spooled wire samples taken from each lot to determine specification compliance. One sample per lot shall be taken for analysis. Each lot of ferritic bare wire electrode shall be identified by the contractor with lot definition as specified in MIL-E-23765.

8.11.1.3 Submerged arc flux-wire combinations. Chemical analysis shall be made from submerged arc flux-wire combinations taken from each wire-flux lot combination to determine specification compliance. Analysis may be made from weld deposits using methods similar to those outlined in MIL-E-22200. Each lot of submerged-arc flux or submerged-arc wire shall be identified by the contractor, with lot definition as specified in MIL-E-23765.

9.0 FORMED MATERIALS AND WELDS

9.1 Scope. This section covers requirements for additional forming of HY-80/100 plate, forgings, and rolled, extruded or fabricated shapes (for castings, see section 16), beyond that permitted by the applicable material specifications.

9.2 Hot forming. Hot forming operations shall be performed between 1600 degrees Fahrenheit and 2150 degrees Fahrenheit.

9.2.1 Contaminants. Prior to hot forming operations, the surfaces of the material to be formed shall be free of oil, grease, zinc, lead, tin, copper, and substances which contain these materials or elements, or other low melting point alloys.

9.2.2 Base material testing. After forming, the material shall be heat treated to produce properties conforming to those specified in applicable material specifications. Test specimens for determining properties shall be removed from material which is an integral part of each hot formed and heat treated piece after final heat treatment and completion of all forming operations. A separate test piece may be used provided it is from the same heat of material, is of approximately the same maximum cross-section, is subjected to the same thermal cycling and is heat treated with the formed material.

9.2.3 Thickness and soundness tests. After heat treatment, each hot formed piece of HY-80/100 material shall be subjected to thickness and ultrasonic soundness tests to the extent required in section 8.

9.2.4 Surface inspection. After heat treatment and cleaning, the surfaces of the hot formed HY-80/100 material shall be inspected in accordance with section 6. Surface areas that are elongated in excess of 15 percent in the process of hot forming shall be MT inspected in accordance with section 6. Figure 17 may be used as an aid in determining elongation. When repairs are required, they shall be performed in accordance with sections 13 and 14.

9.2.5 Welding procedure qualification for hot formed and heat treated welds. A level number 1 procedure qualification test, as described in MIL-STD-248, shall be performed to qualify any electrode employed for weld joints, temporary welds, or welded surface repairs in material which is to be subjected to hot forming and heat treatment after such welding. The qualification test plate shall undergo cycling representative in magnitude and time at temperature of that employed in hot forming and subsequent heat treating operations.

9.2.6 Production weld testing. Weld metal impact and tensile tests shall be performed for each piece of hot formed and heat treated material which contains a weld deposit prior to hot forming or heat treating. Test results shall meet the requirements of MIL-E-22200/10 for minimum yield

acceptance standard of section 7.

strength, elongation, and impact strength. These tests may be taken from run off tabs of the same material.

9.2.6.1 MT inspection of hot formed welds and base metal repair welds. After heat treatment, all weld joints, temporary weld sites, or areas of welded surface repair, welded prior to heat treatment, shall be subjected to a MT inspection in accordance with section 6.

9.2.6.2 RT inspection of hot formed welds. After heat treatment, all complete penetration butt welds in hot formed HY-80/100 material shall be radiographed in accordance with section 6.

9.2.6.3 Hot formed welds and base metal repair welds. Hot formed welds and base metal repair welds inspected and accepted after forming and heat treating in accordance with the requirements herein, shall be considered as base metal for the purpose of any further inspection requirements stated in section 6.

9.3 Cold forming. Cold forming operations shall be performed below 500 degrees Fahrenheit. Cold forming may be done on fully heat treated material and welds in such material.

9.3.1 Surface inspection requirements for cold formed material. MT inspection shall be performed on all finished tension surfaces of any HY-80/100 material which is cold formed in excess of 12 percent total elongation. When these tension surfaces are machined, final MT inspection shall be performed after finish machining. Figure 17 may be used as an aid in determining elongation.

9.3.2 Inspection requirements for cold formed base material, butt and repair welds. MT inspection shall be performed on all welds that are cold formed (including straightening) during fabrication when required by section 6. Repair welds to plate edges which will be subsequently covered with weld metal and base metal repair welds, accomplished, inspected and accepted prior to forming, do not require this inspection.

9.3.3 Requirements for cold formed welds. Welds shall not be cold formed in excess of six percent total elongation unless otherwise approved.

9.3.4 In-process heating for cold forming. If in-process heating is employed, it shall not exceed 500 degrees Fahrenheit for cold forming.

9.4 Forming restrictions. Forming in the temperature range between the hot and cold forming temperatures is prohibited due to embrittling effects.

10. WELDING MATERIALS

10.1 Scope. This section covers filler materials to be employed for fabrication of HY-80/100 materials.

10.2 HY-80/100 to HY-80/100 or other ferritic material. Unless otherwise approved, the filler material type, specifications, and the associated welding processes shall be restricted to the application listed in table VII.

10.2.1 HY-80/100 to HSS or OSS steel. MIL-7018-M and MIL-8018-C3 covered electrodes may be used for welding HSS or OSS steel (0.30 C maximum) materials to HY-80/100 provided the covered electrode exposure and coating moisture content are controlled within the limitations for covered electrodes specified in 10.6. In addition, MIL-8018-C3 electrode moisture content and moisture resistance shall meet the requirements of MIL-E-22200/10 and be specifically approved by NAVSEA (see note 5/ of table VII). Equivalent bare wires may also be used. When HY-80/100 is joined to OSS/HSS and a high strength joint is required by design analysis, the applicable drawing(s) shall specify the joint be welded with the applicable high strength welding materials specified in table VII for joining HY-80/100 steel to itself.

10.3 HY-80/100 to non-ferrous and austenitic materials. Unless otherwise approved, the filler material type, specifications, and the associated welding process shall be restricted to the applications listed in table VIII.

10.4 Receipt inspection. Welding materials shall be receipt inspected as required by section 8.

10.5 Conditioning and maintenance of MIL-7018-M, MIL-8018-C3, MIL-10018-M1, MIL-11018-M, and MIL-12018-M2 electrodes. These electrodes may be used directly from manufacturer's hermetically sealed containers without baking prior to initial issue. (See note 5/ of table VII for moisture and moisture resistance restrictions on MIL-8018-C3 and MIL-11018-M electrodes). Subsequent issue shall meet the requirements of 10.6. Where the moisture requirements of 10.6 are exceeded or where deemed necessary by the activity concerned, baking followed by storage in holding ovens shall be accomplished in accordance with the following.

TABLE VII. Filler materials, HY-80/100 to HY-80/100 or other ferritic steels.

Process	Filler material		Application
	Type	Specification number	
SMAW	MIL-12018-M2 1/	MIL-E-22200/10	HY-100 to HY-100
	MIL-10018-M1	MIL-E-22200/10	All 2/ HY-100 weld repairs 3/
	MIL-11018-M 1/ 4/ 5/	MIL-E-22200/1	All 2/
	MIL-7018-M	MIL-E-22200/10	OSS to HY-80/100 HSS to HY-80/100
	MIL-8018-C3 5/	MIL-E-22200/1	
GMAW, SAW, GTAW semi-automatic or automatic	MIL-120S-1 6/ 7/	MIL-E-23765/2	HY-100 to HY-100
	MIL-100S-1 6/ 8/	MIL-E-23765/2	All 2/
	MIL-70S 6/ 9/	MIL-E-23765/1	OSS to HY-80/100 HSS to HY-80/100
FCAW	MIL-110TC MIL-101TC MIL-101TM MIL-101TS MIL-100TC MIL-100TM MIL-100TS	MIL-E-24403/2	All 2/ 10/
	MIL-7XT-1-HY MIL-7XT-X-HY MIL-7XTX-X-HY MIL-8XTX-X-HY	MIL-E-24403/1	OSS to HY-80/100 10/ HSS to HY-80/100 10/

1/ Lower strength filler materials may be used for tack welds not to exceed three weld layers in joints subsequently completed with MIL-120 type weld materials when used with a welding procedure qualified in accordance with section 4 and when approved by NAVSEA.

2/ Except HY-100 to HY-100.

3/ Limited use for repair of fillet or groove tee welds in HY-100 material as permitted in section 13.

4/ MIL-11018-M electrodes must be specifically approved by NAVSEA.

5/ MIL-8018-C3 and MIL-11018-M type electrodes in accordance with MIL-E-22200/1 must meet the moisture and moisture resistance requirements of MIL-E-22200/10 and be specifically approved by NAVSEA.

6/ The use of the SAW process for HY-100 applications is not allowed unless approved by NAVSEA on a case basis.

7/ For the SAW process, use qualified neutral granular flux MIL-120S-1F with reduced moisture requirements and use wire with reduced hydrogen requirements as specified in MIL-E-23765/2.

8/ For the SAW process, use qualified neutral granular flux MIL-100S-1F.

9/ For the SAW process, use qualified neutral granular flux MIL-70S-1F.

10/ The FCAW process is limited to non-pressure hull applications unless approved by NAVSEA on a case basis.

TABLE VIII. Filler materials, HY-80/100 to non-ferrous metals and austenitic steels.

Process	Filler material		Application
	Type	Specification number	
SMAW	MIL-309-15/16 MIL-309Cb-15/16 MIL-310-15/16 MIL-310Cb-15/16	MIL-E-22200/2	Welded joints between HY-80/100 and stainless steel and for clad welding these alloys.
SMAW	MIL-4N11 MIL-9N10 MIL-8N12	MIL-E-22200/3	Welded joints between HY-80/100 and nickel copper/copper nickel/nickel chromium iron alloys and for clad welding these alloys.
	MIL-1N12		Cladding.
GMAW, GTAW, SAW 1/	MIL-309 MIL-309Cb	MIL-E-19933	Welded joints between HY-80/100 and stainless steel and for clad welding these alloys.
GMAW, GTAW, SAW 1/	MIL-EN60 MIL-EN61 MIL-EN62 MIL-EN-82 MIL-EN625	MIL-E-21562	Welded joints between HY-80/100 and nickel copper/copper nickel/nickel chromium iron alloys and for clad welding these alloys.
GTAW	MIL-RN60 MIL-RN61 MIL-RN62 MIL-RN82 MIL-RN625	MIL-E-21562	Welded joints between HY-80/100 and nickel copper/copper nickel/nickel chromium iron alloys and for clad welding these alloys.

1/ The use of the SAW process for HY-100 applications is not allowed unless approved by NAVSEA on a case basis.

10.5.1 Baking. These electrodes shall be conditioned by baking at a temperature of 800 degrees Fahrenheit plus or minus 25 Fahrenheit degrees using a total time at temperature of 30 minutes to 1 hour. Variation to this time and temperature may be used provided the procedure is approved.

10.5.1.1 Loading temperature. Electrodes shall not be placed in the oven for baking while the temperature of the oven exceeds 300 degrees Fahrenheit.

10.5.1.2 Heating rate. During baking, the temperature of the oven shall not be raised more than 300 Fahrenheit degrees per hour where oven temperatures are 500 degrees Fahrenheit and above.

10.5.1.3 Time above 500 degrees Fahrenheit. The total elapsed time at oven temperatures above 500 degrees Fahrenheit shall be kept to a minimum.

10.5.1.4 Charging the oven. In charging the oven, the electrodes shall be spread on suitable trays. Electrodes can also be placed into open aluminum cans held in the vertical position. Trays or cans shall not be fabricated using any material which melts at less than 1000 degrees Fahrenheit.

10.5.1.5 Baking oven type. Automatically controlled, forced convection or circulation ovens capable of baking electrodes in accordance with 10.5.1 shall be used.

10.5.1.6 Baking controls. Oven controls and recording instruments shall be checked at periodic intervals in accordance with an established calibration program.

10.5.2 Storage in holding ovens. Electrodes which have been baked should be transferred to holding ovens while still hot without being allowed to cool below 150 degrees Fahrenheit. Transfer shall be protected from inclement weather.

10.5.2.1 Holding oven temperature. Holding oven temperature shall be 225 to 300 degrees Fahrenheit. Holding ovens shall be used for storage of electrodes removed from the baking ovens.

10.5.3 Rebaking. Electrodes may be baked by the receiving activity more than once provided each electrode brand is initially tested after a maximum proposed number of baking cycles and shown to meet specification requirements for moisture, usability, all-weld-metal tensile mechanical properties, and chemistry. Re-certification of each electrode brand to the above requirements shall be performed annually.

10.6 Exposure of MIL-10018-M1, MIL-11018-M, MIL-12018-M2 electrodes (and MIL-7018-M, MIL-8018-C3, when used as permitted under 10.2.1). Upon removal from the manufacturer's hermetically sealed containers or holding ovens, electrodes shall not be used after being exposed to the atmosphere for

a total period of more than 9 hours. During exposure, suitable means shall be provided to protect electrodes from inclement weather.

10.6.1 Returned electrodes. Electrodes turned in before 9 hours exposure shall be returned to the holding ovens for 8 hours prior to re-issue. Electrodes turned in after 9 hours exposure shall be rebaked subject to the restriction of 10.5.3.

10.6.2 Moisture tests. At least four electrode moisture test samples shall be taken per week from welders at their job sites. The moisture determination shall be made in accordance with procedures outlined in MIL-E-22200. Where the average number of welders per week is six or less, the moisture samples may be reduced to sampling one-half of the welders. If two or more samples in the same week or one sample in each of two consecutive weeks exceed the coating moisture limitations of the applicable electrode specifications, corrective and preventative action shall be taken and the sampling frequency shall be increased to at least twice each week until the condition is corrected. When it can be demonstrated that conformance with specification requirements is in control, the level of inspection (number of samples and surveillance frequency) may be reduced in accordance with a NAVSEA approved procedure. Records shall be kept as required by section 5.

10.7 Austenitic and non-ferrous covered electrodes. Low hydrogen type stainless steel and non-ferrous covered electrodes shall be used within 9 hours after issue or if otherwise exposed to the atmosphere, shall be held for at least 8 hours in a vented holding oven maintained at 150 to 300 degrees Fahrenheit prior to re-issue.

10.8 Bare filler metal storage. Bare filler metal shall be stored in a dry area.

10.9 Neutral granular flux. Neutral granular flux shall be stored in a dry area.

10.9.1 Preparation for use. Prior to the start of any welding operation, neutral granular flux shall be heated to 250 degrees Fahrenheit minimum and used while warm to the touch. Flux shall be heated in clean uncoated metal containers.

10.9.2 Re-use. Unfused neutral granular flux may be re-used subject to the following conditions:

a. Flux shall be collected from clean dry work pieces.

b. If flux is not warm to the touch, it shall be reheated to 250 degrees Fahrenheit minimum.

10.9.3 Neutral granular flux for HY-100 SAW.

7/ Alternative electrodes must be specifically approved by NAVSEA

10.9.3.1 Preparation for use. Neutral granular flux for use with HY-100 SAW may be used directly from the manufacturer's hermetically sealed container without baking prior to initial use. Where the moisture requirements of MIL-E-23765/2 are exceeded or where deemed necessary by the activity concerned, baking followed by storage in holding ovens shall be accomplished in accordance with an approved procedure.

10.9.3.2 Storage. Upon removal from the manufacturer's hermetically sealed container or after baking, neutral granular flux for use with HY-100 SAW shall be stored in holding ovens at a minimum temperature of 250 degrees Fahrenheit.

10.9.3.3 Re-use. Unfused neutral granular flux for use with HY-100 SAW may be reused subject to the following conditions:

a. Flux shall be collected from clean, dry work pieces.

b. Flux shall be re-baked in accordance with an approved procedure prior to re-use.

10.9.3.4 Contractor responsibility. The contractor shall establish and maintain written flux control procedures which will ensure that flux moisture levels in the production welding process do not exceed filler material procurement specification requirements.

10.10 Identification. Electrodes, welding wire, and the flux shall be identified up to the point of usage.

10.10.1 Coated electrodes. Each coated electrode shall have distinguishable color code, type designation, or classification number marking. If markings are destroyed by baking or other means, electrodes shall not be used until suitable identification is restored.

10.10.2 Bare filler metal. Each spool or coil of bare filler metal shall carry an identifying label. Each piece of bare filler metal shall have distinguishable color code, type designation, or classification number marking.

10.10.3 Neutral granular flux. Each container of neutral granular flux shall be labeled by type.

11. WELDING DESIGN

11.1 Scope. This section governs the use of certain weld joint designs in each design group with respect to selected HY-80/100 submarine structure, specifies the minimum weld joint efficiency requirements for structural connections, and encourages designing for fabrication.

11.2 Design for HY-80/100 pressure hull structure welding. All welds in or to the pressure hull structure should be designed to permit fabrication by the GMAW process. Manufacturing plans for detailing fabrication or erection sequences, welding processes and procedures, and NDT shall be developed concurrently with the detailed design plans. The manufacturing plan shall be approved by the shipyard welding engineer. The shipyard welding engineer shall determine: (1) if the GMAW or SAW process can be used based on the accessibility for welding equipment, etc., (2) if an alternate welding process should be used, (3) if structure redesign is necessary for welding.

11.3 Functional joint requirements. The required joint efficiencies of table IX, column 2, are the minimum efficiencies which will develop the intended functional strength of the itemized connections and shall be used. The group of joint configurations permitted for use in fulfilling the required joint efficiencies shall be as specified in table IX, column 3. The notes in column 4 are applicable to the specific item.

TABLE IX. Weld joint design requirements.

Column 1	Column 2	Column 3	Column 4
Structural category and connection or type of weld	Minimum required efficiency (percent) 1/	Weld joint design group 2/	Notes
I. Pressure hull structure.			
A. Pressure hull envelope.			
1. Welds in pressure hull envelope.			
(a) Welds joining pressure hull envelope material (unless otherwise stated below).	100	B, T, C	

See footnotes at end of table.

TABLE IX. Weld joint design requirements. - continued

Column 1	Column 2	Column 3	Column 4
Structural category and connection or type of weld	Minimum required efficiency (percent) 1/	Weld joint design group 2/	Notes
(b) Compensating penetrations.	100	T, PT, C	3/ 4/
(c) Noncompensating penetrations.	100	T,PT, C	4/
2. Welds to pressure hull envelope.			
(a) Frames and floors to hull.			
(1) External.	100	T	
(2) Internal.	100	T,PT	5/
(b) Hard tank stiffeners to hard tank plating.			
(1) Stiffeners on pressure side.	100	T, PT	5/
(2) Stiffeners not on pressure side.	75	T, PT	
(c) Attachment welds (see 3.38.1).	100	T, PT	
(d) Connections of foundations, tanks, bulkheads to pressure hull envelope.	100	T, PT	6/
(e) Attachment of fairwater and superstructure.	100	T, PT	7/
(f) End connection of primary and secondary stiffeners.	100	T, PT	5/

See footnotes at end of table.

TABLE IX. Weld joint design requirements. - continued

Column 1	Column 2	Column 3	Column 4
Structural category and connection or type of weld	Minimum required efficiency (percent) 1/	Weld joint design group 2/	Notes
(g) Stiffeners of trunks, tunnels, missile tubes, and seachests to boundary plating.			
(1) External.	100	T	
(2) Internal.	75	T, PT	
(h) Attachment of vertical keel.	100	T, PT	5/
(i) Attachment of non-support structure to pressure hull envelope.	75	T, PT	
B. Support structure.			
1. Welds joining support structure.			
(a) Welds joining support structure material (unless otherwise stated below).	100	B, T	10/
(b) Pressure hull envelope frame web to flange.	100	T, PT	6/
(c) Bulkhead primary stiffener.			
(1) End connections.	100	T, PT	5/
(2) Web to flange and tank or bulkhead.	75	T, PT, C	
(d) Bulkhead secondary and panel stiffener.			
(1) End connections.	100	T, PT	6/

See footnotes at end of table.

TABLE IX. Weld joint design requirements. - continued

Column 1	Column 2	Column 3	Column 4
Structural category and connection or type of weld	Minimum required efficiency (percent) 1/	Weld joint design group 2/	Notes
(2) Web to flange, tank or bulkhead.			
(a) For 1/8 length from ends.	75	T, PT, C	
(b) Remainder.	50	T, PT, C	
(e) Penetrations.			
(1) Compensating.	100	T, PT, C	4/
(2) Penetrations through special sandwich bulkheads with solid filler.	100	PT	4/ 8/
(3) Water or oil tight.	75	T, PT, C	4/
(4) Other penetrations not listed above.	50	T, PT, C	4/
2. Welds to support structure.			
(a) Tilting brackets.	50	T, PT, C	
(b) Attachment welds.	100	T, PT, C	9/
(c) Connections of foundations, tanks to support structure.	100	T, PT, C	11/
II. Containment structure - joint design requirements for containment structure shall be obtained by referring to the applicable support structure in category I.B.1 above.			

See footnotes at end of table.

TABLE IX. Weld joint design requirements. - continued

Column 1 Structural category and connection or type of weld	Column 2 Minimum required efficiency (percent) 1/	Column 3 Weld joint design group 2/	Column 4 Notes
III. Non-pressure hull structure.			
A. Intermediate pressure tanks.			
1. Welds in intermediate pressure tanks.			
(a) Welds joining intermediate pressure tank material unless otherwise stated below).	100	B, T, C	
(b) Penetrations.			
(1) Water or oil tight.	75	T, PT, C	4/
(2) Other.	50	T, PT, C	4/
2. Welds to intermediate pressure tanks.			
(a) Stiffener web to plating.			
(1) Stiffener on pressure side.	100	T, PT	6/
(2) Stiffener not on pressure side.	75	T, PT	
(b) End connections of stiffeners.	100	T, PT	6/
(c) Stiffener web to flange.	75	T, PT, C	
(d) Tilting brackets.	50	T, PT, C	

See footnotes at end of table.

TABLE IX. Weld joint design requirements. - continued

Column 1	Column 2	Column 3	Column 4
Structural category and connection or type of weld	Minimum required efficiency (percent) 1/	Weld joint design group 2/	Notes
(e) Connection to structure other than pressure hull envelope.	100	T, C	
(f) Attachment welds.	100	T, PT, C	9/
B. Low pressure (soft) tanks.			
1. Welds in low pressure tanks.			
(a) Welds joining low pressure soft tank material (unless otherwise stated below).	100	B, C, T, PT	7/
(b) Pentetrations.			
(1) Water or oil tight.	75	T, PT, C	4/
(2) Other.	50	T, PT, C	4/
2. Welds to low pressure tanks.			
(a) Connection to structure other than pressure hull envelope.	100	T, PT, C	7/
(b) Stiffener end connections.	100	T, PT	7/
(c) Stiffener web to flange and stiffener web to tank plating.	75	T, PT, C	
(d) Tilting brackets.	50	T, PT, C	9/
(e) Attachment welds.	100	T, PT, C	9/

See footnotes at end of table.

See footnotes at end of table.

TABLE IX. Weld joint design requirements. - continued

Column 1	Column 2	Column 3	Column 4
Structural category and connection or type of weld	Minimum required efficiency (percent) 1/	Weld joint design group 2/	Notes
C. Foundations.			
1. Welds in foundations.			
(a) Welds joining foundation material (unless otherwise stated below).	100	B, T, PT, C	7/
(b) Penetrations.			
(1) Water or oil tight.	75	T, PT, C	4/
(2) Other.	50	T, PT, C	4/
2. Welds to foundations.			
(a) Connection to structure other than pressure hull envelope.	100	B, T, PT, C	7/ 9/
(b) Tilting brackets.	50	T, PT, C	
(c) Attachment welds and welds to foundations.	100	T, PT, C	
D. Non-support structure.			
1. Welds in non-support structure.			
(a) Welds joining non-support structure material (unless otherwise stated below).	100	B, T, PT, C	7/
(b) Butt welds in vertical keel.	100	B	

See footnotes at end of table.

TABLE IX. Weld joint design requirements. - continued

Column 1	Column 2	Column 3	Column 4
Structural category and connection or type of weld	Minimum required efficiency (percent) 1/	Weld joint design group 2/	Notes
(c) Penetrations.			
(1) Water or oil tight.	75	T, PT, C	4/
(2) Other.	50	T, PT, C	4/
(d) Welds in masts.	100	B, T, PT	
(e) Deck and platform stiffener web to deck or flange.	75	T, PT, C	
2. Welds to non-support structure.			
(a) Stanchion butt weld and head and heel connection.	100	B, T, PT, C	7/
(b) Web to plating or flange connection in superstructure and fairwater.	75	T, PT, C	
(c) Connection of decks, floors and platforms to structure other than pressure hull envelope.	75	T, PT, C	
(d) Vertical keel to structure other than pressure hull envelope.	75	T, PT	
(e) Tilting brackets.	50	T, PT, C	
(f) Welds to the masts.	100	T, PT	
(g) Attachment welds.	100	T, PT, C	9/

See footnotes at end of table.

NOTES TO TABLE IX

1/ The weld joint efficiency may be reduced by use of MIL-STD-1628 when approval is obtained on a case basis.

2/ Where specific connections are listed, the minimum required joint efficiency and the allowed design group are shown in columns 2 and 3. Where specific connections are not listed in column 1, the joint efficiency and weld joint design group for this connection shall be that required for similar connections in the same structural category.

3/ Only joint PT2V.2 and PT2J.2 of design group PT may be used.

4/ Weld buildup is required on all penetrations containing 0.20 percent carbon and higher, prior to welding into structure.

5/ Only joint PT2V.5 of design group PT may be used with a NAVSEA specifically approved automatic or semi-automatic welding procedure. (Modification of PT2V.5 joint design for welding procedures using automatic SAW for all weld passes will be considered by NAVSEA). No group PT joints (except for round bar or tubing connections, see figure 18) shall apply to welds in reactor plant tanks, or to that portion of frame to pressure hull envelope welds, interrupted by penetrations (such as trunks or valves) within a distance of two times the frame depth from the penetrations, or to the periphery joints of holding bulkheads.

6/ Only joint PT2V.5 of design group PT shall be used. No group PT joints (except for round bar or tubing connections, see figure 18) shall apply to welds in reactor plant tanks, or to that portion of frame to pressure hull envelope welds, interrupted by penetration (such as trunks or valves) within a distance of two times the frame depth from the penetration, or to the periphery joints of holding bulkheads.

7/ Joint efficiency of 90 percent is acceptable when a backing bar is required due to inaccessibility. When a backing bar joint is used, the nominal stress at the joint shall not exceed 90 percent of the normally allowable stress.

8/ See figure 19.

9/ C2S.1 joint design is also allowed for attachment welds (see 3.38.1) to category I.B, II, and III structures.

10/ Grooved backing may be used for pressure hull framing butt welds to facilitate welding from one side, but must be removed upon completion of welding.

11/ No backgouging is required for pressure hull frame web and flange to tank top.

11.4 Design group classification.

11.4.1 General. Permissible weld joints referenced in 11.4.2 through 11.4.5 shall be in accordance with MIL-STD-22 except:

a. Permanent backing strap joints shall not be used in joints subject to cyclic loading where the weld root will be subject to a tensile bending stress equal to 1/2 the base metal yield strength or greater.

b. The material thickness limitation of MIL-STD-22 is not applicable.

The limitation of 11.4.2 through 11.4.5 apply only to joint designs used in the pressure hull envelope, containment and support structure. Groove joints within the same design group may be interchanged without drawing change provided joint efficiencies are not reduced. Full penetration joint designs may be used where partial penetration joint designs are specified. Where this is done, the inspection requirements for the partial penetration joint design apply.

11.4.2 Group B joints. Group B joints are butt welds (B1V.1, B1V.2, B1V.3, B2V.1, B2V.3, B2U.1, B2U.2, B2U.3, B2U.4, and B2U.5). When a backing strap is used in a butt joint and is not removed, the efficiency shall be 90 percent maximum. If the backing strap is removed and weld exposed by removal of the backing bar passes the required NDT, the joint has an efficiency of 100 percent.

11.4.2.1 Butt welding of members of unequal thickness, including inserts in pressure hull structure and structural intermediate pressure tanks, shall require chamfering of the thicker member as specified in MIL-STD-22. Periphery welds of inserts located elsewhere may be designated as corner or tee joint welds.

11.4.3 Group T joints. Group T joints are groove tee welds (T2V.1, T2V.2, T2J.1, T1V.1, T1V.2, and T2J.2). Groove tee joints when welded from both sides with electrodes of section 10 or combinations thereof have a maximum efficiency of 100 percent. When backing straps are used and not removed, the maximum efficiency shall be 90 percent. If the backing strap is removed and the weld exposed by removal of the backing bar passes the required NDT, the joint has an efficiency of 100 percent.

11.4.4 Group PT joints. Group PT joints are partial penetration groove tee or double fillet tee joints (PT2S.1, PT2V.1, PT2J.1, PT2J.2, PT2V.2, PT2V.3, PT2V.4 and PT2V.5). In the case of round bar or tubing, they are single fillet joints (PT1S.1). The strength of group PT welded joints shall be in accordance with MIL-STD-1628. Since MIL-STD-1628 is based on double fillets, PT1S.1 single fillet sizing must be doubled. When welded with filler

materials specified in section 10, joints PT2V.3, PT2V.4 and PT2V.5 are 100 percent efficient.

11.4.5 Group C joints. Group C joints are corner joints (C2V.1, C2V.2, C2V.4, C2V.5, C2V.6, C2U.1, C2J.2, C2J.3, C2J.4, C2J.5 and C2J.6). Full penetration corner joints welded from both sides with the electrodes of section 10 or combinations thereof have an efficiency of 100 percent. When backing straps are used and not removed, the maximum efficiency shall be 90 percent. If the backing strap is removed, and the weld exposed by removal of the backing bar passes the required NDT, the joint has an efficiency of 100 percent.

11.4.6 Other joints. When joint configurations other than those specified in this section are employed, the joining shall be detailed on the drawing and approved for the ship involved, or the special joint shall be specifically approved by NAVSEA as an acceptable alternate and contained in a qualified welding procedure. Such joints shall meet the efficiency and design requirements contained herein or any limitations imposed via approval.

11.5 Design requirements.

11.5.1 Penetrations. The toes of welds connecting penetrations in the pressure hull envelope shall be separated from the toe of any full penetration or partial penetration weld in or to the pressure hull envelope by a minimum of 3/4 inch. If either is a fillet weld, the minimum separation shall be 1/2 inch. Penetrations not in the pressure hull envelope are exempt from this requirement.

11.5.1.1 Penetrations in the pressure hull envelope shall not intersect full penetration welds except where absolutely necessary. In those instances where it is necessary for a penetration to intersect a butt weld, the penetration should preferably be centered on the butt weld or shall intersect the butt weld with the penetration weld overlapping the butt weld by at least 3/4 inch as shown on figure 20.

11.5.1.2 The distance between the centerline of a penetration in the pressure hull envelope and an adjacent frame, floor, or bulkhead shall be a minimum of 20 percent of the frame space, subject to non-interference with flanges for welding accessibility.

11.5.2 Projection of penetrations or liners. The projection of penetrations greater than 4 inches in diameter or liners through the pressure hull envelope shall be one inch or less for the full circumference or length of the penetration or liner, unless the joint can be UT volumetrically inspected as specified in 6.8.4. Any exception to this requirement, must be approved on a case basis.

11.5.3 Inserts, patches, and small access plates. The minimum diameter of an insert, patch, or small access plate in the pressure hull envelope shall be 4T (four times the thickness (T) of the member penetrated) or 6 inches,

ugh d, shall have weld toe to toe distance as specified the above items a. throu

whichever is greater. The minimum diameter of an insert, patch, or small access plate in plating and structure other than the pressure hull envelope shall be 4T or 3 inches, whichever is greater. Corners of inserts, patches, or small access plates in the pressure hull envelope shall have a minimum radius as shown on figure 21, except where those inserts, patches, or small access plates land on full penetration butt welds. Corners of inserts, patches, or small access plates in plating and structure other than pressure hull envelope shall have a minimum radius as shown on figure 22.

11.5.3.1 Inserts, patches, or small access plates in the pressure hull envelope shall not intersect any other full penetration butt welds unless they land on these welds or cross them at an angle of 90 plus or minus 15 degrees as shown on figure 23. When the boundaries of inserts, patches, or small access plates in the pressure hull envelope land on existing full penetration butt welds, the common length of weld shall not be less than 12 inches. When the boundaries of inserts, patches, or small access plates in the pressure hull envelope do not land on existing full penetration butt welds, the toes of the insert, patch or small access plate welds shall be a minimum of 3 inches from the toes of any other full penetration butt welds, except for the following:

a. Circular inserts.
b. Circular patches.
c. Circular small access plates.
d. Penetrations.
e. As outlined in 11.5.3.2.

The above items a. through d. shall have weld toe-to-toe distance as specified in 11.5.1.

11.5.3.2 When inserts, patches or small access plates in the pressure hull envelope terminate on other full penetration butt welds, one of the existing longitudinal or circumferential butt welds shall be cut back a minimum of 3 inches except where such cut back would result in less than 2 inches of existing weld remaining between the end of the cut back and adjacent frame web, bulkhead surface or tank top. In such cases, the minimum cut back shall be terminated not less than 2 inches from the adjacent frame, bulkhead surface or tank top but in no case shall the cut back be less than 2 inches long. When it is anticipated that this latter situation will occur, the weld toes of insert, patch or small access plate welds shall be limited to a minimum of 4 inches from the weld toes of the adjacent frame web, bulkhead surface or tank top.

11.5.4 Access and closure plates. Corners of access and closure plates in the pressure hull envelope shall have a minimum radius of 6 inches, except when a boundary lands on an existing hull longitudinal or circumferential butt weld. In the latter instance, the corners shall intersect the butt weld at 90 plus or minus 15 degrees.

11.5.4.1 Boundaries of access and closure plates in the pressure hull envelope shall either land on existing hull (circumferential or longitudinal) butt welds, or the weld toe-to-toe spacing from any adjacent hull butt weld shall be a minimum of 3 inches, except for the items shown in 11.5.3.1.a., b., c. and d. These items shall have weld toe-to-toe distances as specified in 11.5.1. When a transverse boundary of an access or closure plate does not land on an existing butt weld, it shall be located so that the center of the weld is between 15 and 25 percent of the frame spacing from the face of the adjacent frame or bulkhead.

11.5.4.2 When access or closure plate welds in the pressure hull envelope terminate on other full penetration butt welds, one of the existing longitudinal or circumferential butt welds shall be cut back a minimum distance of 3 inches except where such cut back would result in less than 2 inches of existing weld remaining between the end of the cut back and adjacent frame web, bulkhead surface or tank top. In such cases, the minimum cut back shall be terminated not less than 2 inches for the adjacent frame, bulkhead surface, or tank top but in no case shall the cut back be less than 2 inches long. When it is anticipated that this latter situation will occur, the weld toes of the access or closure plate welds shall be limited to a minimum of 4 inches from the weld toes of the adjacent frame web, bulkhead surface or tank top.

11.5.5 Permanent snipes. Where water or oil tightness or strength is not a consideration, use of permanent corner or scallop snipes in members joining to plating shall be permitted to provide accessibility for welding and for vents and drains. The radiused type snipe shown in figure 24 shall be used for vents, drains, or permanent snipes.

11.5.6 Pressure hull envelope attachment. Every effort should be made to minimize welded structure and miscellaneous attachment to the pressure hull envelope. Attachments to the pressure hull envelope, which are on the opposite side of the pressure hull plating from the frames, shall be located on the frame line whenever possible. For this purpose, the frame line is defined as a width equal to the hull plate thickness on either side of the enterline of the frame web. Arc stud welds or capacitor discharge welded studs, not more than 1/4 inch diameter, may be applied anywhere on the pressure hull, provided the requirements of 12.4.2 are satisfied.

to the masts. ... welds

12. ERECTION REQUIREMENTS

12.1 Scope. This section contains the requirements necessary for fabrication and erection of HY-80/100 steel in submarine structure. Where other design structural erection tolerances are specified in the ships specification, they shall apply.

12.2 General requirements.

12.2.1 Mechanical surface indentations. Mechanical surface indentations, such as prick punch layout marks, on the submarine structure should be kept to a minimum and shall be repaired if required by 14.6.2.

12.3 Temporary attachments. Welded temporary attachments, such as erection clips, fairing bolts, staging braces and brackets, should be kept to an absolute minimum and should be used only when attachments which do not require welding cannot be used.

12.4 Studs (drawn arc or capacitor discharge).

12.4.1 General. Studs shall be welded and inspected in accordance with section 13.

12.4.2 Locations. Permanent studs may be located on or near existing welds. The toe-to-toe distance between the stud weld and any existing full penetration weld shall be 1/4 inch or more when it does not land on the existing weld, with the exception of arc stud welds or capacitor discharge welded studs not more than 1/4 inch diameter.

12.5 Spiders, bracing and temporary lifting pads.

12.5.1 General. Spiders may be used in all cylindrical and transition sections during fabrication and erection.

12.5.2 Alignment devices and staging braces. Every attempt should be made to use mechanically fastened frame alignment devices or staging braces.

12.5.3 Lifting devices. Lifting devices such as slings, belly bands, mechanically fastened lifting clamps and pads should be used to the maximum extent possible in lieu of welded lifting pads.

12.6 Structural requirements.

12.6.1 Circularity.

12.6.1.1 Circularity requirements. Circularity measurements shall be made in those portions of the pressure hull that are designed to be circular. These measurements shall be made in accordance with written validated full or partial circularity procedures which have been approved by NAVSEA. Full circularity procedures are defined as those where the entire hull contour is

y may be used for pressure hull framing butt welds to grooved backin

established at the same time; partial circularity procedures are defined as those where the hull contour is measured at different times. The pressure hull circularity shall meet the following requirements:

a. The trace of the actual contour shall not deviate from the mean circle by more than 1/2 the thickness of the pressure hull plating or 1/2 inch, whichever is less, or as specified in the ship's detailed specification.

b. The radius of the mean circle shall not depart from the design radius by more than 1/2 the thickness of the pressure hull plating or 1/2 inch, whichever is less, or as specified in the ship's detailed specifications.

12.6.1.1.1 Location of final acceptance circularity measurements. Final acceptance circularity measurements of pressure hull envelope shall be recorded at the following stations (The fore and aft tolerance of each station shall be plus or minus 6 inches and the actual reading location shall be recorded. In no case shall circularity be taken on a transverse hull but weld.):

a. One set on at least every third frame.

b. One set on the frame (exclusive of structural bulkheads) nearest each circumferential butt.

At each station, circularity measurements of the actual hull contour shall be made at points not more than approximately 5 degrees apart. Circularity measurements are required in way of tank floors or bulkheads that form part of the hull structure when the mean circle is calculated using the circularity measurements.

12.6.1.1.2 Sequence of final acceptance circularity measurements. Circularity measurements shall be taken after all major welding has been completed, after all spiders, bracing and temporary support structure have been removed or released, and after the structure has cooled to ambient temperature. For circularity measurements, major welding is considered to be the accomplishment of full penetration (or 100 percent efficient partial penetration) welds in either the measured frame, the pressure hull plating in an adjacent frame bay, or an adjacent frame.

12.6.1.1.3 Circularity measurements in way of hull penetrations, inserts, and closure patches. For new construction, these measurements shall be full circularity measurements. During a ship's life, acceptable hull circularity may be verified by either full circularity measurements or by the procedure stated in 12.6.1.4, which uses the following:

12.6.1.1.3.1 Complementary circularity measurements. Complementary circularity measurements are measurements of that portion of the hull contour

not covered by partial circularity. The complementary circularity measurements shall be made by the activity prior to making the hull cut, unless the circularity procedure used does not require hull closure to establish the hull contour over the measured arc and has been approved by NAVSEA for such measurements. In addition, the radial location of the end points shall be established relative to bench marks on undisturbed frames forward and aft of the proposed cut. These end points shall be coincident with those of the partial circularity that completes the hull contour.

12.6.1.1.3.2 Partial circularity measurements. Partial circularity measurements are measurements over a transverse arc length equal to twice the transverse arc length of the proposed cut, but not to exceed 30 degrees beyond each end of the cut. The transverse arc shall be centered on the proposed cut except where tank tops or stiff or rigid (strong-back type) coamings intersect the pressure hull, in which case the partial circularity end points may terminate at the tank top or coaming. In all cases, the radial location of the end points for the partial circularity check shall be established relative to bench marks on adjacent undisturbed frames forward and aft of the proposed cut.

12.6.1.2 Documentation requirements for circularity procedures. NAVSEA approval shall be obtained for any circularity procedure used to develop final acceptance circularity measurements, including both full and partial circularities. The documentation required for NAVSEA approval shall be written for each circularity procedure and shall include the following:

a. Qualification requirements for personnel responsible for taking circularity measurements. (Records shall be kept as required by 5.3.4.1.) The qualification requirements shall include:

(1) Training and written examination of the personnel in the structural significance of hull circularity measurements.

(2) Training and written examination of the personnel in the specific operations they will be responsible for in establishing hull circularity measurements.

(3) Written certification by supervisory level personnel that their personnel have a thorough understanding of their function in establishing hull circularity measurements and have demonstrated satisfactory performance in both the operations for which they are being certified and the results of the above written exams.

(4) Continued certification of previously certified personnel shall be required every three years and shall consist of item (3) above.

b. A requirement that compliance to circularity procedures shall be monitored in accordance with the activity's quality program. Monitoring shall be on a quarterly basis.

c. Documentation of the activity's calibration standards for the equipment and a requirement that all measurements be made with calibrated equipment.

d. Process instruction delineating all steps followed in establishing the hull circularity deviations. If more than one approach will be used for any step, procedure documentation shall be included for each approach. Examples of steps to be included, as appropriate, are:

(1) Laying out measurement points on the hull.

(2) Establishing control frame of reference to uncut frames (for partial circularities).

(3) Taking the hull circularity measurements.

(4) Developing the mean circle radius (for full and complementary circularities).

(5) Determining the hull contour eccentricity.

e. Identification of all limitations associated with implementing the steps outlined by the process instruction of d. above.

f. Qualification data for the procedure that demonstrates acceptable accuracy and repeatability of circularity measurements obtained with that procedure. This data shall reflect the limitations stated in e. and shall demonstrate the applicability of the procedures as a function of hull form, diameter, stepped hull plate, and areas of hull inserts. This data shall be taken by the personnel responsible for the production use of the procedure and shall be taken with the cylinder in the worst orientation (axis horizontal or vertical) in which it will be used by the activity. For full circularity procedures, the qualification data shall consist of the following:

(1) Demonstration of the procedure accuracy by comparing measurements made with the procedure to a set of baseline measurements (NAVSEA approval shall be obtained on a case basis as to what constitutes a baseline; photogrammetry is one approach that is considered appropriate for obtaining a baseline). Acceptable accuracy shall require that (a) the mean circle radius determined by the procedure vary from the baseline mean circle radius by no more than 0.07 inch and (b) the hull eccentricity determined by the procedure at

each measurement location, relative to the procedure mean circle radius, vary by no more than 0.07 inch from the baseline hull eccentricity, relative to the baseline mean circle radius, at the same measurement location.

(2) Demonstration of the procedure repeatability by measuring a single hull contour five times using different personnel and equipment setups. Acceptable repeatability shall require that (a) the five mean circle radii do not vary by more than 0.05 inch and (b) at any measurement location, the difference between the five eccentricity measurements, relative to their individual mean circle radii, varies by no more than 0.05 inch.

g. The qualification data for partial circularity procedures shall consist of the following:

(1) Demonstration of the procedure accuracy by comparing measurements made with the procedure to a set of baseline measurements (NAVSEA approval shall be obtained on a case basis as to what constitutes a baseline). Acceptable accuracy shall require that, at any measurement location, the hull contour determined by the procedure, relative to a control frame of reference, vary no more than 0.07 inch from the baseline hull contour, relative to the same control frame of reference.

(2) Demonstration of the procedure repeatability by measuring a single hull contour five times using different qualified personnel and equipment setups. Acceptable repeatability shall require that, relative to a control frame of reference, the five hull contours do not vary by more than 0.05 inch at any measurement location.

h. Continuance of procedure qualification shall require redoing steps f. and g. on a five year basis.

12.6.1.3 Establishing hull circularity using full circularity measurements. Circularity measurements shall be taken so that the actual hull contour at any station may be analyzed for eccentricity. A circle, defined as the mean circle, shall be developed to characterize the hull radius at the station where the circularity measurements are taken. The mean circle shall be positioned over the actual measured contour and may be positioned such that the maximum deviation between the mean circle and hull contour is minimized. The deviations between the mean circle and the measured hull contour shall be calculated at each circularity measurement point, if discrete points on the hull are measured, or at every 5 degrees, if a continuous measurement is made of the hull contour. These deviations are not required to be calculated or

evaluated for those areas in way of tank floors or bulkheads that form part of the hull structure.

12.6.1.4 Establishing acceptable hull circularity using partial circularity measurements. As required by 12.6.1.1.2, the verification of acceptable circularity shall be accomplished after completion of all major welding. If this verification is done using full circularity measurements, the procedure of 12.6.1.3 applies. If this verification is to be accomplished by taking partial circularity measurements, as specified in 12.6.1.1.3.1 and 12.6.1.1.3.2, the radial location of the end points taken prior to installation must be checked against the radial location of the end points taken after the installation. After adjusting the end points to account for any change in the bench marks from pre-installation to post-installation, if either end point at a station has changed by more than 1/16 inch, a full circularity shall be taken at that station. If the radial end point locations are satisfactory, accomplish one of the following:

a. Superimpose the partial circularity contour (12.6.1.1.3.2) after installation on the pre-installation complementary circularity contour (12.6.1.1.3.1). Develop a total hull contour, adjusting the post-installation partial contour for any radial movement of the end points, and a mean circle corresponding to this hull contour and calculate the deviations between the measured hull contour and the mean circle at the locations specified in 12.6.1.1.1. If the mean circle radius, or the deviations from the mean circle, exceed the limits of 12.6.1.1.a. or 12.6.1.1.b., a full circularity measurement shall be made.

b. Compare the partial circularity contour after installation to the pre-installation partial hull contour. A full circularity measurement shall be made if any of the following occur:

(1) The geometry relative to zero end points (lines B and either D or E of figure 8.E) shows a difference at any location along the arc that exceeds the limit of 12.6.1.1.a.

(2) The difference between the contour measurements before installation (line B of figure 8.E) differs by more than 1/8 inch from the contour measurements after installation (either line D or E of figure 8.E) at any point on the contour.

12.6.1.5 Records of circularity checks. Records shall be kept of all circularity checks and the method of taking circularity shall be included in the record. Record format shall be similar to those shown on figures 6, 7, and 8.

12.6.1.6 Resolution of circularity deviations. When as-arrived circularity measurements of operational submarines show deviations that exceed

the specified tolerances, they shall be referred to NAVSEA.

12.6.2 Pressure hull frames.

12.6.2.1 Frame dimensional tolerances. After welding of the flange to web is finished (including all required NDT), the flange width and flange unbalance of fabricated frames shall be within the tolerances of table X. In-process inspection of the flange to web tilt should be made. After finish welding of the frames to the hull plating, including completion of all required NDT (except expansion requirements of section 6), the tilt of the web from its designed position, the tilt of the flange to the web and the depth of all frames shall be within the tolerance specified in table X. Such measurements shall be made at intervals of not more than 45 degrees.

TABLE X. Pressure hull frame tolerances. 1/ 2/

Depth of frame (inches)	Frame depth H (inches)	Web tilt maximum	Flange tilt maximum	Flange width W(inches)	Flange unbalance $G-G_1$
Up to and including 12	+3/16 -1/8	±2 degrees	±2 degrees	±1/8	±3/16
Greater than 12 to and including 15	+1/4 -1/8	±2 degrees but 7/16 inches maximum	±2 degrees	±1/8	±3/16
Greater than 15 to and including 24	+5/16 -1/8	7/16 inches maximum	±2 degrees but 17/32 inches maximum	±1/8	±3/16
Greater than 24	+3/8 -1/8	7/16 inches maximum	17/32 inches maximum	±1/8	±3/16

1/ Overdepth (H) and overwidth (W) tolerances may be exceeded provided the resulting overweight does not exceed 3 percent of the weight of the cross-section specified on the drawing. The nominal thickness of the cross-section as shown on the drawing shall be used in determining this overweight.

2/ See figure 25.

12.6.2.2 Frame flange curvature. For fabricated frames, flange curvature (transverse bow) shall not deviate from a reference line tangent to the top of the flange on flanges less than 12 inches wide by more than 1/8 inch and on flanges 12 inches wide and over by more than 3/16 inch.

12.6.2.3 Frame spacing. The distance between adjacent frame webs shall be measured and shall be as stated in table XI, the ship's detailed specification or, if not stated in the detailed specification, shall be within plus 1/8 inch minus 1/4 inch of the designed dimension, except in way of circumferential butts where the distance shall be plus 1/8 inch minus 1/2 inch of the designed dimension. This dimension shall be measured perpendicular to the frame within 1 inch of one web toe of the hull attachment weld and may be adjusted for web tilt. Care should be taken to ensure that the accumulation of these tolerance allowances permits proper alignment of attached or installed foundations or other components.

TABLE XI. Tolerances for frame spacing.

Class	Tolerances for other than reactor compartment		Tolerances for reactor compartments
	In way of hull butt	Other than hull butt	
SSN 688 and SSBN 726	±3/8 inch	±1/4 inch	See NAVSEA approved drawings
SEAWOLF	±3/8 inch	±3/8 inch	See NAVSEA approved drawings

12.6.2.4 Frame butt alignment. The transverse and vertical offset of abutting surfaces at weld joints in webs and flanges of pressure hull frames shall not exceed 1/8 inch, unless so designated. If any point across the flange face exceeds 1/8 inch, but does not exceed 1/4 inch, it shall be faired by grinding to a four to one taper. These limits are applicable after completion of welding and cool down.

12.6.2.5 Records of pressure hull frames. Records shall be kept of all checks on frame dimensions and frame spacing. Forms for records are shown on figure 9.

12.6.3 Fairness and alignment.

12.6.3.1 Pressure hull structure alignment. When pressure hull plating and support structure are tacked and are ready for welding, the misalignment of surfaces projected to the centerline of joints shall not exceed the limits of table XII.

TABLE XII. Alignment tolerance.

Thickness (inches)	Maximum misalignment (inches)
Pressure hull structure	
5/8 and less	1/16
Over 5/8	1/8
Non-pressure hull structure	
Less than 3/8	1/16
3/8 to 3/4	1/8
Over 3/4 to 1-1/2	3/16
Over 1-1/2	1/4

12.6.3.1.1 Non-pressure hull structure alignment. When non-pressure hull structure is tacked and is ready for welding, and special requirements for fairness, flatness or alignment are not otherwise specified, the misalignment of structure projected to the centerline of joints shall not exceed the limits of table XII.

12.6.3.1.2 Intercostal structure alignment. Discontinuous members on opposite sides of a through member shall line up back-to-back within one-half the thickness of the through member. Where the discontinuous member is a structural shape, both webs and flanges shall be aligned within this limit.

12.6.3.2 Flat plate panel unfairness. Unfairness of welded flat plate panels in free flooding areas, and structural bulkheads shall be in accordance with tolerances on figure 26.

12.6.3.3 Correction of misalignment and unfairness. Except as noted, misalignment and unfairness exceeding the tolerances of 12.6.2 and 12.6.3 shall be corrected by releasing the joints in way of the condition, aligning

and fairing by strong backing only, and then rewelding the released joints. HY-80/100 material shall not be faired or straightened by use of heat. When releasing the joint is not practical, weld buildup to 3/8 inch may be used. Weld buildup shall be a minimum four to one slope and applied to one or both surfaces, as required by application. Weld buildup over 3/8 inch in thickness shall require approval.

13. WELDING REQUIREMENTS

13.1 Scope. This section contains the requirements for welds in HY-80/100 submarine structure.

13.2 Qualification. Welding procedures, welders, and welding operators shall be qualified in accordance with section 4 prior to their employment in production work.

13.2.1 Gas metal arc welding - short circuiting transfer (GMAW-short arc). Gas metal arc welding - short circuiting transfer (GMAW-short arc) shall not be used for welds in submarine structure except when approved by NAVSEA.

13.3 Joint preparation. Plate edges shall be prepared for welding in accordance with section 14. In addition to weld buildup to correct oversize root openings, weld buildup may be used on surfaces or edges of HY-80/100 materials in way of penetrations or connections prior to making joint fit-up. As an alternate, temporary backing (HY-80/100, HSS or approved non-metallic materials) may be used in the joint root to allow welding across the excessive root opening provided it is subsequently removed prior to completing the weld. In all cases involving welding to correct excessive root opening, the joint edges shall not be joined until the oversize root opening is corrected to within the requirements of MIL-STD-22.

13.3.1 Joint configuration. Weld joint configurations prior to welding shall be in accordance with section 11, with the following special considerations:

a. Unbalanced double-bevel butt joints or single bevel butt joints may be welded from either side first.

b. Double sided tee and corner joints, except C2V.4 and C2J.5, may be welded from either side first.

c. Double-bevel weld joint designs may be prepared by beveling one side prior to any welding, and the second side beveled after sufficient welding on the first side. Joint preparation technique shall be in accordance with section 14.

d. Single or double bevel groove joints within the same design group may be interchanged provided joint efficiencies are not reduced. For partial penetration type joint designs, square, single or double bevel joints may be interchanged provided that joint efficiencies are not reduced and the joint design is allowed per table IX. Full penetration joint designs may be substituted where partial penetration joint designs are specified. Where this is done, the inspection requirements of the partial penetration joint design applies.

13.3.2 Joint fit-up. Joint fit-up in submarine structure shall be in conformance with this document prior to release of the weld joint or partial weld joint for welding.

13.3.3 Material identification. The materials to be welded shall be positively identified.

13.4 Welding materials. Welding materials shall comply with section 10.

13.5 Erection requirements. Fabrication and erection requirements including sequence of welding and manufacturing plans shall comply with the requirements of 11.2 and section 12.

13.5.1 Tack welds. Tack welds shall be made using an approved type of electrode and shall be deposited in accordance with the requirements herein. Cracked tack welds and those of poor quality shall be removed. Cracked or poor quality tack welds deposited on the backside of a weld joint need not be removed prior to welding the first side if the backside is to be backgouged. Sufficient restraint must be provided by the remaining unbroken tack welds. Tack welds in full penetration welds shall be inspected in accordance with section 6 prior to being incorporated into the final weld.

13.5.2 Block tack welds. Block tack welds which are made by qualified welders (not tack welders) in accordance with the requirements of this section and are inspected in accordance with the requirements of section 6 are considered initial increments of the final weld.

13.6 Preheat and interpass temperature.

13.6.1 Welding. Unless otherwise stated in 13.6.1.1, temperatures required for welding in or to HY-80/100 steel are listed in table XIII. The temperature shall be based on the thicker joint member.

TABLE XIII. Temperature requirements for HY-80/100 welding.

Thickness (inches)	Minimum preheat and interpass 1/ (degrees Fahrenheit)	Maximum preheat and interpass (degrees Fahrenheit)
1-1/8 and over 2/	200	300
Over 1/2 but less than 1-1/8	125	300
1/2 or less	60 3/	300

1/ See 13.6.2 and 13.6.5.
2/ For thicknesses over 2-3/4 inches when using filler materials specified for HY-80 or HY-100, minimum preheat shall be 200 degrees Fahrenheit in all cases. The special welding conditions of 13.6.1.1.a., b. or c. shall not alter this requirement.
3/ For butt and corner joints, this temperature shall be 125 degrees Fahrenheit minimum.

13.6.1.1 Special welding conditions.

a. After either one or both members of an HY-80 or HY-100 weld joint, except for SAW of HY-100 with MIL-120S filler metal, is built up 3/16 inch minimum or two layers prior to joint welding, the 200 degree Fahrenheit minimum preheat and interpass temperature of the built-up member or members may be reduced to 150 degrees Fahrenheit minimum when making the final weld.

b. For initial joint welding using ferritic type SMAW electrodes other than MIL-10018-M1, MIL-11018-M, and MIL-12018-M2, the 200 degree Fahrenheit minimum preheat and interpass temperature may be reduced to 150 degree Fahrenheit minimum. For repair welding, the preheat and interpass temperature conditions of table XIII shall apply.

c. For GMAW or SAW, except for SAW of HY-100 with MIL-120S filler metal, using filler metals listed in table VII, the 200 degree Fahrenheit minimum preheat and interpass temperature may be reduced to 150 degrees Fahrenheit minimum.

d. For welding with austenitic or non-ferrous type filler metals listed in table VIII (see 10.3), the 200 degree Fahrenheit minimum preheat and interpass temperature may be reduced to 125 degrees

Fahrenheit minimum when welding in or to the pressure hull envelope and either temperature may be reduced to 60 degrees Fahrenheit when welding other than pressure hull envelope.

e. After an HY-80/100 member is clad or buttered 3/16 inch minimum or two layers with austenitic, non-ferrous, or approved ferrous weld metal, the 125 degree Fahrenheit minimum preheat and interpass temperature in d. above may be reduced to 60 degrees Fahrenheit minimum for continued buttering, cladding, or welding of a joint between the buttered surface and austenitic or non-ferrous material.

f. A preheat procedure shall be prepared for welding in close proximity to materials, such as polyethylene, where changes from the above requirements are found necessary. NAVSEA approval of this procedure is required.

g. Ferritic welds shall not be deposited over austenitic or non-ferrous welds.

h. Welding procedures using alternative preheat/interpass temperatures other than those in table XIII or this paragraph shall require NAVSEA approval.

13.6.2 Tack welding. The preheat for tack welding shall be as required in 13.6.1.

13.6.3 Arc stud welding. Preheat of HY-80/100 material is not required for the welding of temporary and permanent studs providing the material surface is dry. Preheat shall be used to dry the surface of the material when moisture or moisture producing conditions (vapor or condensation) are present.

13.6.4 Application of preheat.

13.6.4.1 Methods. Preheat may be applied by any of the following methods used either singly or in combinations:

a. Resistance heaters.

b. Radiant and infra-red heaters.

c. Electrical induction.

d. Soft gas torch (gas-air).

e. Oxy-fuel torch.

13.6.4.2 Heating. The heating shall be of the uniform soaking type, applied preferably by means of electric heaters (resistance or induction) uniformly distributed on or around the area being welded. The spacing and wattage of heaters shall be such as to ensure that the entire welding area is up to the required minimum temperature.

13.6.4.3 Control of heating (general). Shielding for protection from wind and inclement weather shall be employed during welding and maintained until the structure has cooled to within approximately 50 degrees Fahrenheit of ambient temperature. Control of the required temperature range during welding may be accomplished by distribution of welders or by the use of welding sequence. Cyclic heating and the occurrence of temperature differentials greater than 100 degrees Fahrenheit along the joint during welding should be avoided to maintain thermal expansion and contraction stresses at a uniform level.

13.6.4.4 Control of minimum temperature. The minimum required temperature shall be established prior to welding. Loss of the minimum required temperature shall require reheating, as necessary, prior to resumption of welding. If the minimum specified temperature on HY-80/100 base material 1-1/8 inches and over in thickness drops below 113 degrees Fahrenheit when welding with ferritic filler material, the partially completed welds shall be MT inspected in accordance with 6.5 and accepted to the requirements of section 7 before resumption of welding. Reheating to within the specified temperature range prior to the resumption of welding may be done before or after this inspection.

13.6.4.5 Control of maximum temperature. The maximum required temperature shall be checked as specified in 13.6.5 and section 6. If at any time during welding (except during deposition of a weld pass) the base metal temperature is found to be above 300 degrees Fahrenheit, the weld area shall be allowed to cool to within the required temperature prior to any subsequent welding.

13.6.4.6 Torch heating. Hand-held torch heating shall be confined to tack or temporary welding operations or to those applications involving welding within a localized area. When torch heating is used for welding operations within a localized area, base material shall be brought up to preheat temperature with sufficient time allowed for the heat to soak through the thickness of the parts being welded. Heat shall be applied over an area approximately 6 inches beyond the weld site in all directions. Exceptions to the above are:

a. Those instances in which torch heating is used an accessory device to decrease the time required for reaching preheat temperature on material which is being heated with electric heaters.

b. Those instances in which an element of a weld joint provides insufficient heat sink capacity to warrant the use of electric heaters because of the rapid increase of interpass temperature

which will occur when welding is initiated. Examples of the latter are face plates or coamings on lightening and access openings, and flanges on light stiffening members.

c. For miscellaneous hanger and attachment welds where the 6 inch distance is impractical, the distance may be reduced to suit job conditions.

13.6.5 Temperature checks. Preheat temperature shall be checked prior to welding and interpass temperature shall be checked during welding. Surveillance of preheat and interpass temperatures shall be in accordance with 6.3.1. Temperatures of 113 degrees Fahrenheit and above shall be checked using temperature indicating crayons or other temperature measuring devices. When the ambient temperature is below the required 60 degrees Fahrenheit or there is evidence of moisture on the material surface, preheat shall be applied until the area is dry and warm to the touch. Otherwise, no check of material temperature is required. Temperature indicating crayons shall not be applied to the weld metal or weld groove.

13.6.5.1 Preheat temperature measurement. Preheat temperature shall be measured on the surface of the material on the side from which welding will be performed and within 3 inches of the area to be welded.

13.6.5.2 Interpass temperature measurement. Interpass temperature shall be measured on the surface of the base material on the side from which welding will be performed, within 1 inch of the weld joint edge and along the joint within 3 inches of the start of the next weld pass.

13.7 Heat input.

13.7.1 Requirement. When welding with any process in or to HY-80/100, the limits for heat input as measured in joules per inch, based on the thickness of the thinner member, shall conform to the values listed in table XIV unless otherwise approved by NAVSEA or as permitted herein. When welding HY-80/100 to other materials, the maximum heat input shall be based on the HY-80/100 thickness. Heat input shall be checked during welding. In-process monitoring of heat input shall be in accordance with 6.3.1.

TABLE XIV. Heat input limitations.

Thickness (inches)	Maximum (joules/inch) 1/ 2/
Less than 1/2	45,000
1/2 and greater	55,000

See footnotes at end of table.

NOTES TO TABLE XIV.

1/ The word "maximum" shall not be interpreted as either nominal or average.

2/ For MIL-10018-M1 and MIL-12018-M2 electrodes 1/8 inch diameter and smaller, the maximum heat input in the flat welding position shall be 45,000 joules per inch for thicknesses 1/2 inch thick and greater and 35,000 joules per inch for thicknesses less than 1/2 inch thick.

13.7.1.1 Alternative heat inputs. For the GMAW and SAW processes when welding HY-80, the alternative heat input limitations of table XV may be used.

TABLE XV. Alternate heat input limitations.

Welding process 1/ 2/	Electrode filler wire 3/	Shielding gas/flux 4/	Material thickness 5/	Alternate heat input (maximum joules/inch)
SAW	MIL-E-23765/2 type 100S-1	MIL-E-23765/2 type 100S-1F or equal qualified product	1 inch and greater	100,000
GMAW (spray and pulsed arc mode)	MIL-E-23765/2 type 100S-1	M-2 ($98Ar-20_2$) or C-5 ($95Ar-5CO_2$)	1 inch and greater	100,000

1/ Separate procedure qualification is required when using these alternate heat inputs. Qualifications shall be performed on HY-80 using a thickness that represents the thinnest material intended to be used in production. The qualification will only be applicable to the specific brand of welding electrode wire or wire/flux utilized for procedure qualification with the exception that qualification of an alternative brand of wire may be based on presently existing acceptable data. The minimum heat input used during qualification shall be 110,000 joules per inch. Preheat and interpass temperature shall be 200 to 300 degrees Fahrenheit throughout welding. NDT and destructive tests shall be as specified in MIL-STD-248, except that regardless of test plate thickness, weld metal Charpy V-notch or 5/8 inch dynamic tear specimens

as well as two all weld metal tensile tests are required. Minimum acceptable mechanical test results are as follows:

(a)	Yield strength:	82,000 pounds per square inch minimum
(b)	Elongation(in 2 inches):	16 percent
(c)	Charpy V-notch:	20 ft-lbs at minus 60 degrees Fahrenheit (average of 3 specimens with no specimen less than 15 ft-lbs and no more than one specimen less than 20 ft-lbs), and 60 ft-lbs at 0 degrees Fahrenheit (average of 3 specimens with no specimen less than 55 ft-lbs and no more than one specimen less than 60 ft-lbs)
(d)	5/8 inch dynamic tear test: (may be used in lieu of Charpy V-notch):	250 ft-lbs at minus 20 degrees Fahrenheit (average of 3 specimens with no specimen less than 200 ft-lbs and no more than one specimen less than 250 ft-lbs), and 425 ft-lbs at 30 degrees Fahrenheit (average of 3 specimens with no specimen less than 400 ft-lbs and no more than one specimen less than 425 ft-lbs)

In the event of a dispute between Charpy V-notch and dynamic tear test results, the dynamic tear values shall govern.

2/ Production testing and recording for each activity shall be as follows:

(a) Production testing of weldment run-off tabs. Weldment run-off tabs shall be provided on each of the first three production run high heat input welding subassemblies for the purpose of establishing the mechanical properties of the weld metal for each high heat input welding process. High heat input welding is defined as welding in the range of 55,000 to 100,000 joules per inch. The runoff tab shall represent the highest heat input of the range used in the subassembly for each welding process. Insofar as is practicable, the run-off tabs shall be produced as early as possible in the initial welding of a subassembly because of the consequences of failure of the weld metal to meet the mechanical property requirements. NDT and destructive tests shall be performed on the runoff tabs in accordance with MIL-STD-248, except that the destructive tests shall consist of two all weld metal tensile tests, six Charpy V-notch tests and six 5/8 inch dynamic tear tests.

(b) All destructive tests shall meet the minimum requirements of note 1/ above. Failure of any test to meet these requirements shall be cause for the shipbuilder to cease all high heat input welding for the welding process involved. The failure test results shall be examined for validity in accordance with AWS B4.0. If failure results are found valid, all the welding represented by the welding process involved shall be rejected. The shipbuilder shall be permitted to salvage the base material by removing completely all of the non-conforming welds and rewelding using a qualified process. Six months after the initial production testing, the shipbuilder shall select a subassembly at random, and for this subassembly shall provide one weldment runoff tab for each high heat input welding process used. The runoff tab weldment shall be subjected to the same testing requirements and failure provisions as for the initial production runoff tabs. Thereafter, one weldment runoff tab from a subassembly for each welding process shall be selected and tested on a yearly basis for the next three years. If there are no failures at the end of the three-year period, the certification of high heat input welding for the specific welding process shall be considered satisfactorily completed (see 17.3).

3/ Welding electrode wire and wire/flux conformance testing and marking shall be as follows:

(a) Marking. Existing lots of welding electrode wire and wire/flux and future procurements that have been conformance tested and qualified for high heat input welding shall be marked in a distinctive manner in addition to the other markings required by this standard. Other Navy approved material control systems may be used.

(b) Conformance testing. Conformance testing of existing lots and future procurements of welding electrode wire and wire/flux lot combinations for use with high heat input procedures is required. Conformance testing shall be conducted in accordance with MIL-E-23765/2, type MIL-100S-1.

4/ The qualification for SAW at the alternative heat input is based on the formulation of flux used in procedure qualification and any change in formulation shall require re-qualification of the welding procedures. The shipbuilder shall be responsible for insuring that they are advised of any change in formulation and the subsequent notification of NAVSEA of such changes.

5/ For the welding of tee and corner type joints, a lower limit thickness of 3/4 inch for one member may be used provided the thickness of the

other member is at least 1-1/2 inches and special weld procedures are approved by NAVSEA for each welding process and position used in the welding of these tee and corner joints.

13.7.1.2 Root passes. Root passes which will be removed during backgouging may be exempted from the requirements of 13.7.1. Root passes (including twin arc) not removed during backgouging may be exempted from the requirements of 13.7.1 when the following conditions are met:

a. the total cross-sectional root deposited weld thickness does not exceed 3/8 inch, and

b. the joint design is such that the surface of the root beads will not be less than 3/8 inch from the finished weld surface.

13.7.1.3 Computation of heat input. For computing the heat input (joules/inch), the following formula applies:

$$\text{Heat input (joules/inch)} = \frac{\text{Arc voltage x welding amperage x 60}}{\text{Rate of travel (inches per minute)}}$$

Activities may use this formula to calculate, and incorporate in their welding procedures, acceptable burn off lengths for SMAW electrodes.

13.8 MIL-120S SAW weld metal hydrogen removal requirements. All SAW welds made with MIL-120S filler material shall be exposed to the weld soak requirements as follows:

a. All weld soak treatments shall be applied before the weld is allowed to cool below the minimum preheat temperature.

b. For welds 1 inch up to and including 2 inches in thickness, or for weld repairs 1 inch in depth up to and including 2 inches in depth, the minimum post weld soak shall be at least 24 hours at a temperature of 300 degrees Fahrenheit minimum, 600 degrees Fahrenheit maximum or shall be at least 12 hours at a temperature of 350 degrees Fahrenheit minimum, 600 degrees Fahrenheit maximum.

c. For welds 1 inch up to and including 2 inches in thickness, or for weld repairs 1 inch in depth up to and including 2 inches in depth, an intra-weld soak of at least 4 hours at a temperature of 300 degrees Fahrenheit minimum, 600 degrees Fahrenheit maximum may be performed on each 1/2 inch or less of weld deposited on any one side of the joint in lieu of b. above.

d. For welds greater than 2 inches in thickness, or for weld repairs greater than 2 inches in depth an intra-weld soak of at least 4 hours at a temperature of 300 degrees Fahrenheit minimum, 600 degrees Fahrenheit maximum shall be performed on each 1/2 inch or less of weld deposited on any one side of the joint.

e. For loss of preheat on material 1 inch and greater in thickness, an intra-weld soak of at least 4 hours at a temperature of 300 degrees Fahrenheit minimum, 600 degrees Fahrenheit maximum shall be performed.

f. Alternate hydrogen removal procedures shall be submitted with supporting test data to NAVSEA for approval.

13.8.1 Weld thickness determination. The weld thickness shall be based on design thicknesses and shall be:

a. the throat thickness for single fillet welds.

b. the throat thickness of the larger weld for double fillet weld attachments.

c. the thickness of the intersecting member (beveled member) for full penetration tee welds or corner welds or the sum of the bevels for partial penetration tee welds. If the tee weld or corner weld is fillet reinforced, 1/2 of the leg size for each fillet shall be added to the thickness of the intersecting member to determine the weld thickness.

d. the thickness of the thicker member for butt welds.

e. the actual depth of the build-up or depth of the gouge, as applicable for weld build-up or weld repair of base metal gouges.

f. for loss of preheat, the actual weld throat thickness for partially completed fillet welds and the actual deposited weld thickness for partially completed full and partial penetration welds.

13.9 Repairs. Workmanship requirements shall be in accordance with section 14. Inspection of repairs shall be in accordance with section 6. For the purpose of this standard, all repairs shall be considered as falling into one of the following categories.

13.9.1 Repair of HY-80/100 base material plate and shape defects at the mill. Welding requirements for repair of plate and shape defects shall be in accordance with this section and may be performed prior to or after forming. Limits on depth of plate and shape defects shall be in accordance with section 8. Notation shall be made on the plate inspection records required in

section 5 of areas repair welded or requiring weld repair. In addition, the areas which have been repair welded shall be marked such that marking will not be removed prior to performing all inspections as required by this document. On completion and acceptance, base material repair welds shall be considered as base metal for subsequent cold forming and straightening.

13.9.2 Repair of HY-80/100 forging defects. Where weld repairs are authorized, they shall meet the requirements of 13.9.1.

13.9.3 Repair of HY-80/100 casting defects. Welding requirements for repair of castings shall be in accordance with this section. Repair limitations, inspection requirements and record requirements are contained in section 16.

13.9.4 Repairs of HY-80/100 base material fabrication scars and other fabrication damage at shipyard. Repair welding shall be limited to those locations which cannot be corrected by grinding to the extent specified in section 14. Repairs may be accomplished prior to or after forming.

13.9.5 Repairs to welds. Removal of defects shall be considered repair.

13.9.5.1 Repairs by grinding. Every effort should be made to avoid the necessity for repair welding of minor defects that can be corrected by grinding. Defects may be repaired by grinding provided the limits of section 14 are not exceeded. For welds other than in pressure hull envelope when the requirements of section 14 cannot be met, defects may be repaired by grinding provided the weld is not reduced below minimum design thickness.

13.9.5.2 Repairs by welding. Repair welding shall be performed subject to all other specification requirements which applied to the original weld. Type MIL-10018-M1 electrodes for HY-100 material may be used for repair of fillet or groove tee welds that were originally made with other electrodes listed in 10.2 provided:

a. The length of such repair does not exceed 6 inches and adjacent repairs within the same weld joint are more than 3 feet apart.

b. Fillet or partial penetration groove tee welds shall be resized in way of the repair area to account for any difference in strength level of the type MIL-10018-M1 electrode when compared to the electrode employed for the original weld being repaired.

c. Non-ferrous or austenitic stainless steel weld deposits are not involved in the repair.

13.10 Arc stud welding. Stud welding is permitted using procedures and equipment qualified in accordance with section 4. Either automatically timed arc or capacitor discharge stud welding may be used with approved stud

configuration for the respective processes. Capacitor discharge stud welding shall be limited to 1/4-inch maximum diameter, unless otherwise approved.

13.10.1 Pressure containing openings. Production studs used in connection with openings in water tight and pressure containing compartments shall be tension tested by torquing in accordance with 13.10.2.2.

13.10.2 Pressure and non-pressure containing. Automatic timed arc or capacitor discharge welded studs for all permanent applications shall be inspected at the beginning of each set-up (diameter change) or shift duration by bending or torque testing five consecutively welded studs.

13.10.2.1 Bend testing. If bend testing is performed, the studs to be tested shall be welded to a piece of scrap held in the vertical position, unless production welding is to be limited to flat position work. Bend testing of production studs is prohibited. Test studs shall be bent to an angle of 15 degrees and returned using a device similar to that shown on figure 27.

13.10.2.2 Tension testing by torquing. Studs may be tension tested by the use of the torque test. Any convenient means may be used for applying the tensile load axially to the stud, such as the application of a sleeve over the stud using a washer and nut with force being applied by a torque wrench. The torque test and axial load used shall be calculated as follows:

$$\text{Axial Load (pounds)} = \frac{(D^2 \times \pi \times YS)}{4} \times 0.8$$

$$\text{Torque (inch-pounds)} = \text{Axial load} \times D \times K$$

where

D is the stud minor diameter (inches) (see table XVI).
YS is the stud minimum yield strength (pounds per square inch) as specified in the applicable stud specification.
K is the lubrication factor. To ensure the weld is loaded primarily in tension, the threads of the stud shall be lubricated with molybdenum disulfide, graphite base or comparable lubricant in which case K is 0.15. If stud lubrication is prohibited, the stud shall be tested with no lubricant in which case K is 0.20.

TABLE XVI. Stud minor diameters.

Stud size	Minor diameters 1/	
	UNC, NC Class 2A	UNF, NF Class 2A
10	.1379	.1508
1/4	.1876	.2052
5/16	.2431	.2603
3/8	.2970	.3228
7/16	.3485	.3749
1/2	.4041	.4374
5/8	.5119	.5554
3/4	.6255	.6718
7/8	.7368	.7858
1	.8446	.8960
1-1/8	.9475	1.0210
1-1/4	1.0725	1.1460

1/ For use of studs having minor diameters other than those listed, calculation of appropriate torque and axial load will be required. Such calculation shall be included in the procedure qualification.

13.10.3 Temporary attachments. No test is required for temporary attachment studs. (See table I and 6.5.2 for inspection of areas where studs are removed).

13.10.4 Rejection procedure. Studs which show signs of failure shall be removed, the surface of the metal ground smooth, the condition causing failure rectified, and new studs welded and tested. Bent studs which meet all other acceptance standards shall not be rejected.

13.11 Welding of penetrations. If the toe of any full penetration or partial penetration weld connecting a penetration in the pressure hull envelope is located closer than 3/4 inch to the toe of any full penetration or partial penetration weld, two layers of weld metal shall be deposited on the base metal surface between the adjacent toes of the welds as shown on figure 28. If either is a fillet weld and the distance between the toes is less than 1/2 inch, the base metal surface between the toes shall be similarly welded. Weld buildup is required on all penetrations containing 0.20 percent carbon and higher prior to welding into structure.

13.12 Insert, patch, access and closure plate requirements. Except as outlined in 13.12.1, when the design requirements of 11.5.3 and 11.5.4 cannot be met because of cutback and proximity limitations, changes shall require approval.

13.12.1 When full penetration butt welds in the pressure hull envelope intersect at an angle of less than 75 degrees, the metal bounded by the acute angle on both sides of the plate shall be built up by welding. The weld buildup shall consist of two layers of weld metal and shall extend from the point of butt weld intersection to a point where the length of the chord formed between the intersecting welds is 1.5T minimum (where T is the thickness of the plating at the point of intersection). The buildup shall be VT and MT inspected as required in section 6. However, re-RT of the adjacent strength welds is not required. When exterior grinding is required for hydrodynamic or other considerations, application of exterior weld layers is not required provided the molded line of the hull is maintained and minimum thickness is achieved within the area bounded by the acute angle.

13.13 Snipes.

13.13.1 Temporary snipes. Temporary snipes shall be provided as necessary in all systems of intersecting full penetration welds to allow the deposition of sound weld metal at such intersections. The location of temporary snipes shall be governed by the details of welding sequence, and snipe dimensions shall be the minimum required to allow satisfactory completion of welding in the through joint. Figures 29, 30, 31 and 32 specify dimensions of temporary snipes for the geometries shown. Bevels shall be provided on temporary snipes to allow proper closure welding and such welding shall be done in accordance with this section.

13.14 Slag removal. In multiple pass welds, slag shall be removed from all weld beads before starting to deposit subsequent beads. Slag shall be removed by chipping, grinding, or other suitable mechanical means. Silicates formed during GTAW or GMAW need only be removed to the extent necessary that they do not interfere with welding or required NDT.

13.15 Weld repair of holes in the pressure hull envelope.

13.15.1 General. Holes cut into or through the pressure hull envelope may be welded provided the original hole diameter does not exceed 2-1/2 inches. Holes less than 1/2 inch in diameter shall be opened to 1/2 inch to 1 inch diameter. The openings shall be shaped to 20 degrees minimum included taper (see figure 33). Weld repairs shall be made in accordance with this section. Holes greater than 2-1/2 inches in original diameter shall be repaired by expanding the hole size as required by 11.5.3 and welding a patch into the plating.

13.15.2 Partial penetration holes. Hole depths 3/4T or less (where T is the thickness) may be repaired provided the original diameter does not exceed 2-1/2 inches. The holes shall be sized and prepared as shown on

figure 33. The completed weld repair shall be inspected to the requirements of section 6.

13.15.3 Full penetration holes. The hole shall be sized and prepared as shown on figure 33. A 3/16 inch minimum backing plate of OSS, HSS, HY-80, or HY-100 or approved non-metallic material shall be employed as shown on figure 33 and the hole welded in accordance with the requirements stated herein. The backing material shall be removed and the completed weld inspected in accordance with section 6.

13.16 Stainless steel weld attachment sites. Where attachments welded with stainless steel filler are removed from pressure hull structure, complete removal of the stainless steel weld metal shall be assured by an etch test.

13.17 Weld buildup. Where buildup by welding on the joint surface to correct oversize root opening or errors in joint preparation is accomplished, it should be done prior to fitting and unless specially approved otherwise, such buildup of each joint edge shall not exceed 1/2T or 1/2 inch, whichever is less (where T is the thickness of the thinner member being welded). Where one joint edge is inaccessible, the buildup allowed for both joint edges may be applied to one joint edge. Buildup may be employed for fairing or for other correction over or adjacent to welds in accordance with 12.6.3.3. This buildup shall be considered part of the involved weld. The buildup shall be deposited with electrodes as specified in section 10 using methods and procedures in accordance with section 13. Temporary backing (HY-80/100 or approved non-metallic materials) may be used to assist in this buildup.

13.18 Stress relief. HY-80/100 material or weldments shall not be stress relieved or post weld heat treated. The post weld heat soaking as detailed in 13.8 is not considered a post weld heat treatment.

14. WORKMANSHIP REQUIREMENTS

14.1 Scope. This section contains the requirements for workmanship practices and methods associated with welding of or to HY-80/100 material in submarine fabrication.

14.2 Surface preparation.

14.2.1 Processes. Surfaces shall be prepared by any one or any combination of the following methods. Manual oxy-fuel gouging shall not be used.

a. Machining (such as planing and shearing).

b. Oxy-fuel cutting.

c. Arc-air gouging.

d. Chipping.

e. Grinding or burring.

f. Automatic oxy-fuel gouging.

g. Plasma arc cutting.

14.2.2 Weld joint surface preparation. Surfaces to be welded upon and adjacent surfaces for a distance of a minimum of 1/2 inch from the expected weld area shall be clean, dry and free of surface matter and defects such as:

a. Paint.

b. Oil, grease.

c. Moisture.

d. Objectionable scale.

e. Objectional oxide or rust.

f. Objectionable nicks, gouges and irregularities.

g. Zinc or galvanizing.

h. Excess slag.

14.2.3 Surface finish. Flame or arc-cut surface finish of pressure hull structure shall be in accordance with the requirements of NAVSEA 0900-LP-999-9000.

14.2.4 Fabrication inspection. When inspected in accordance with section 6, joint preparation shall be in accordance with section 11 or other approved configurations including those in approved welding procedures. When fit-up tolerances exceed the limitation of approved joint designs, correctional buildup by welding may be employed within the limitations of section 13. When the opening between elements of PT2S.1 joints exceeds 1/16 inch as a nominal condition along the joint, fillet weld size shall be increased by an amount equal to the excess of opening above 1/16 inch.

14.2.5 Structure. Completed structure shall meet the requirements of sections 7, 12, and 14 when inspected as required by section 6.

14.3 Welds, repair excavations and backgouged roots. Welds in or to HY-80/100 shall be inspected as required in section 6 to assure compliance with this document.

14.3.1 Weld root cleaning. The roots of full penetration joints, welded from both sides, shall be backgouged after sufficient welding has been done on one side and before any welding is started on the opposite side. The weld root area shall be cleaned to sound metal in accordance with 14.2.2, shall meet the workmanship requirements of section 14, and shall be contoured in accordance with 14.3.2. Exception to this requirement is permitted only by NAVSEA special weld procedure approval. Prior to deposition of any weld from the second side, MT inspection shall be conducted in the root area as required by 6.5.

14.3.2 Weld root and repair excavation contour. Backgouged roots and weld repair areas shall be contoured to produce an excavation which is fully visible to the welder and allows access of the electrode to all weld surfaces. The gouged area configuration should have side walls sloping without sharp breaks or keyholing from the surface to the bottom, a bottom radius of approximately 1/8 inch minimum, and width sufficient to allow proper electrode accessibility and manipulation (see figure 34).

14.3.3 Completed welds. Welds and 1/2 inch of adjacent base material shall comply with the requirements of section 7. Where possible, mechanical means such as grinding or burring shall be used in lieu of welding to reduce surface irregularity to an acceptable contour. When welding is required to correct improper contouring, it shall be performed in conformance with sections 13 and 14. Ground or repaired welds shall comply with section 7.

14.3.3.1 Undercut and other weld edge correction. Undercut and other weld edge conditions which do not exceed the depth limitations specified in 7.4.8 are acceptable. Undercut and other weld edge conditions which exceed depth limitations shall be corrected by mechanical means such as grinding or burring provided the area ground for this purpose does not exceed the maximum

depth/length limitations specified in 7.4.8. Undercut or other weld edge conditions which exceed these limits shall be repaired by welding.

14.4 Weld contouring. Weld contouring by grinding, burring, or peening and grinding (see 14.5) may be done on any groove butt weld, groove tee weld, or groove corner weld, but shall be done to the welds listed below. Final MT inspection shall be performed after contouring. For the applications noted below, recontouring is also required after weld repairs. Weld contouring shall meet the requirements of figure 16. When as deposited undercut is not present and the weld edges blend smoothly into the base material, grinding is not required.

a. Groove tee or corner joint connection of the pressure hull envelope to penetrations.

b. Bulkhead and bulkhead stiffener connections to the pressure hull envelope.

c. Hard tank groove tee or corner welds (see figure 4).

d. All groove tee joint welds in or to HY-80/100 in neutron shield tank structure and other groove tee welds to the pressure hull envelope in the reactor compartment.

e. All groove tee and corner boundary welds in sea chests and trunks which are attached to the pressure hull envelope.

f. Battery space bar frames.

g. Flange connections of pressure hull frames to tank tops (except web side of flange).

h. Reactor compartment frame to pressure hull envelope welds.

i. All other full penetration welds to the pressure hull envelope in the reactor compartment.

14.5 Mechanical peening of welds. When required by specification or procedure, the method described herein shall be used for mechanical peening of welds.

14.5.1 General. If weld bead overlap, excessive roughness or re-entrant bead contour is present, it should be corrected by grinding prior to peening. Movement of metal by the peening tool shall remove any sharp discontinuities between the toe of the weld and the base material surface, and the peened area shall taper gradually into the base material. Peening may be used to correct distortion or minimize residual stresses. Peening of the last layer is permitted provided the last layer is ground prior to MT to remove any

evidence of peened surface. Peening shall not be performed on the first layer of a multiple layer weld unless approved by NAVSEA.

14.5.2 Peened contour. The finished contour of the groove shall be lightly ground or burred sufficiently to remove indications of peening prior to MT inspection. For those applications which are being peened for contour grinding reasons, the finished contour shall be in accordance with figure 16.

14.5.3 Peening tools. Peening tools shall be ground as required to obtain specified weld toe contours. Suggested peening tool tips are shown in figure 35.

14.6 Base material.

14.6.1 Edge laminations. Laminations not acceptable to the requirements of section 7 shall be closed by excavating to a depth of approximately 3/4 inch, or less if the indication is removed prior to reaching 3/4 inch from the plate edge and filling the excavation with weld metal.

14.6.2 Arc strikes, nicks, gouges, and other fabrication scars. Arc strikes, nicks, gouges, and other fabrication scars up to and including 1/32 inch depth are acceptable without repair. Arc strikes, nicks, gouges and other fabrication scars in excess of 1/32 inch, but within the limitations listed below shall fair smoothly into the base material or shall be repaired by mechanical means or welding. Arc strikes, nicks, gouges and other fabrication scars in excess of these limits shall be repaired by welding. All arc strikes on materials identified in 14.8 shall be dispositioned in accordance with 14.8.

Base material thickness	Maximum allowable size (inches)
Less than 1/2 inch	1/32
1/2 inch and greater	1/16

14.6.2.1 Arc weld metal spatter. All arc weld metal spatter greater than 1/8 inch diameter shall be removed.

14.6.3 Removal of welded temporary attachments. Welded temporary attachments shall be removed at least 1/16 inch away from the permanent member to which it is attached by chipping, arc air gouging, or oxy-fuel cutting, followed by grinding to restore base material or scarf surface as specified in 14.6.4. Attachments may also be removed by grinding only. Except for arc welded studs and spot welds 1/4 inch and smaller, removal shall not be accomplished by bending or hammering. All gouges, undercuts, or nicks produced during removal shall be faired out by grinding, or repair welded.

14.6.3.1 Inspection of welded temporary attachment sites. Upon removal of temporary attachments, the areas in way of such attachments which are ground or repair welded shall be MT inspected when required by 6.5.

14.6.4 Base metal surface correction. Where temporary attachments are removed or where weld repairs are required, the final repaired surface shall be ground smooth and flush (within 1/16 of an inch above) with the adjacent surface. The maximum depth of depression after the grinding shall not exceed 1/32 inch below base material surface except that in base material 1/2 inch thick and greater, the criteria of 7.4.8 may be applied.

14.7 Mechanical surface indentations. Indentations in pressure hull envelope shall be kept to a minimum. Material identification or layout indentations shall be made with low stress die stamps.

14.8 Arc strike corrections on heat treated materials. For all arc strikes, including discoloration, that occurred after final heat treatment in OSS/HSS (S-1) with carbon content greater than 0.30 percent, carbon molybdenum steel (S-3), alloy steel with chromium content not to exceed 3/4 percent and total alloy not to exceed 2 percent (S-3A), alloy steel with chromium content 3/4 percent to 2 percent and total alloy content 2-3/4 percent maximum (S-4), alloy steel with total alloy content 10 percent maximum (S-5), martensitic stainless high alloy steels (S-6) and specialty martensitic stainless high alloy steels (S-6A), complete removal of the heat affected zone shall be verified with an etchant that has been demonstrated to disclose heat affected zone structure in the material involved unless repair welding is required. Etchants shall be prepared and used in accordance with good metallurgical practice.

15. NDT INSPECTION METHOD REQUIREMENTS

15.1 Scope. This section contains the requirements for performing the following NDT used to detect surface and internal discontinuities in metals:

a. RT inspection.

b. MT inspection.

c. PT inspection.

d. UT inspection.

e. VT inspection.

NDT processes, procedures, techniques, equipment and materials, other than those specified in this document, may be used provided prior NAVSEA approval is obtained.

15.2 General.

15.2.1 Personnel qualifications. Personnel performing NDT shall be qualified and certified in accordance with section 4.

15.2.2 Test procedures. Each organization performing NDT in accordance with this standard shall prepare written test procedures and shall qualify these procedures in accordance with section 4.

15.3 RT inspection.

15.3.1 General. RT inspection procedure and technique requirements shall be as specified in MIL-STD-271.

15.3.2 Casting RT standard shooting sketches. Shooting sketches in accordance with MIL-STD-271 shall be provided to assist in interpretation of casting radiographs.

15.4 MT inspection.

15.4.1 General. MT inspection procedure and technique shall be as specified in MIL-STD-271 except as noted herein.

15.4.2 Equipment.

15.4.2.1 Circular magnetization equipment (DC prod). Equipment for circular magnetism shall involve the use of low voltage and high amperage current passed into the item being tested by the use of prods.

15.4.2.2 Longitudinal magnetization equipment (AC yoke). Equipment for longitudinal magnetization shall permit the use of an electromagnetic yoke or AC prods in order to induce the magnetic flux.

15.4.3 Inspection procedures.

15.4.3.1 Circular magnetization (DC prod). Circular magnetization shall be used to perform magnetic particle inspection of welds as specified in section 6. DC or rectified AC shall be passed through the part. Contact electrodes (prods or leeches) shall be used.

15.4.3.1.1 Technique. MT inspection procedure and technique shall be as specified in MIL-STD-271, except surface defects detected shall be re-evaluated by applying the prods parallel to the defect.

15.4.3.2 Longitudinal magnetization (AC yoke). Longitudinal magnetization shall be used to perform inspection of welds as specified in section 6.

15.4.3.2.1 Technique. MT inspection procedure and technique shall be as specified in MIL-STD-271, except surface defects detected shall be re-evaluated by applying the yoke perpendicular to the defect.

15.5 PT inspection. PT inspection procedure and technique shall be as specified in MIL-STD-271.

15.6 UT inspection.

15.6.1 UT inspection of welds. UT methods and techniques for inspection of welds shall be in accordance with MIL-STD-271.

15.6.2 UT inspection of plates for thickness and soundness. UT methods and techniques for inspection of plates for thickness and quality shall be as specified in MIL-STD-271 and the applicable material specification or acquisition document.

15.6.3 Records. Records shall be in accordance with sections 5 and 8.

15.7 VT inspection.

15.7.1 General. Inspector accomplishing VT inspection shall be qualified in accordance with section 4 and shall be familiar with the inspection requirements and inspection acceptance standards of this document.

15.7.2 Equipment. Visual aids such as magnifying glasses may be employed to assist in inspection except where prohibited by this document.

Recommended gauges and tools for dimensional or special inspection are outlined in sections 6 and 14.

15.7.3 Surface preparation. VT inspection of base material and welds shall be accomplished with the surface to be inspected in a clean condition (free of scale and slag which could interfere with the VT inspection). When other NDT is not required, surfaces which have been cleaned and painted with one coat of primer are considered suitable for inspection. Where weld contouring is required by this standard, applicable drawing or detail specifications, the welds shall be inspected in the ground condition.

16. WELD REPAIR OF HY-80/100 CASTINGS

16.1 Scope. This section contains the requirements for repair of HY-80/100 castings which are welded into and become a part of the submarine structure.

16.2 Casting requirements. HY-80/100 castings shall comply with the requirements of MIL-S-23008 and this section. Castings which fail to meet the acceptance standards of section 7 when inspected to the requirements of sections 8 and 16 shall be repaired by grinding or welding, as appropriate. Castings may be repaired by grinding where the thickness is not reduced below the minimum design thickness. Grinding shall produce a smooth depression blended into the surrounding surface in such a manner to remove abrupt changes of the material surface.

16.2.1 Castings which have satisfactorily passed receipt inspection requirements, or have been repaired as necessary to pass the requirements, shall be considered as wrought material for further fabrication purposes except that all casting repairs shall be made in accordance with this section. Temporary attachment sites, arc strikes and other fabrication scars shall be dispositioned accordingly. However, the acceptance standards for casting repair excavations, contained in section 16, shall be applied.

16.3 Cold straightening. Cold straightening of castings for the purpose of avoiding weld buildup because of misalignment between the casting and hull shall require approval.

16.4 Repair welding. Welding requirements for repair of castings shall be in accordance with sections 13 and 16, using procedures and welders qualified in accordance with section 4. Limits of repair welding are contained in 16.5. Inspection requirements are contained in this section. Acceptance standards shall be in accordance with sections 7 and 16. Prior to repair welding, the excavated area shall be fully visible to the welder and shall allow access of the electrode to all weld surfaces (see figure 36).

16.4.1 Heat treatment. Unless otherwise approved by NAVSEA, repairs shall be made using filler metal conforming to the applicable specification, as specified in table VII, subsequent to heat treatment of the casting and completion of acceptance mechanical testing. No post weld stress relief or heat treatment shall be performed after such weld repairs.

16.4.2 Stress relief. HY-80/100 castings shall not be stress relieved.

16.5 Repair limitations. Repairs may be made provided that all requirements of this standard are met. Limitations on repair are set forth below.

16.5.1 Extent of repair. Repair of rejectable indications in castings shall consist of the removal of the defect until the excavation meets the

general limitation requirements of 16.5.3.1, weld repair of the excavation, and NDT of the repair to the applicable acceptance standards.

16.5.2 Repair by grinding. Repairs may be accomplished by grinding without repair welding provided minimum design thickness is maintained and the final contour blends smoothly into adjacent surfaces. Final surfaces shall be inspected by VT and MT to the acceptance standards of section 7.

16.5.3 Repair by welding. Defects that cannot be repaired by grinding in accordance with 16.5.2 or where a minimum design thickness cannot be established shall be repaired by welding.

16.5.3.1 General limitations. Excavated areas to be weld repaired shall meet the contour requirements of figure 36. In addition, the following requirements apply:

a. On casting surfaces which do not require subsequent machining, defects requiring repair shall be excavated until acceptable to the requirements of section 7 (as determined by MT inspection) or until a depth of 3/8 inch is reached. Beyond 3/8 inch and up to and including one inch of depth, the excavation shall be proven free of linear defects over 1/2 inch long by MT inspection prior to repair welding.

b. On casting surfaces which require subsequent machining to produce the final configuration, defects requiring repair shall be excavated until removed (as determined by MT inspection) or until a depth of 3/8 inch below the final machined dimension is reached. Beyond a depth of 3/8 inch and up to and including 1 inch below the final machined dimension, the excavation shall be proven free of linear defects over 1/2 inch long by MT inspection prior to repair welding. RT may be employed after excavation, as detailed in 16.7.3, to determine the soundness of the remaining material.

c. On castings at the shipyard that have satisfactorily passed initial RT, UT and MT, the requirements of a. and b. above apply for excavations up to 1 inch deep. Discontinuities in excavations over 1 inch below the as-cast or final machined surface may be sealed and the excavation repaired provided the root layers are MT inspected and comply with the requirements of 7.5.1.

16.5.3.2 Minor repairs. Minor repairs are repairs of surface defects for which the excavations do not exceed the following limits:

a. The maximum depth does not exceed 1/2 inch or 20 percent of the casting thickness, whichever is less.

b. Individual repair areas do not involve more than 2 percent of the casting surface.

c. The total repair area does not exceed 10 percent of the casting surface.

16.5.3.3 Nominal repairs. Nominal repairs are those which exceed the limitations stated in 16.5.3.2 for minor repairs but which do not exceed 2 inches or half the casting thickness in depth, whichever is less. The total accumulated volume of weld metal involved for nominal repairs shall not exceed 4 percent of the volume of metal in the casting. Adjacent nominal repairs shall be separated by a distance equivalent to the maximum dimension of the smaller repair or 3/4 inch, whichever is less. If this condition is not met, the repairs shall be joined. RT may be employed after excavation, as detailed in 16.7.3, to determine the soundness of the remaining material.

16.5.3.4 Special repairs. Special repairs are those which exceed the limitations of 16.5.3.3 for nominal repairs. Special repairs are permitted only with approval on a case basis (see 17.3 and appendix A). These repairs may include excavations completely through the wall of the casting which may be repaired by employing a suitable contoured insert. The insert shall be HY-80/100 material, as appropriate, and fully documented to this standard. It shall have radius corners (3/4 inch minimum). If adjacent special repairs are closer to each other than 3/4 inch, they shall be joined to make a single repair. Requests for approval of any repairs in this category shall be accompanied by a suitable sketch or photograph showing complete dimensional details, proposed welding and inspection procedures criteria, and in addition, shall include a record of all previous repairs except minor repairs.

16.6 Weld buildup. Weld buildup for correction of casting dimensions or machining errors not exceeding 10 percent of the total area of the casting may be made using welding procedures and welders qualified in accordance with section 4. Weld buildup shall be within the following limitations:

a. 3/16 inch maximum buildup for wall thickness 1 inch and under.

b. 20 percent of wall thickness maximum buildup for wall thickness over 1 inch but not to exceed 3/8 inch.

These thickness limitations apply to the finished condition. Weld buildup exceeding these thickness and area limitations shall be performed only with approval on a case basis. Areas which are built up by welding shall be recorded by sketch, or other means to identify the buildup areas, dimensions, and inspection accomplishment.

16.7 Repair weld inspection. All castings which have been repaired or built up shall be inspected as detailed below.

16.7.1 VT inspection. Each casting shall be inspected after repair for conformance to drawing dimensions, for surface conditions and for identification marking.

required by section 8, shall be maintained for shapes used in pressure hull

16.7.2 MT inspection. MT inspection shall be performed in accordance with section 15 by operators and procedures qualified in accordance with section 4. Acceptance standards shall be as specified in section 7 for cast materials. MT inspection shall be performed on all weld repair and buildup areas in the final repair surface condition. Final inspection shall be made no sooner than 7 days (160 hours) after the weld is completed and has cooled to ambient temperature. At the contractor's or foundry's risk, this minimum 7 day (160 hour) inspection need not delay further processing of the casting, provided the accomplishment of all required inspection is documented.

16.7.3 RT inspection. RT shall be performed by procedures and personnel qualified as required in section 4 to the acceptance standards of section 7. RT is not required for minor repairs ad defined in 16.5.3.2 nor for weld buildup to the extent permitted in 16.6. RT inspection of nominal weld repairs is required if the repair was made to correct an RT detected defect. RT inspection is required for all special weld repairs if that portion of the casting being repaired originally required RT. Repair of casting RT indications is required only to the extent of bringing such indications within the applicable RT acceptance standards. When radiographs are made after repair excavation and prior to weld repair to determine the extent of any remaining discontinuities, the acceptance standards for the designed thickness of the casting in the excavated area shall apply. UT inspection, employed in accordance with an approved procedure, may be used for such determinations.

16.8 Repair weld marking. If reference points do not exist due to surface configuration, castings shall be marked as necessary to provide traceability of the repair records to the location of nominal and special repairs.

16.9 Records. Records of all weld repairs shall be maintained as required in section 5 and except for minor repairs shall include the following:

a. The location, size, and depth of each weld repair (or thickness of buildup) shall be marked on a suitable sketch of the casting. Photographs, with weld repair dimensions shown, may be made of the casting after preparation and prior to repair welding. A scale should be placed on the casting, visible on each photograph, for use in approximating dimensions to assist in subsequent inspection.

b. Reference to welding procedure/electrode qualification document.

c. Weld repair inspection results.

d. Approval authority.

e. Welder identification.

f. Filler metal identification (electrode type, heat, lot, control number, or batch number, as applicable).

17. NOTES

17.1 Scope. This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.

17.1.1 Intended use. This standard is intended to describe the minimum requirements for shipbuilding practices, standards for material, weld joint design, workmanship, welding inspection and record requirements for combatant submarines and noncombatant submersibles constructed of HY-80/100 material.

17.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1, and 2.2).

17.3 Consideration of data requirements. The following data requirements should be considered when this standard is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DoD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

Reference paragraph	DID number	DID title	Suggested tailoring
4.9.1, 5.3.2.1, 5.3.2.2, 5.3.2.3, 5.3.2.4, 5.3.2.5, 5.3.2.6, 5.3.2.7, 5.3.3.1, 5.3.3.2, 5.3.3.3, 5.3.3.4, 5.3.3.5, 5.3.3.6, 5.3.4, 5.3.4.1, 5.3.4.2, 5.3.1.6, 13.7.1.1, 16.5.3.4, and appendix A	DI-MISC-80678	Certification/ data report	---
Table XV	DI-T-2072	Reports, test	---

The above DID's were those cleared as of the date of this standard. The current issue of DoD 5010.12L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

17.3.1 Alternate heat input - production testing of weldment run-off tabs. Copies of the test data from procedure qualification (see 13.7.1.1 and table XV) should be provided to the cognizant Supervisor of Shipbuilding,

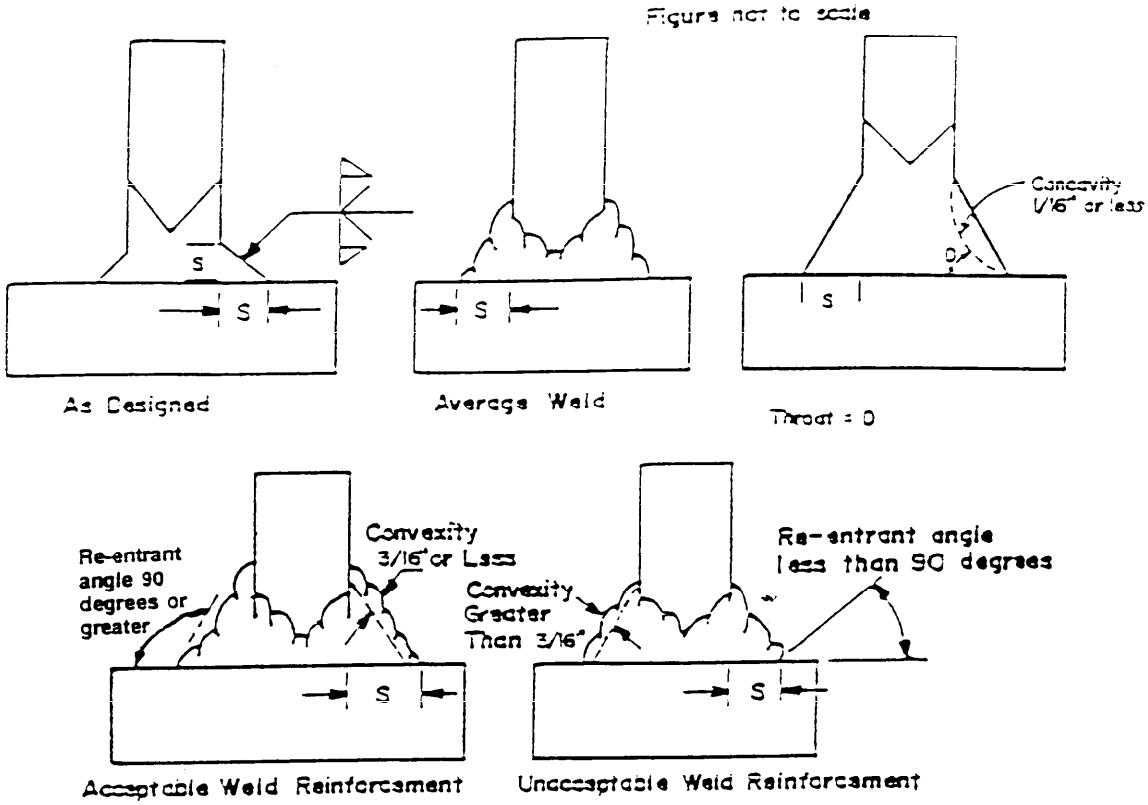
Conversion and Repair, USN; NAVSEA Metals Division, and NAVSEA Structural Integrity Division.

17.4 Subject term (key work) listing.

Arc
Backgouge
Bulkhead
Coaming
Heat soak
Pressure hull structure
Tanks
Web stiffener
Welds

17.5 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Preparing activity:
Navy - SH
(Project THJM-N230)



Notes:

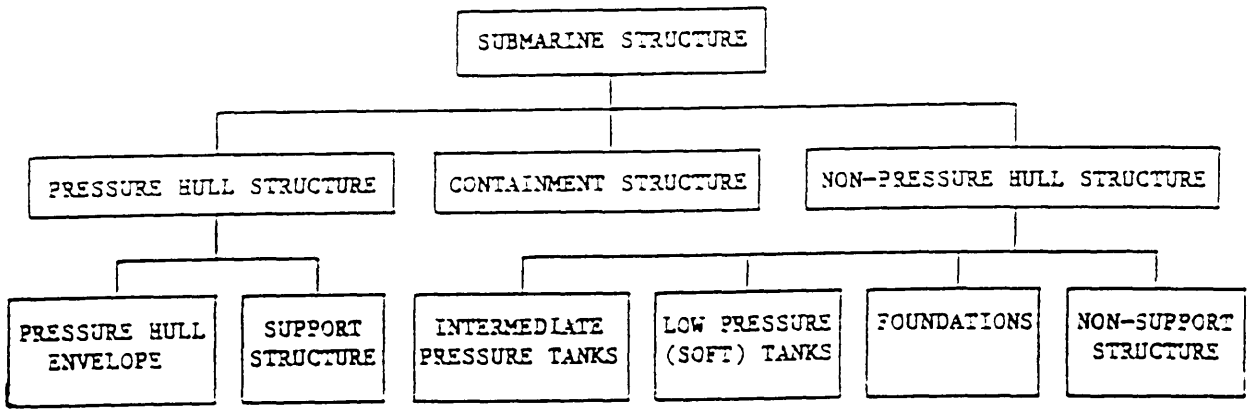
1. Fillet reinforcement size in excess of that required by plan is acceptable provided the contour is in accordance with these figures.

2. Although the fillet contour shown in this figure is for groove tee welds, the same requirements apply for fillet welds.

3. Convexity shall not be more than 3/16 inch.

4. Concavity shall not be more than 1/16 inch; concavity is acceptable provided the minimum throat thickness is at least equal to 70 percent of the required fillet reinforcement size ($D \geq 0.7 \times S$).

FIGURE 1. Typical contour for fillet groove tee welds and fillet welds.



Note:

1. Any component of submarine structure which may fall into more than one of the above categories shall be considered as belonging to that category having the more stringent design and inspection criteria.

FIGURE 2. Functional diagram of HY-80/100 submarine structure.

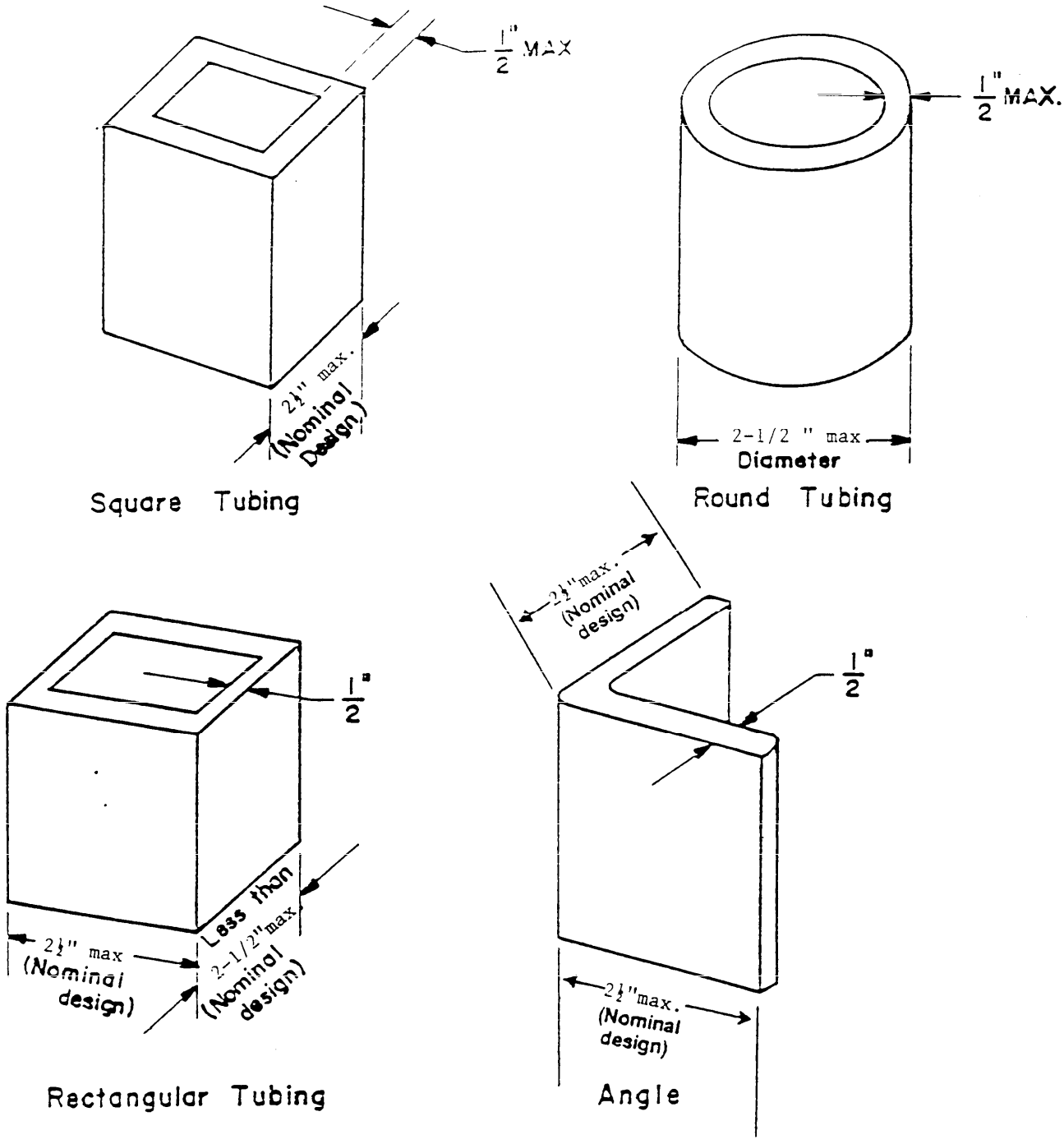
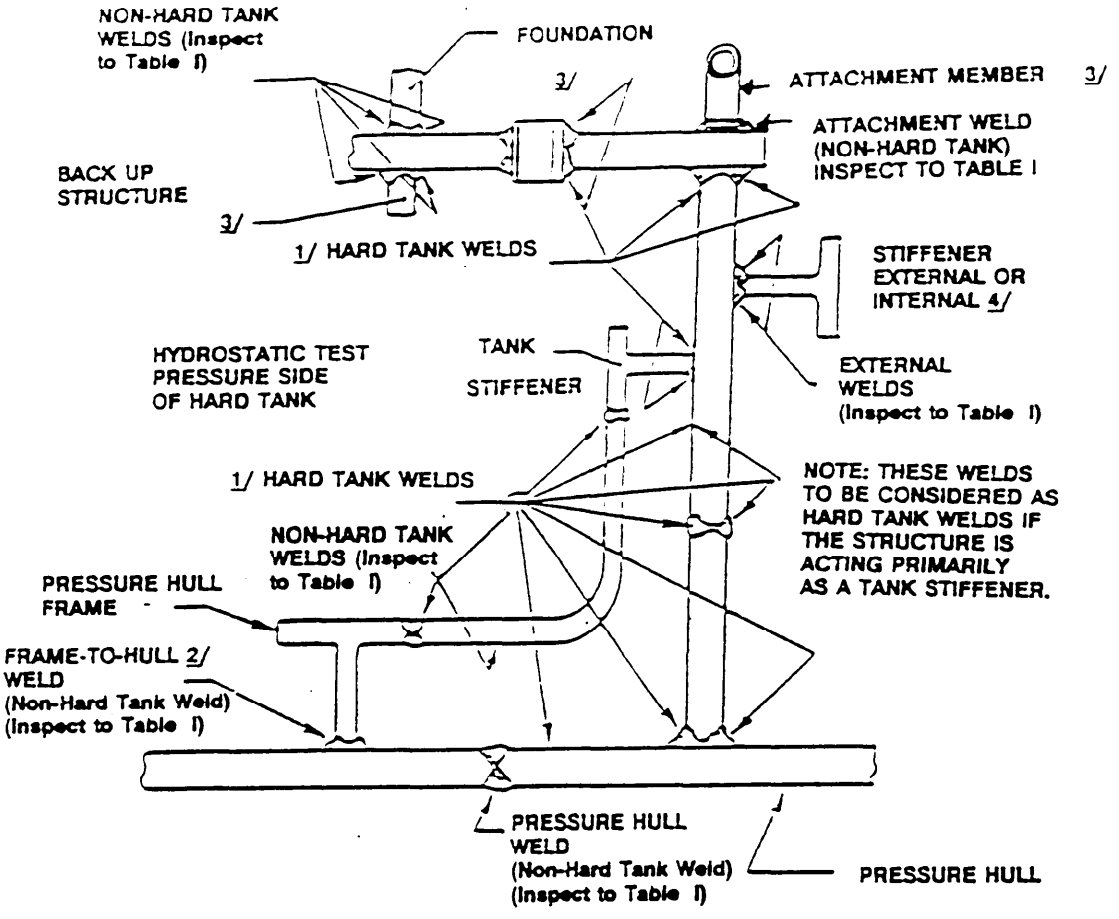


FIGURE 3. Examples of members for attachment welds.



1/ Normally, the hydro test pressure side of the hard tank and the operational pressure side of the hard tank are the same. When exceptions exist, welds in or to both sides of the hard tank plating shall be considered hard tank welds.

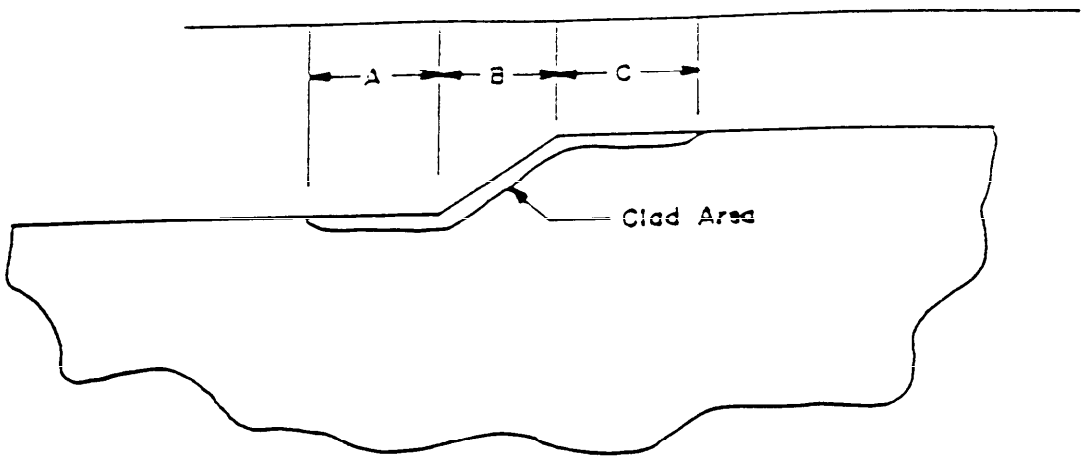
2/ Frame to pressure hull envelope welds and pressure hull welds located within the hard tank are not considered hard tank welds. If the frame to pressure hull weld acts as a tank boundary, it shall be inspected as a tank weld.

3/ Back-up structure for foundations is structure welded to the hard tank plating for the design purpose of supporting foundations and not primarily as a tank stiffener. Inspect back-up structure, foundation and attachment welds to table I.

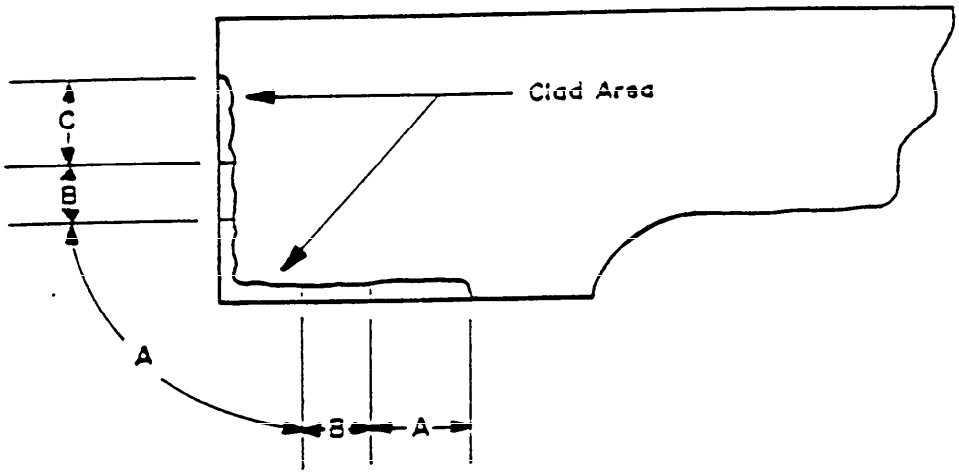
4/ Where the stiffener, external or internal, is not active as a primary tank panel stiffener, inspect the stiffener attachment weld to table I.

5/ Welds not specifically identified in this figure as tank welds are to be inspected in accordance with table I.

FIGURE 4. Hard tank welds. 5/



Typical Clad Area with Single Seating Surface



Typical clad area with double seating surface.

A = Inboard surfaces	Class 3
B = Seating or seal area	Class 1
C = Outboard surfaces	Class 2

Note:

1. The width of zone B shall be the width of the gasket retaining groove in the matching part plus 1/8 inch.

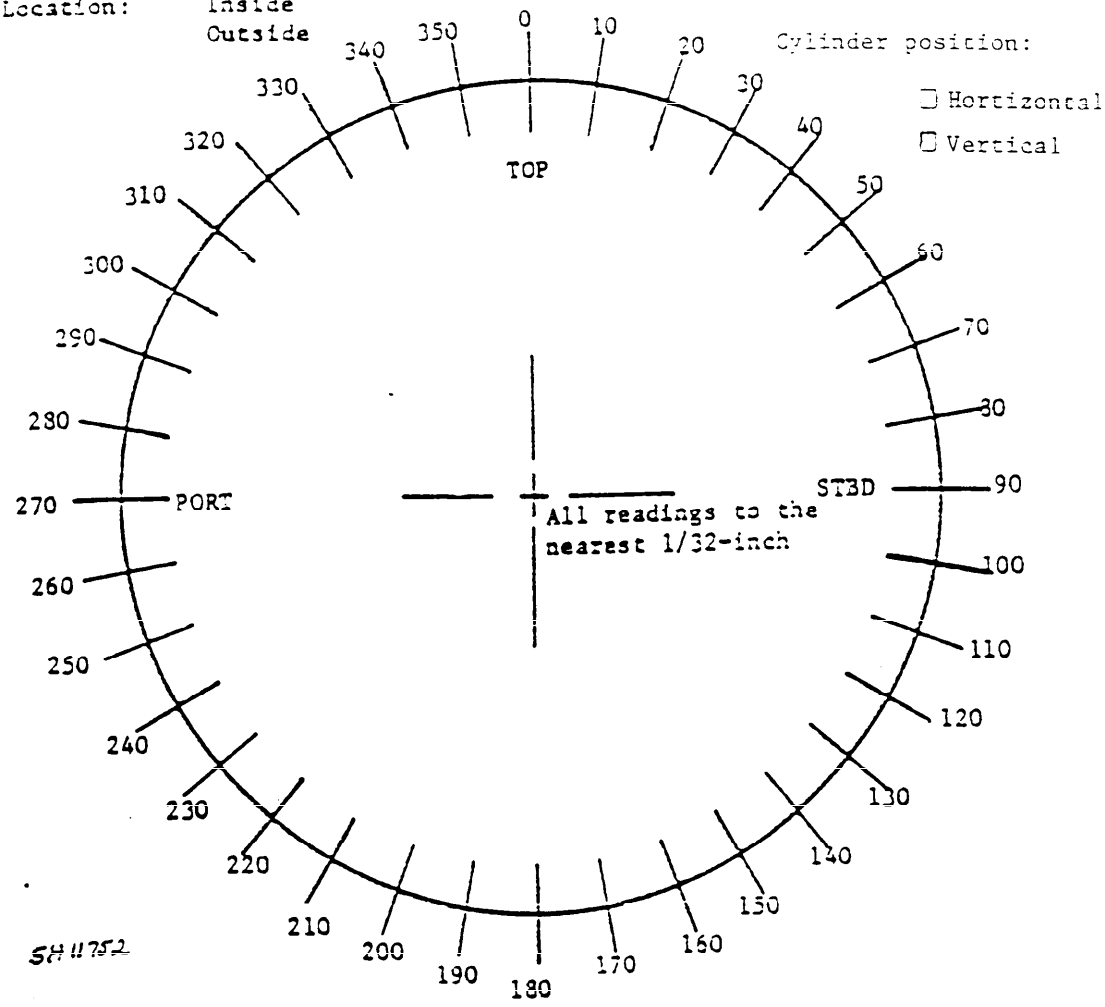
FIGURE 5. Clad areas for O-ring or gasket seating surfaces.

Ship No._____ Actual Station_____ Date of Measurement_____

Method of Measurement: ☐ Swing Arm ☐ Optical Square ☐ Bridge Gage
☐ Template ☐ Internal Radii ☐ Other_____ (State)

Location: Inside Outside

Cylinder position:
☐ Horizontal
☐ Vertical



NOTE: Plus sign indicates actual contour is outside mean circle.
Minus sign indicates actual contour is inside mean circle.

Circularity		Radius
Allow. Diff._____	Design _____	Mean _____
Max. Diff._____	Allow. Diff_____	Actual Diff_____

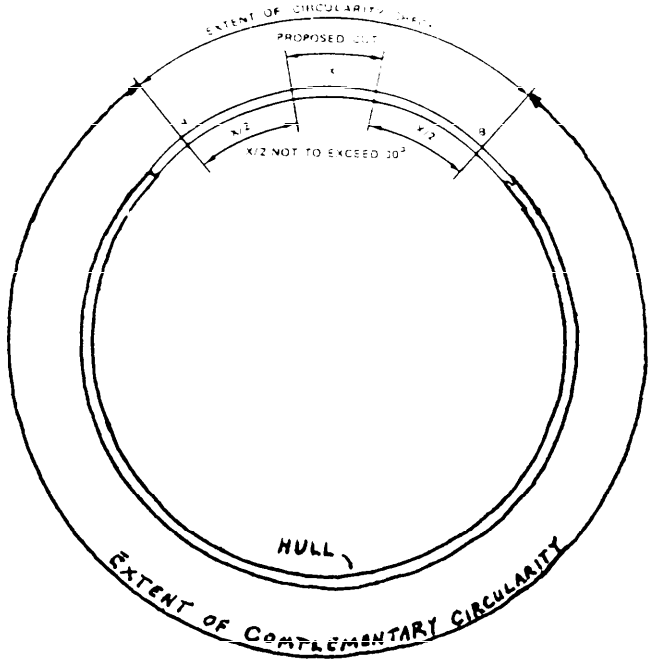
Mechanic _____ Shop/Dept_____

Navy Insp._____ Approved _____

Date _____

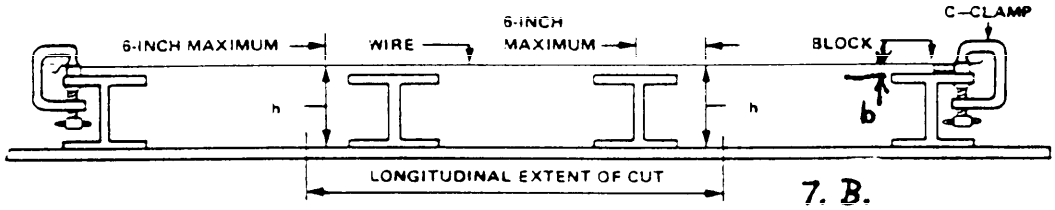
FIGURE 6. Quality control hull circularity measurement record.

1. Total hull circularity based on complementary plus partial circularity measurements shall be made in accordance with 12.6.1.1.3.1. Figure 7.A shows the extent of complementary and partial circularity measurements.



7.A.

2. The elevation of points "A" and "B" in figure 7.A shall be established relative to reference lines from bench marks established on undisturbed frames forward and aft of the proposed cut. This can be done by use of optics, or other methods such as the range wire shown in figure 7.B. The end point elevations, "b" dimensions, shall be recorded for future reference at each frame to be cut. The reference line elevations, "h" dimensions, shall also be recorded.



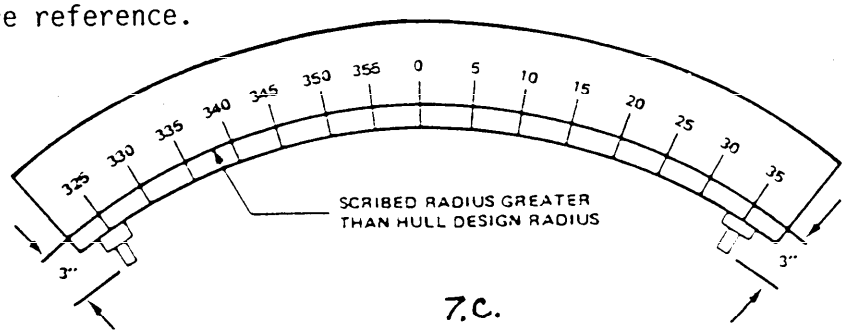
7. B.

3. After the hull has been restored and all major welding completed, the reference lines shall be re-established and the reference line and end point elevations, dimensions "b" and "h", respectively, of figure 7.B shall be again measured and recorded.

FIGURE 7. Complementary circularity measurements.

welds shall not be [illegible] 0.3.3. Requirements for cold formed welds

4. Using an appropriate measurement method, the existing hull radial geometry shall be measured at five degree intervals over the arc from, and including, points "A" and "B". (For illustration purposes only, figure 7.C shows a template approach for taking these measurements.) These measurements shall be recorded for future reference.



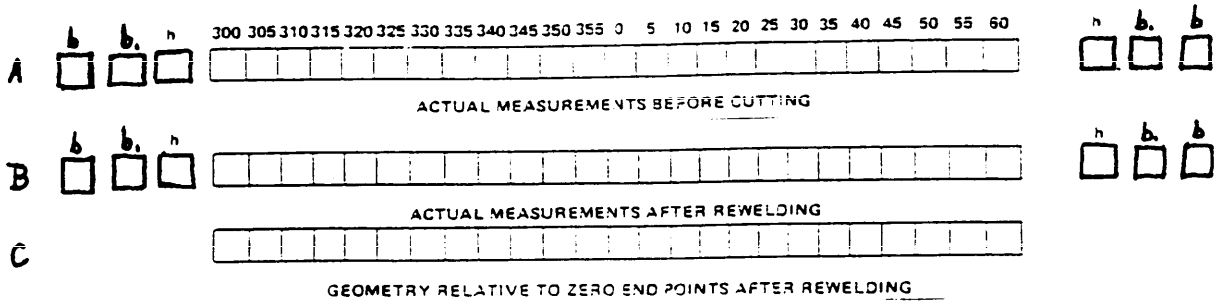
7.C.

5. Figure 7.D illustrates an acceptable method of recording all measurements.

(a) The actual measurements of the bench mark and end point elevations taken before cutting shall be recorded on line "A".

(b) The actual measurements of the reference line elevations, end point elevations and the contour taken after installation shall be recorded on line "B".

(c) If the pre-cut reference lines could not be re-established, the end point elevations recorded on line "B" shall be adjusted to account for any change in the reference line elevations between lines "A" and "B". These adjusted end point elevations shall be recorded on line "C" and shall be considered the post-installation zero points. The contour relative to these zero points shall then be recorded on line "C".

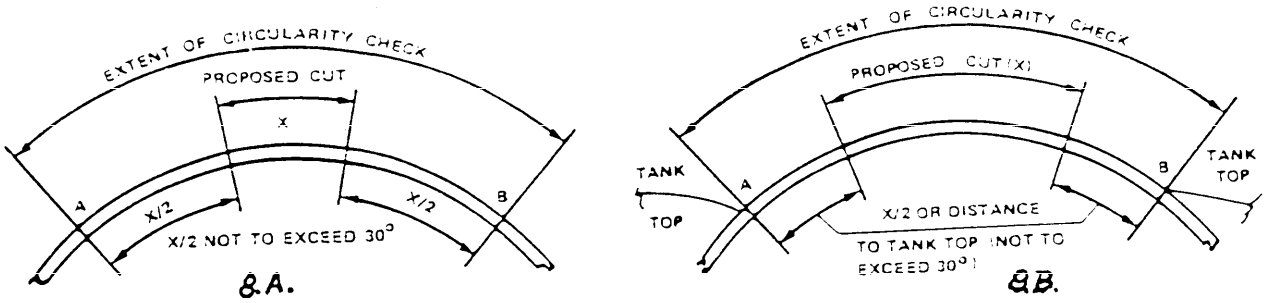


7.D

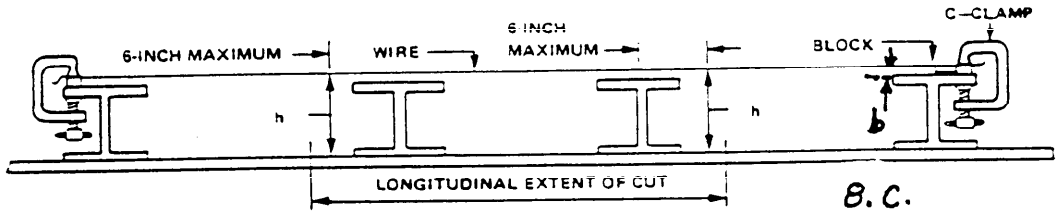
6. Using the partial circularity contour from either line "B" or "C" above, the total hull contour shall be developed and evaluated in accordance with 12.6.1.4.a.

FIGURE 7. Complementary circularity measurements - continued.

1. Partial circularity measurements shall be made in accordance with 12.6.1.1.3.2. Figures 8.A and 8.B show the extent of partial circularities in cases with and without tank structure intersecting the hull.



2. The elevation points "A" and "B" in figures 8.A and 8.B shall be established relative to reference lines from bench marks established on undisturbed frames forward and aft of the proposed cut. This can be done by the use of optics or other methods such as the range wire shown in figure 8.C. The end point elevations, "b" dimensions, shall be recorded for future reference at each frame to be cut. The reference line elevations, "h" dimensions, shall also be recorded.



3. Using an appropriate measurement method, the existing hull radial geometry shall be measured at five degree intervals over the arc from, and including, points "A" and "B". (For illustration purposes only, figure 8.D shows a template approach for taking these measurements.) These measurements shall be recorded for future reference.

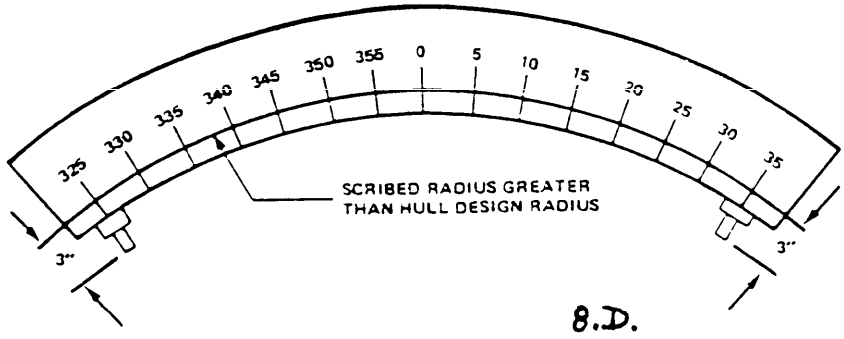


FIGURE 8. Partial circularity measurements.

4. After the hull has been restored and all major welding completed, the reference lines shall be re-established and the reference line and end point elevations, dimensions "b" and "h", respectively, of figure 8.D shall again be measured.

5. The post-installation hull radial geometry shall again be measured at the same points and using the same method as in step 3 above. These measurements shall be recorded.

6. Figure 8.E illustrates an acceptable method of recording all measurements.

(a) The actual measurements of the reference line elevations, end point elevations and the contour taken before cutting shall be recorded on line "A".

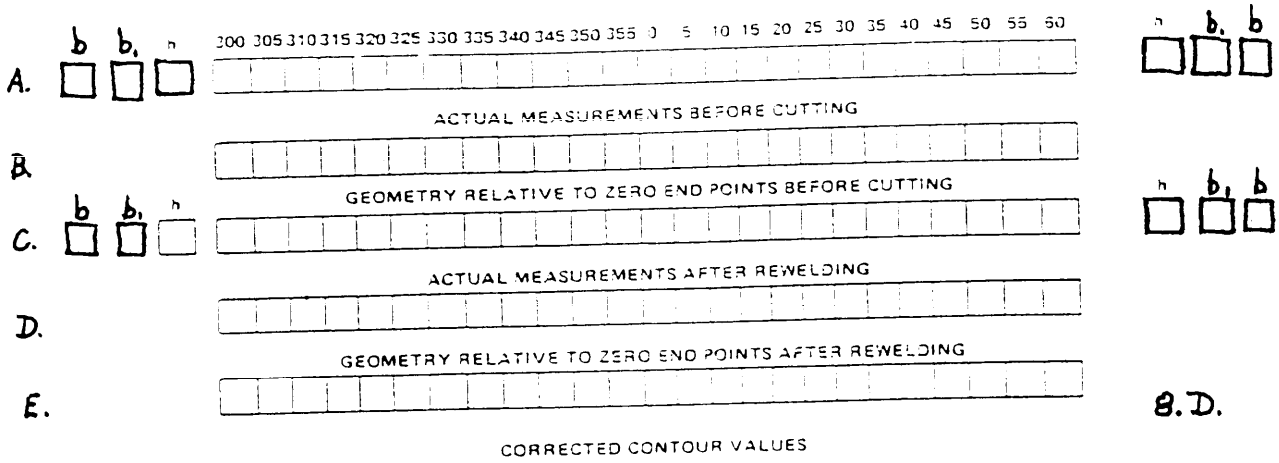
(b) The end point elevations shall be considered zero points. Therefore all reading greater than the zero point distance reveal a dip in the hull and shall be considered negative readings; all readings less than the zero point distance reveal a hump in the hull and shall be considered positive readings. The contour measurements relative to the zero end points before cutting shall be recorded on line "B".

(c) The actual measurements of the reference line elevations, end point elevations and the contour taken after installation shall be recorded on line "C".

(d) If the pre-cut reference lines could not be re-established, the end point elevations recorded on line "C" shall be adjusted to account for any change in the reference line elevations between lines "A" and "C". These adjusted end point elevations shall be recorded on line "D" and shall be considered the post-installation zero points. The contour relative to these zero points shall then be recorded on line "D".

(e) If the end point elevations, "h" dimensions, on line "D" deviate from the "h" dimensions on line "A", corrections shall be made to the contour measurements recorded on line "D". That corrected contour measurements shall be recorded on line "E".

FIGURE 8. Partial circularity measurements - continued.



7. Record the pre-cut hull contour, line "B", with the post-installation hull contour, line "D" or "E", as applicable, on figure 8.F.

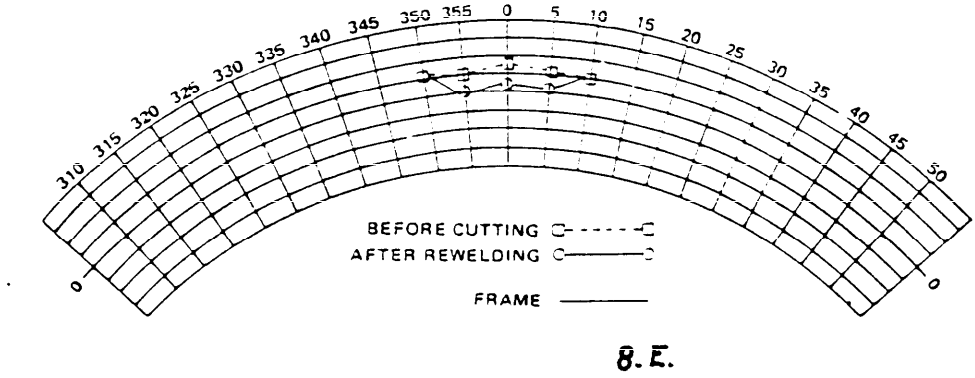


FIGURE 8. Partial circularity measurements - continued.

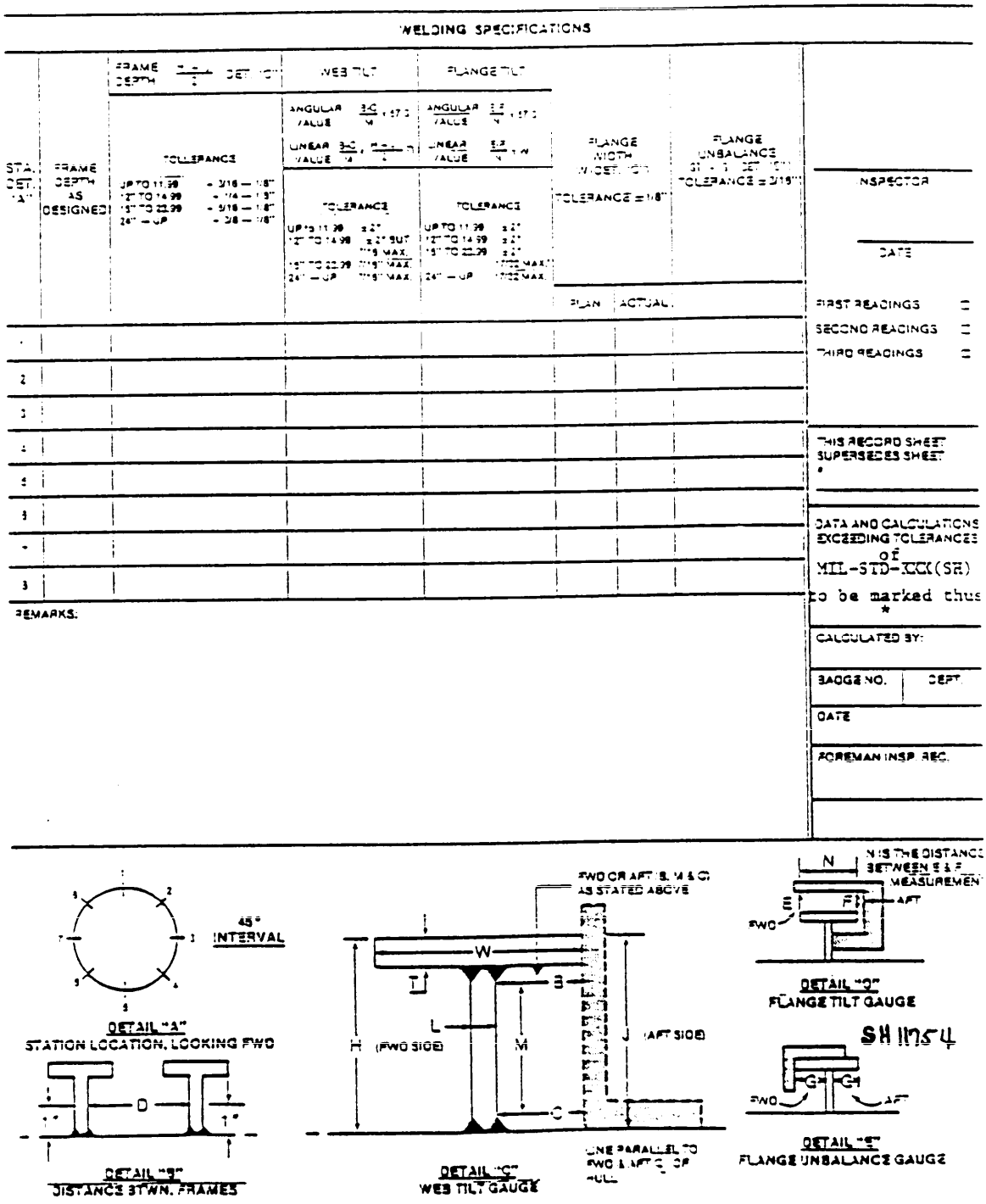


FIGURE 9. Record of frame dimensions.

NO.

RECORD OF FRAME DIMENSIONS

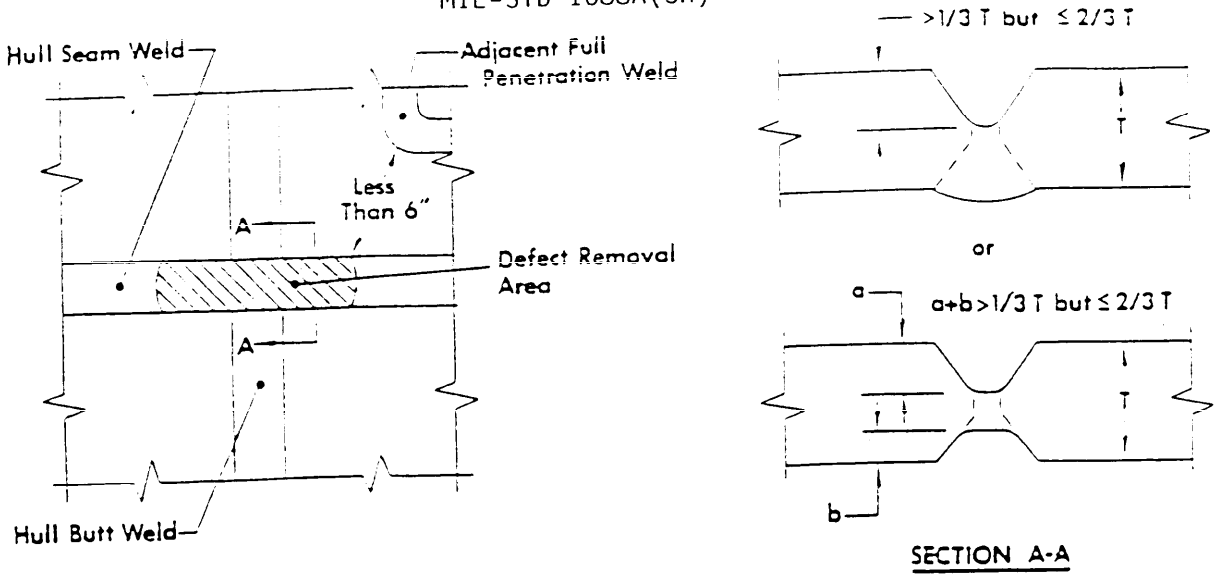
BOAT	PLAN	REV.	FRAME NO.	INTERNAL ☐ EXTERNAL ☐	FABRICATED ☐ EXTRUDED ☐	SHIP ☐	BLOCKS ☐ VENDOR ☐

STA. DET. "A"	ACTUAL DISTANCE STAN FRAMES DET. "A"	GAGE LOCATION: AFT SIDE OF FRAME ☐ FWD SIDE OF FRAME ☐											
		SEE DETAIL "D" BELOW							SEE DETAIL "E" BELOW			SEE DET. "F" BELOW	
	D	L	H	J	B	C	M	T	E	F	N	G	G.
1													
2													
3													
4													
5													
6													
7													
8													

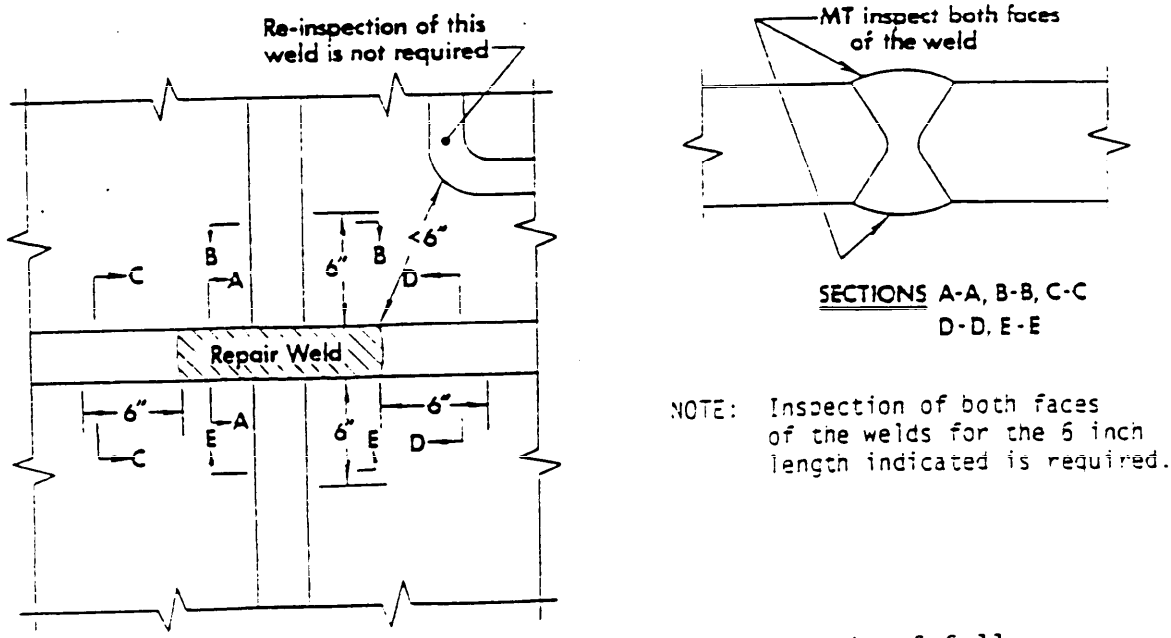
REMARKS:

SH 11754

FIGURE 9. Record of frame dimensions - continued.

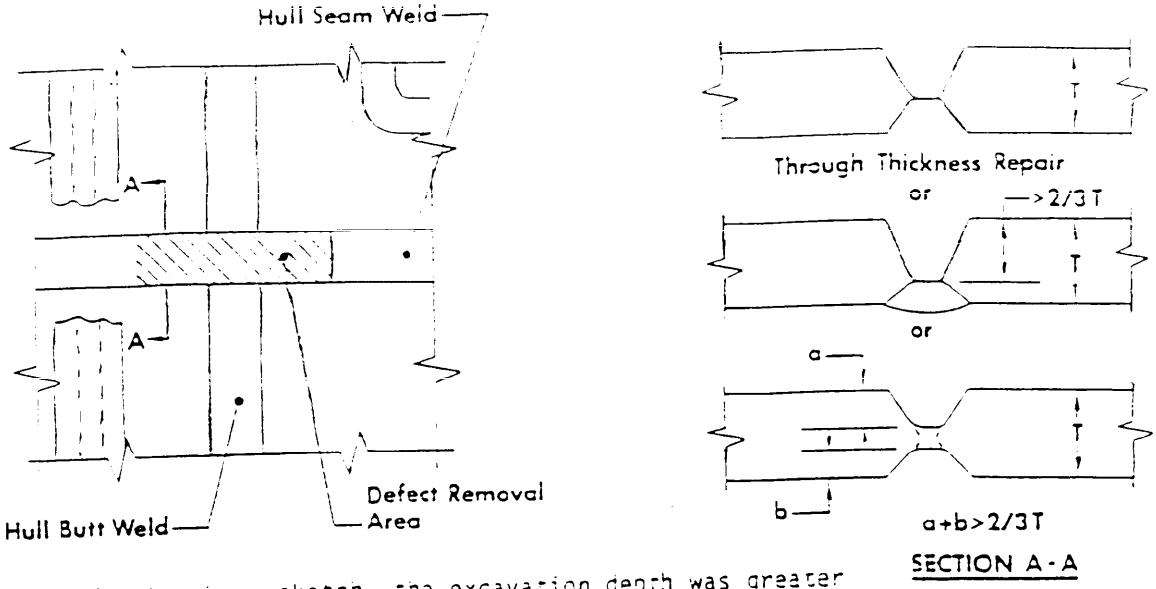


As shown in the above sketch, the excavation depth was greater than 1/3 the plate thickness but less than or equal to 2/3 the plate thickness. Re-inspection requirements are as shown below.

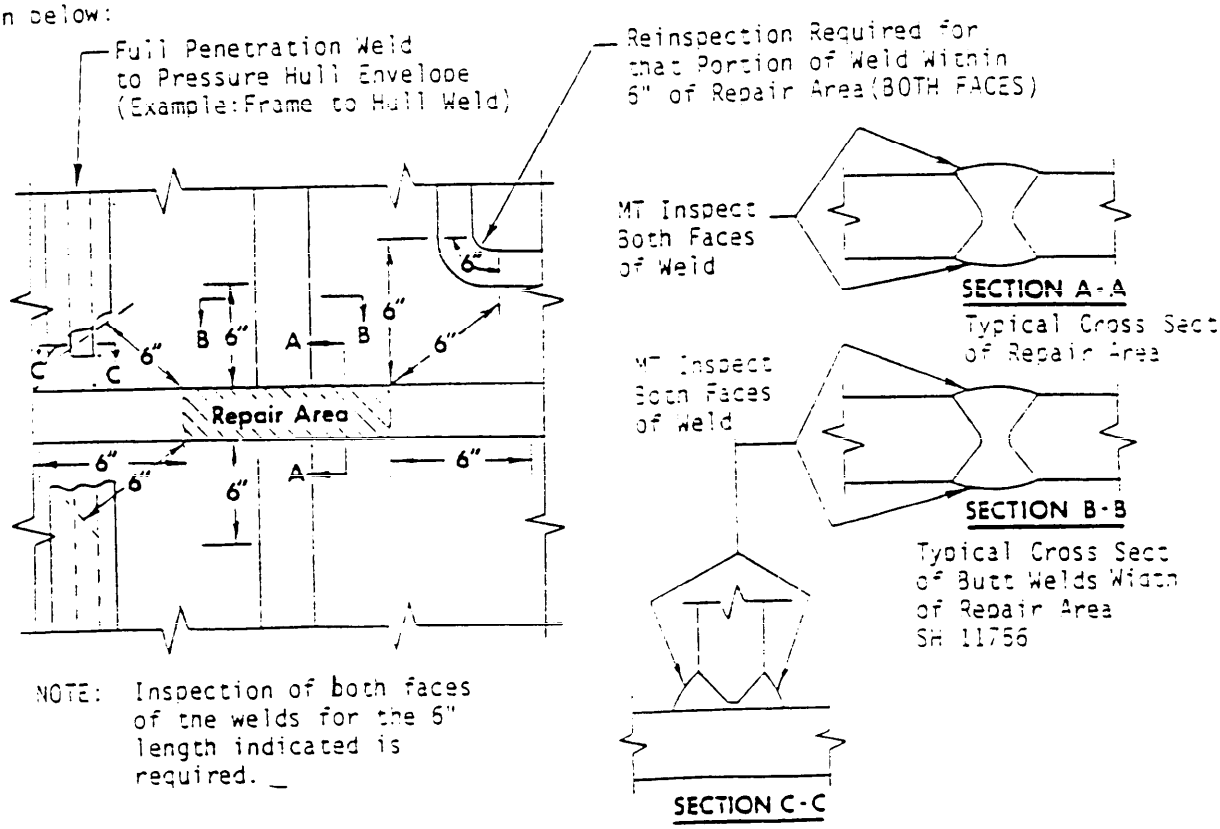


NOTE: Inspection of both faces of the welds for the 6 inch length indicated is required.

FIGURE 10. MT inspection requirements for repair of full penetration welds in the pressure hull envelope where the total repair depth is greater than 1/3 T but less than or equal to 2/3 T.

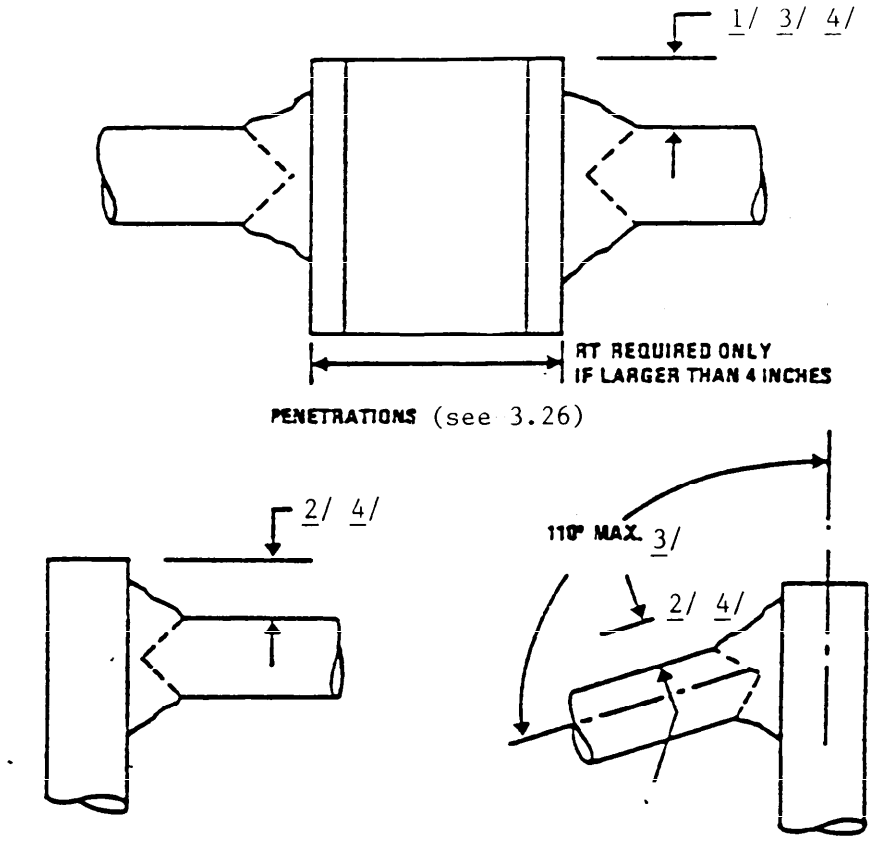


As shown in the above sketch, the excavation depth was greater than 2/3 the plate thickness. Reinspection requirements are as shown below:



NOTE: Inspection of both faces of the welds for the 6" length indicated is required.

FIGURE 11. MT inspection requirements for repair of full penetration welds in the pressure hull envelope where the total repair depth is greater than 2/3 T.



OTHER THAN PENETRATIONS

1/ RT is required when the designed projection is less than or equal to 1 inch for the full circumference of the penetration (see 11.5.2).
2/ RT is required when the designed projection is less than or equal to 1 inch for the full length of the weld (see 11.5.2).
3/ RT or UT is not required for that portion of the weld where the design angle exceeds 110 degrees.
4/ When the design projection is greater than 1 inch at any point along the circumference or weld length, the joint shall be UT volumetrically inspected in accordance with 6.8.4.

FIGURE 12. Application examples of table III, category I.A.2.

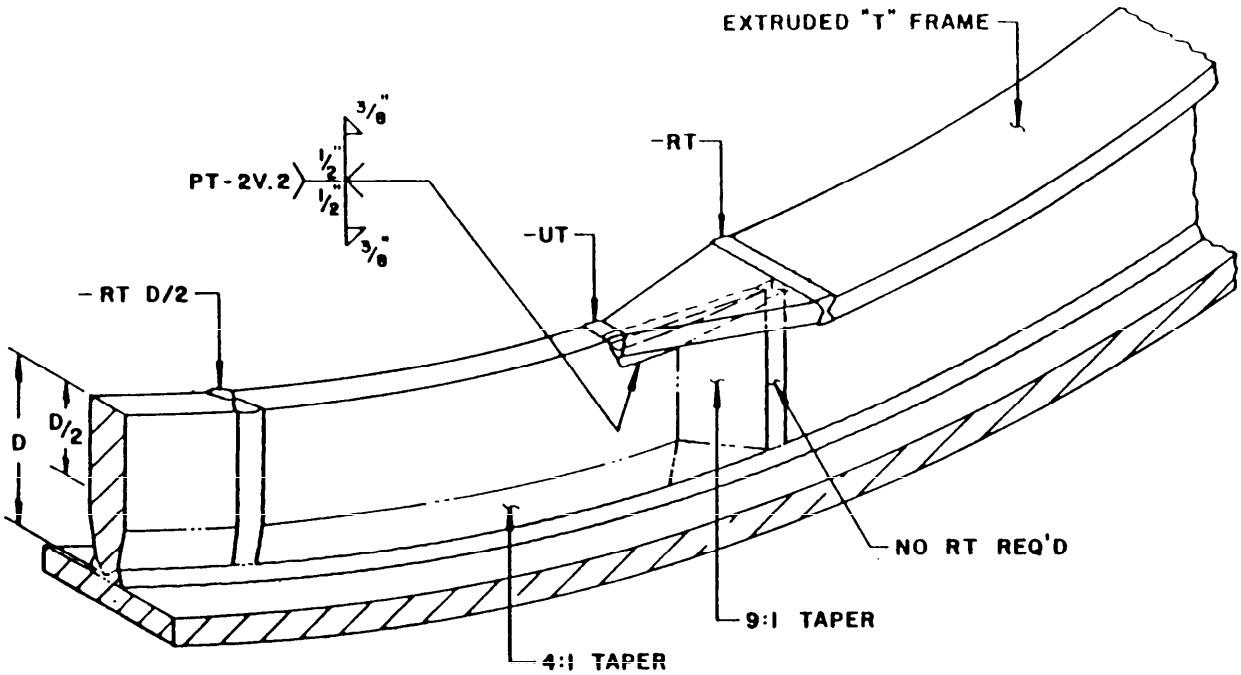
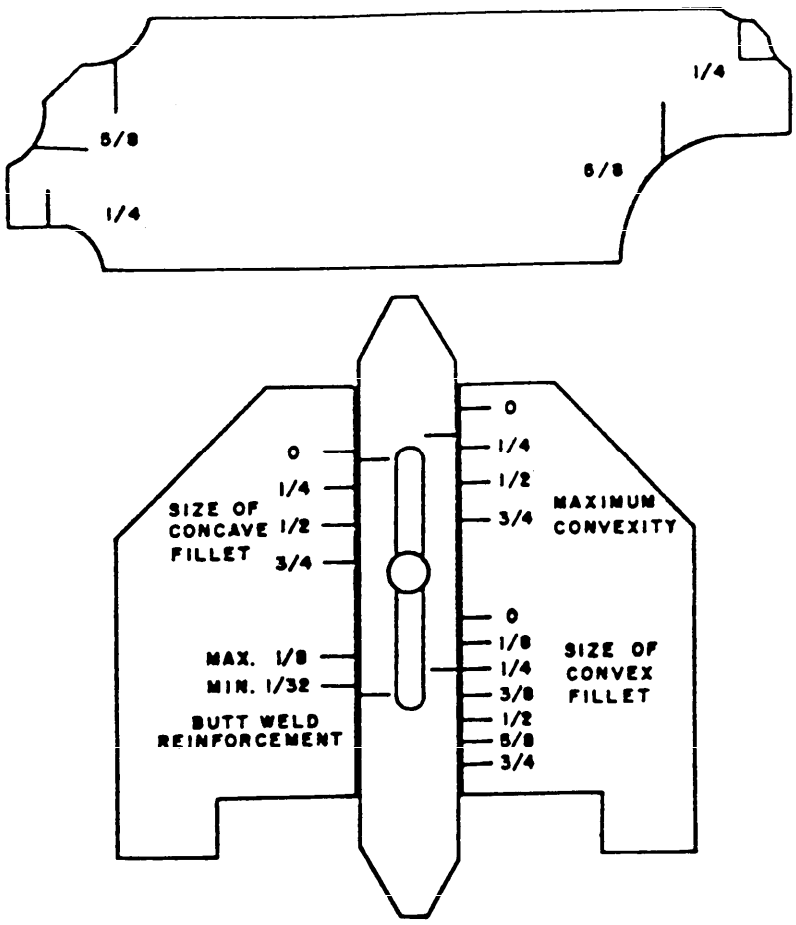
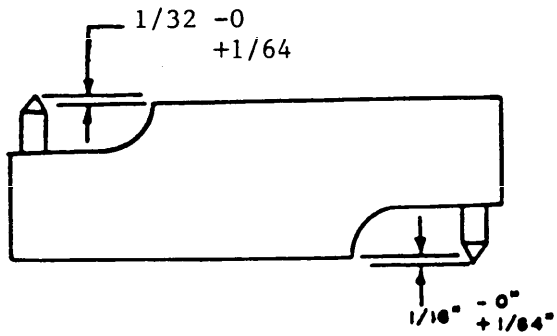


FIGURE 13. RT/UT requirement for flanged to unflanged frame transitions.



TYPICAL WELD REINFORCEMENT GAGES



UNDERCUT DEPTH GAGE

FIGURE 14. Typical gauges.

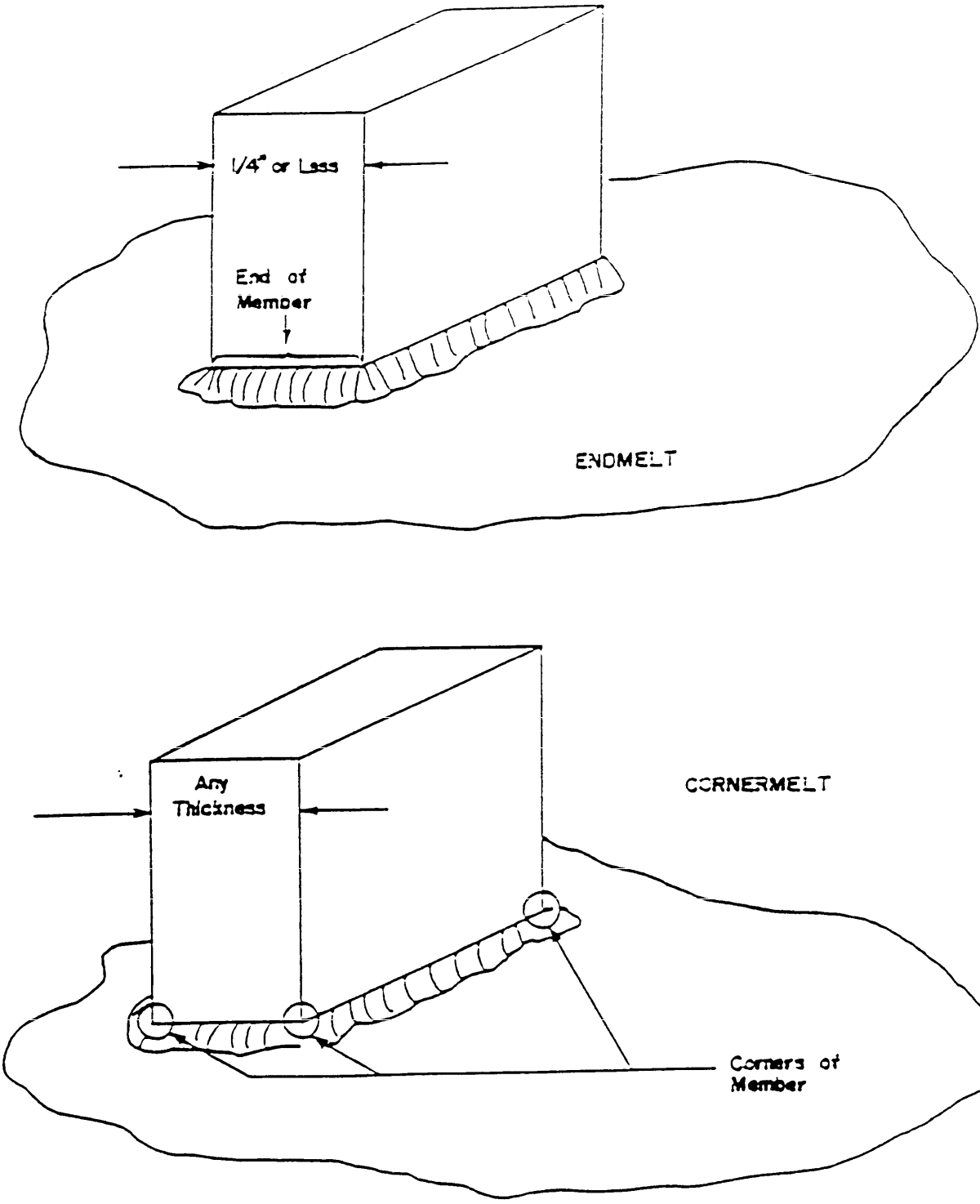
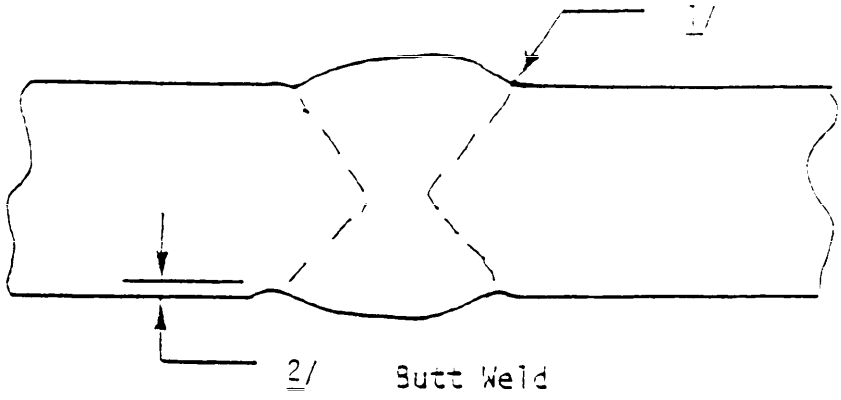
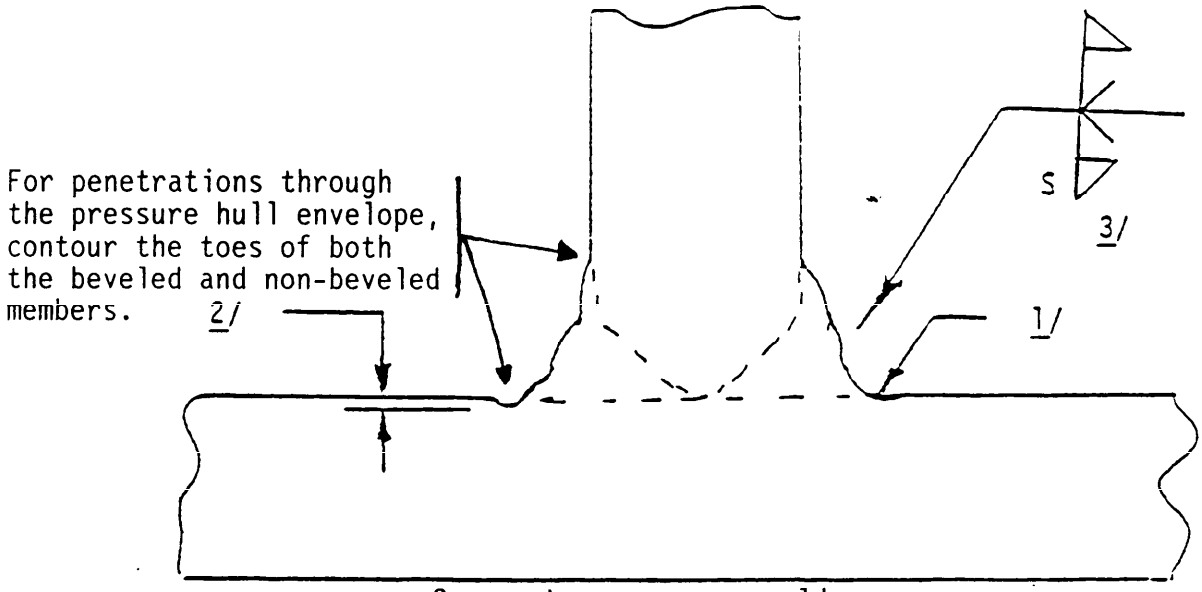


FIGURE 15. End-melt and corner-melt.





Groove tee or corner weld

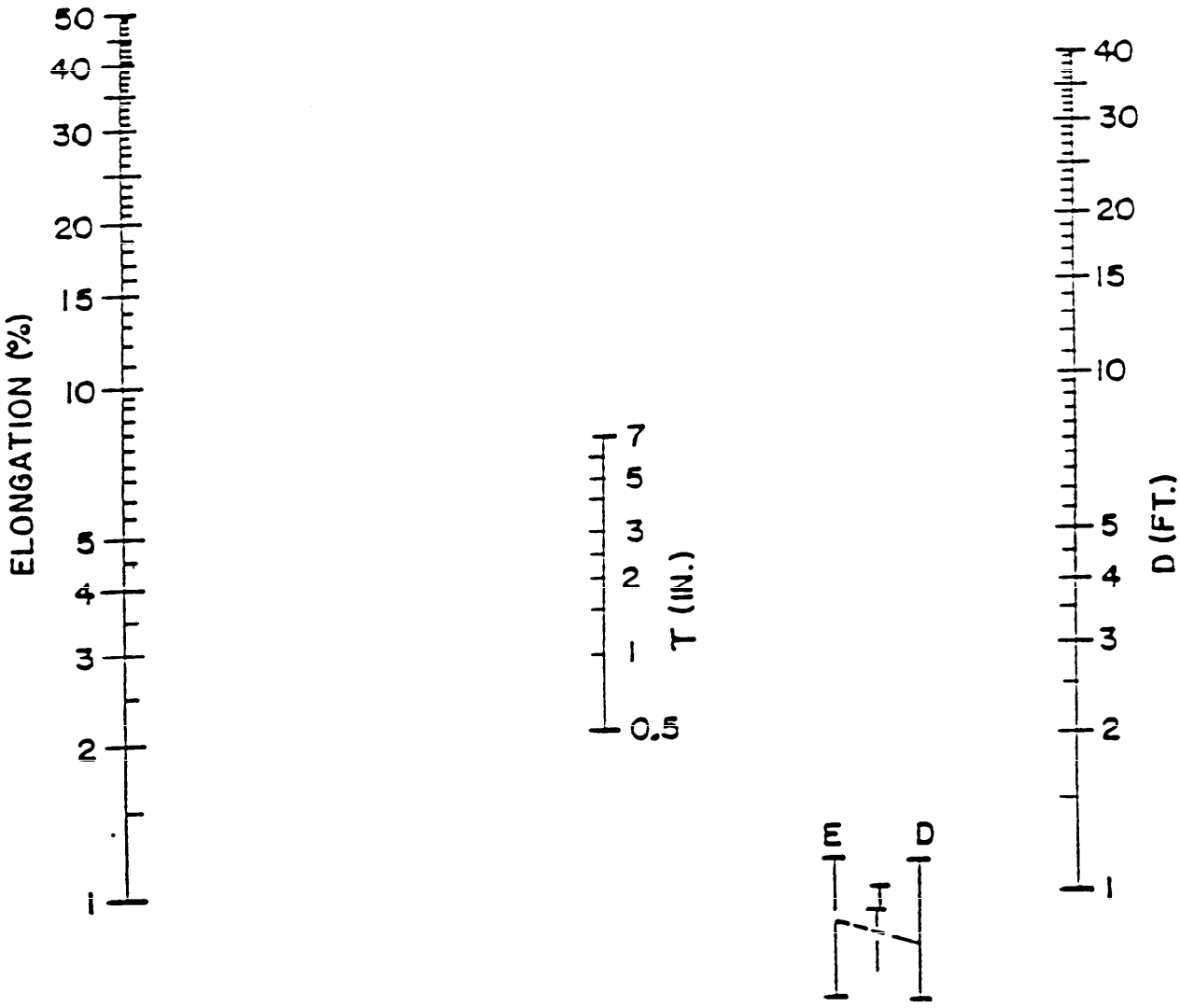
Notes:

1. The weld edges shall blend smoothly into the base material whith no sharp notches.

2. Finished depth of contour below plate surface shall not exceed 3/64 inch, or 5/64 inch provided the length does not exceed 12 inches in any 36 inch length of ground length.

3. S is the required fillet reinforcement. For full penetration groove tee and corner welds, maintain 1/3 "S" minimum after contour grinding. In this case the minimum throat thickness of 7.4.4 need not be maintained.

FIGURE 16. Contoured weld requirements.

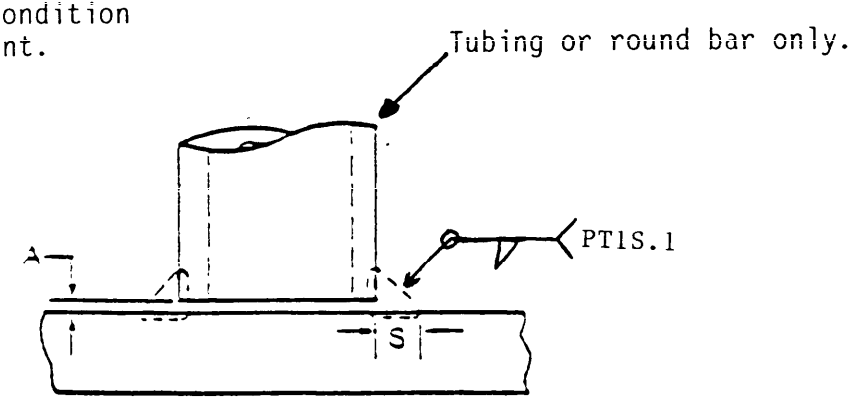


$$E = \frac{100\ T}{12\ D}$$

where E is elongation (outside) (percent),
T is plate thickness (inches), and
D is inside diameter (feet) + T (to neutral axis).

FIGURE 17. Nomograph of outside surface elongation after bending or rolling.

A = 3/16 inch maximum
as a nominal condition
around the joint.

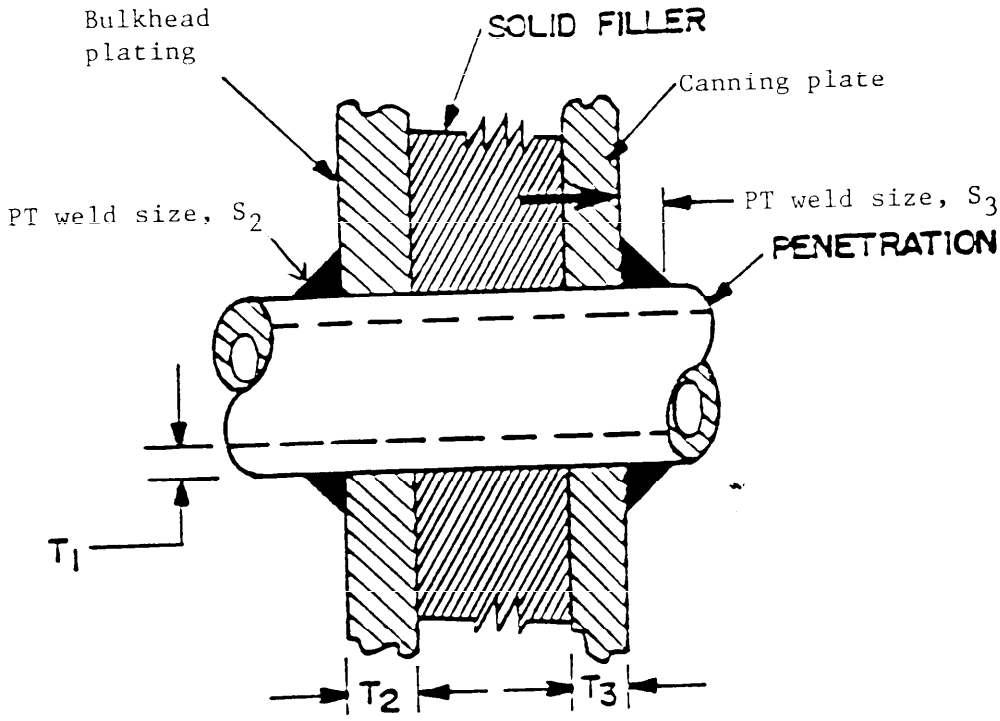


See Notes 1 and 2.

NOTES:

1. Efficiency and strength of double fillet welds shall be based on MIL-STD-1628 with provision made to proportionally increase the size of single fillet welds.
2. Where A is greater than 1/16 inch, S equals required fillet size plus A.

FIGURE 18. Single fillet tee joint.



Notes:

1. Welds (S_2 and S_3) shall be 100 percent efficient per MIL-STD-1628 (size doubled as appropriate for one-sided weld) based on the thickness of the weaker member (T_1 or T_2 for S_2 and T_1 or T_3 for S_3) when bulkhead and canning plate are both structural. Weld S_3 may be 50 percent efficient when canning plate is non-structural.

2. A minimum efficiency of 50 percent is permitted where NAVSEA approved analyses/testing show that a less efficiency is adequate for a specific application.

3. The penetration sleeve is considered the continuous member for designing the welds.

FIGURE 19. Penetration through special sandwich bulkhead with solid filler.

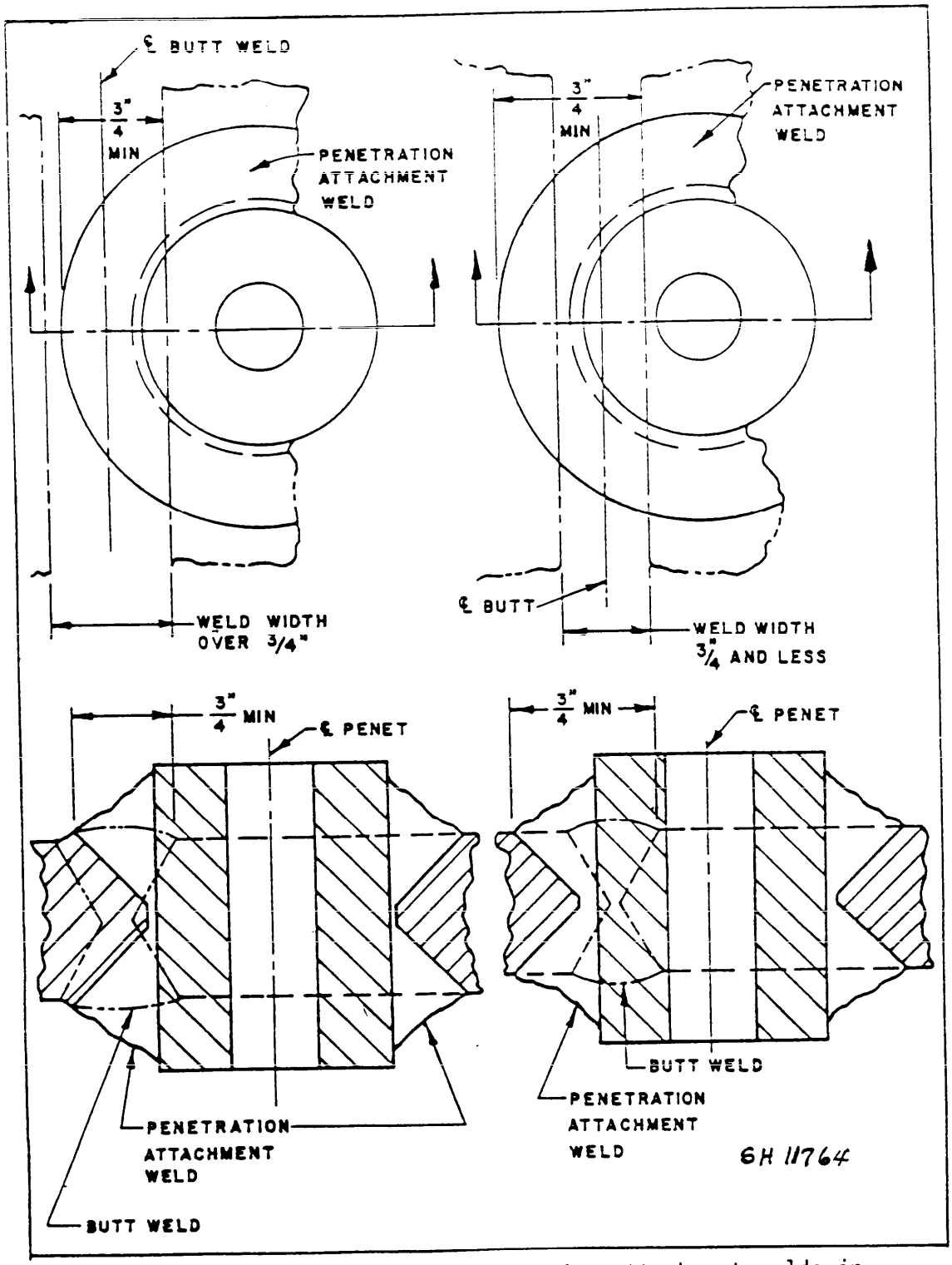
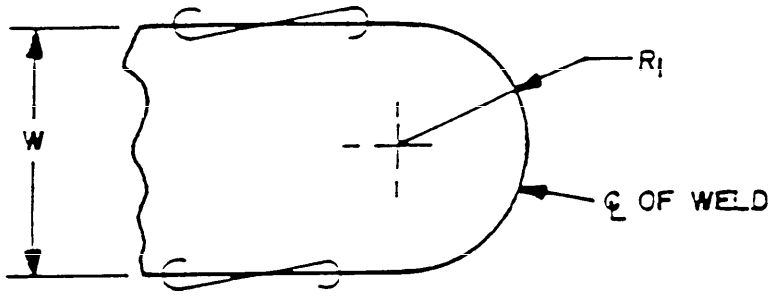
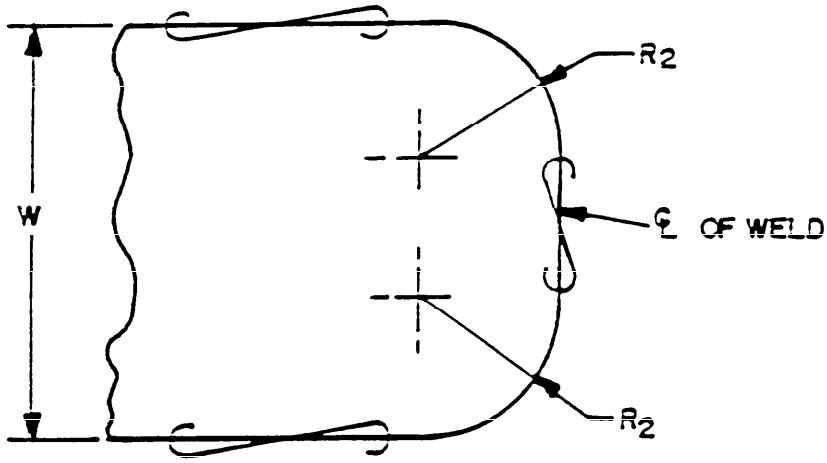


FIGURE 20. Locations of penetration attachment welds in relation to butts and seams.



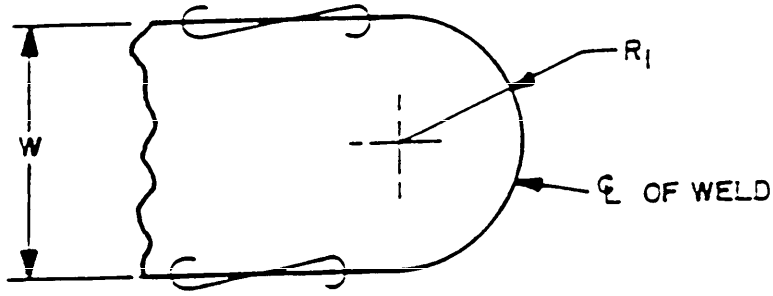
WHEN "W" = 6" MIN., 12" MAX.
THEN $R_1 = \frac{W}{2}$



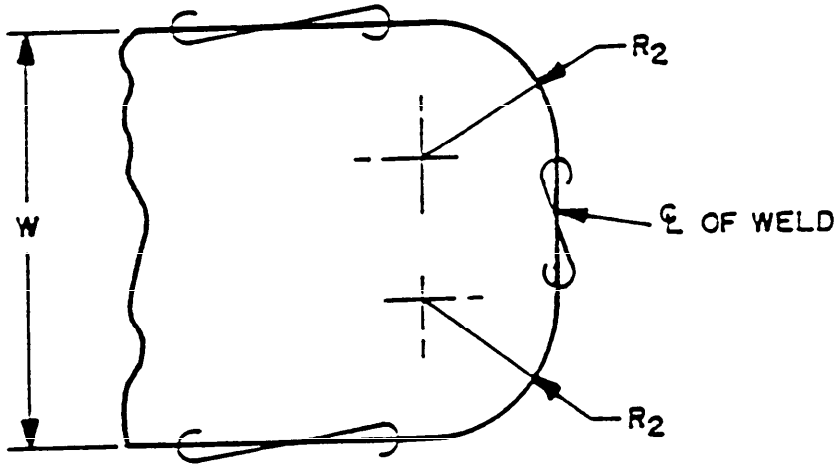
WHEN "W" = 12" MIN.
THEN R_2 = 6" OR 2T WHICHEVER IS LARGER

where T is the thickness of the member penetrated.

FIGURE 21. Inserts, patches and small access plates in pressure hull envelope.



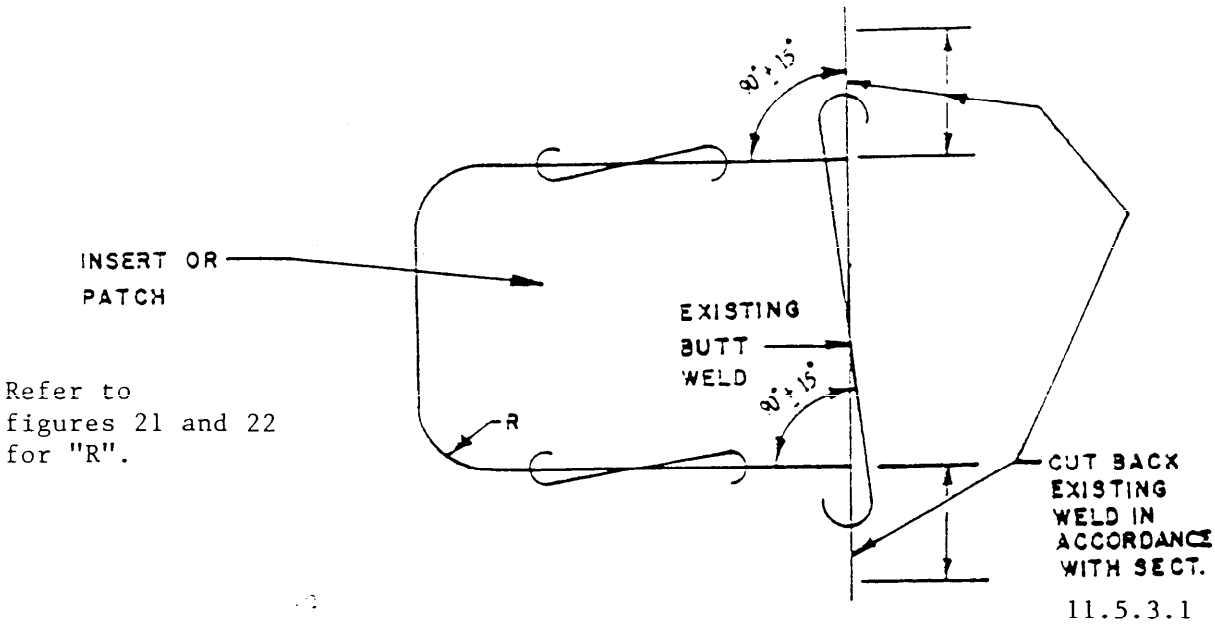
WHEN "W" = 3" MIN., 6" MAX
THEN $R_1 = \frac{W}{2}$



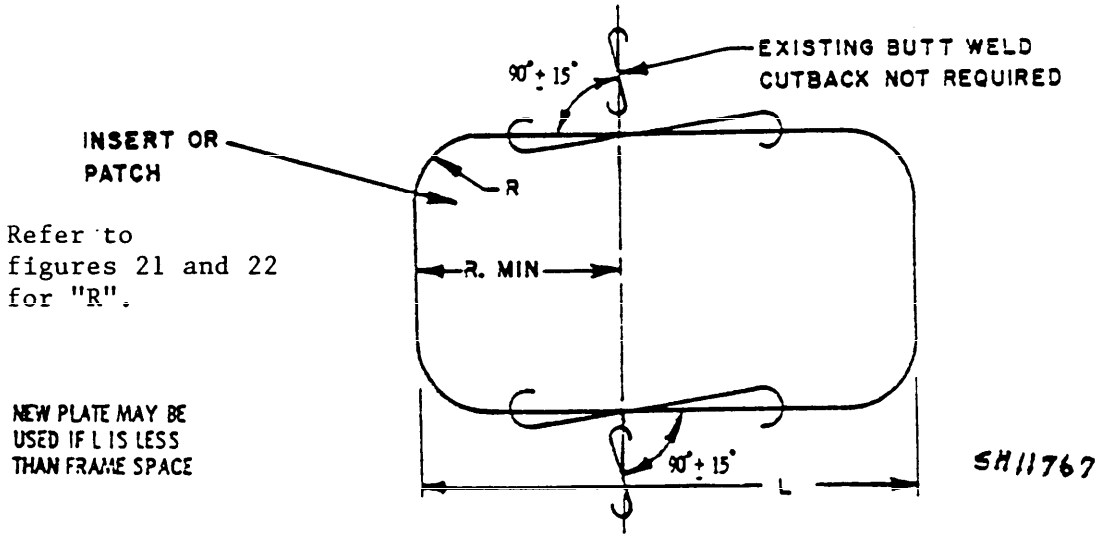
WHEN "W" = 6" MIN
THEN R_2 = 3" OR 2T WHICHEVER IS LARGER

where T is the thickness of the member penetrated.

FIGURE 22. Inserts, patches and small access plates in plating and structure other than the pressure hull envelope.

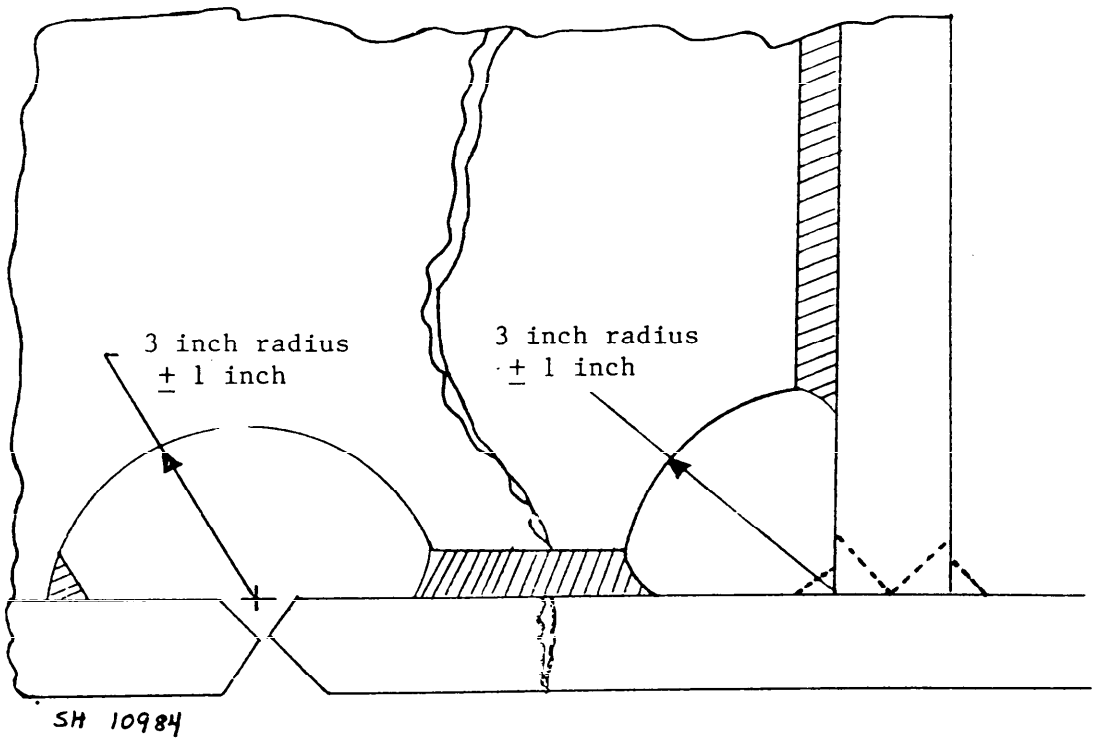


INSERTS, PATCHES OR SMALL ACCESS PLATES
WHICH LAND ON EXISTING BUTT WELDS



INSERTS, PATCHES OR SMALL ACCESS PLATES WHICH
CROSS EXISTING BUTT WELDS

FIGURE 23. Inserts, patches or small access plates in pressure hull envelope which land on or cross existing butt welds.



Note:

1. Close off end end of opening with a 3/8 inch fillet weld.

FIGURE 24. Drain, vent or permanent snipe opening.

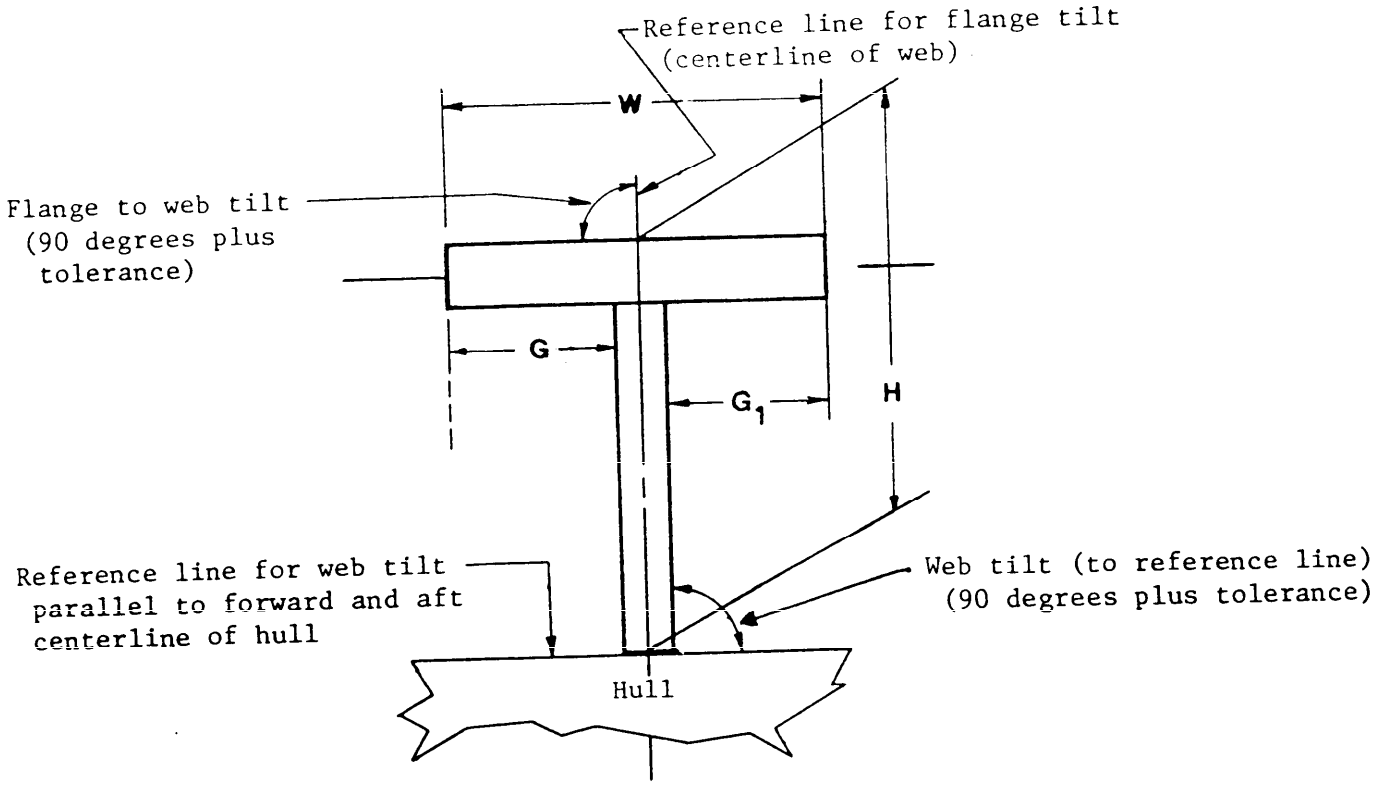
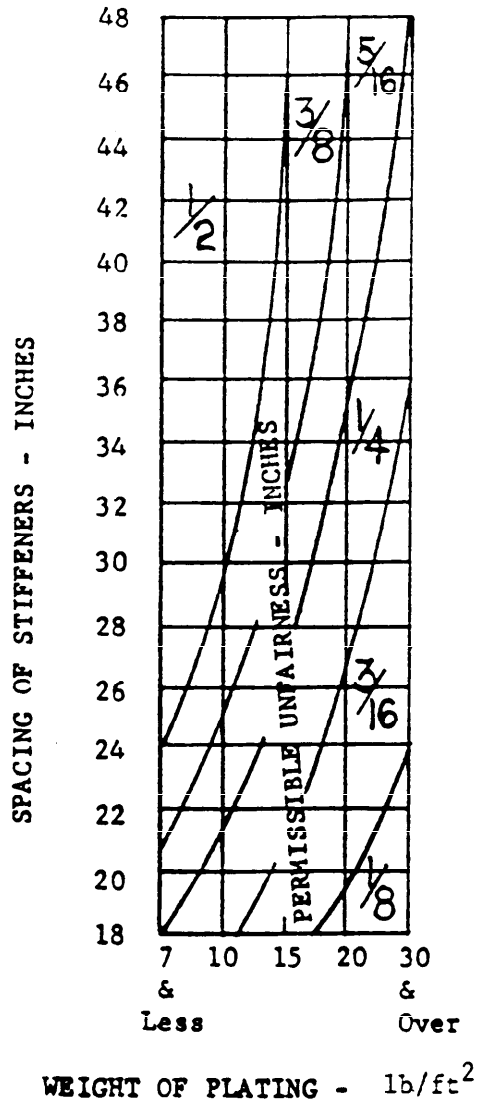


FIGURE 25. Pressure hull frame tolerances.



Note:

1. In applying the above tolerances, the unfairness of the plating shall be measured across the minor dimension of the panel.

FIGURE 26. Tolerance for unfairness of welded plate panels.

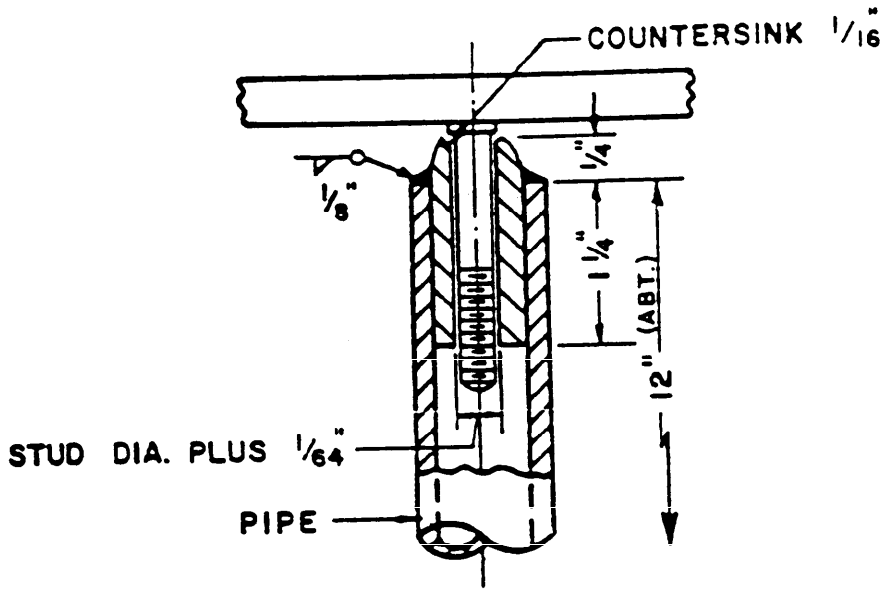
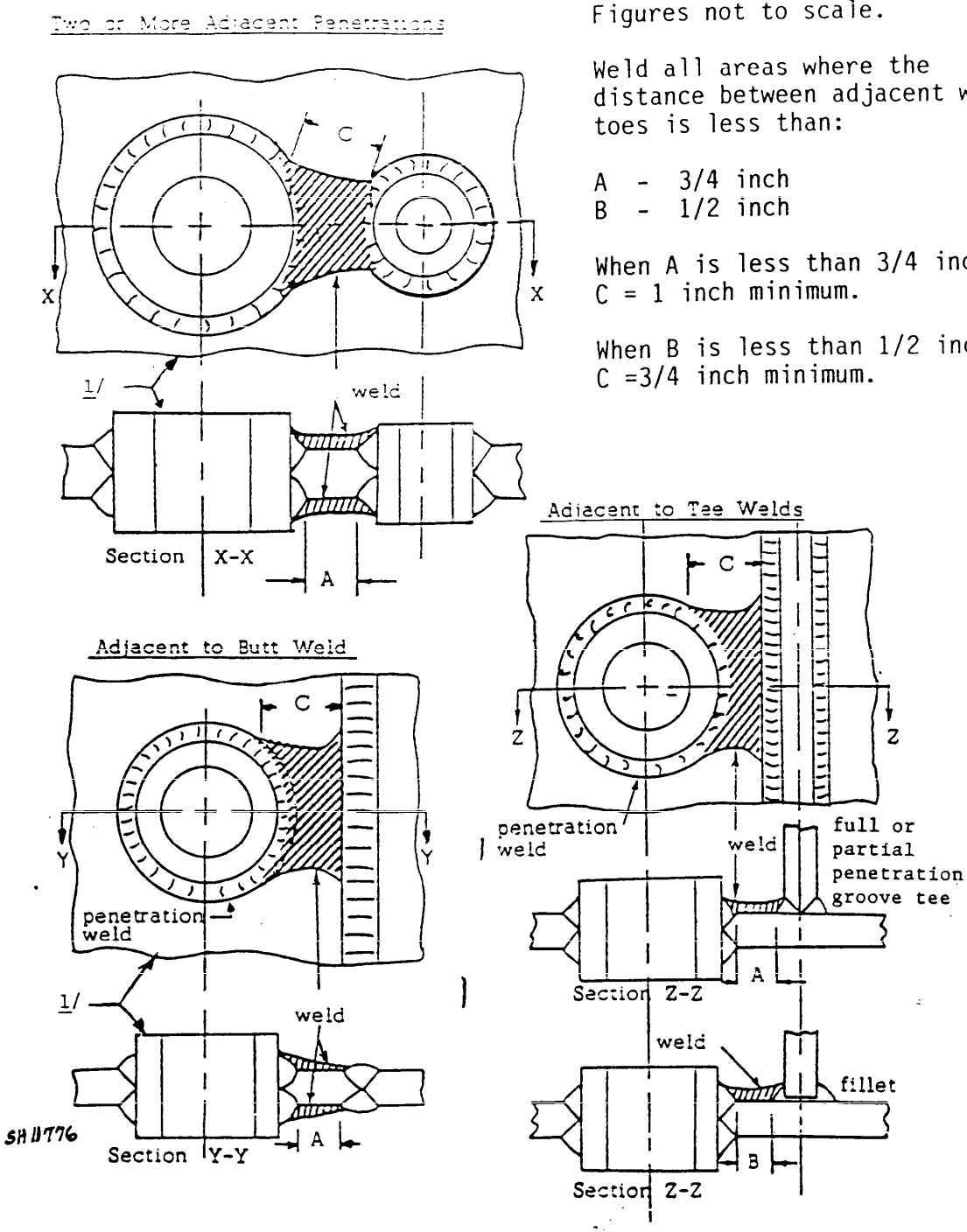


FIGURE 27. Device for bend testing welded studs.



Figures not to scale.

Weld all areas where the distance between adjacent weld toes is less than:

A - 3/4 inch
B - 1/2 inch

When A is less than 3/4 inch, C = 1 inch minimum.

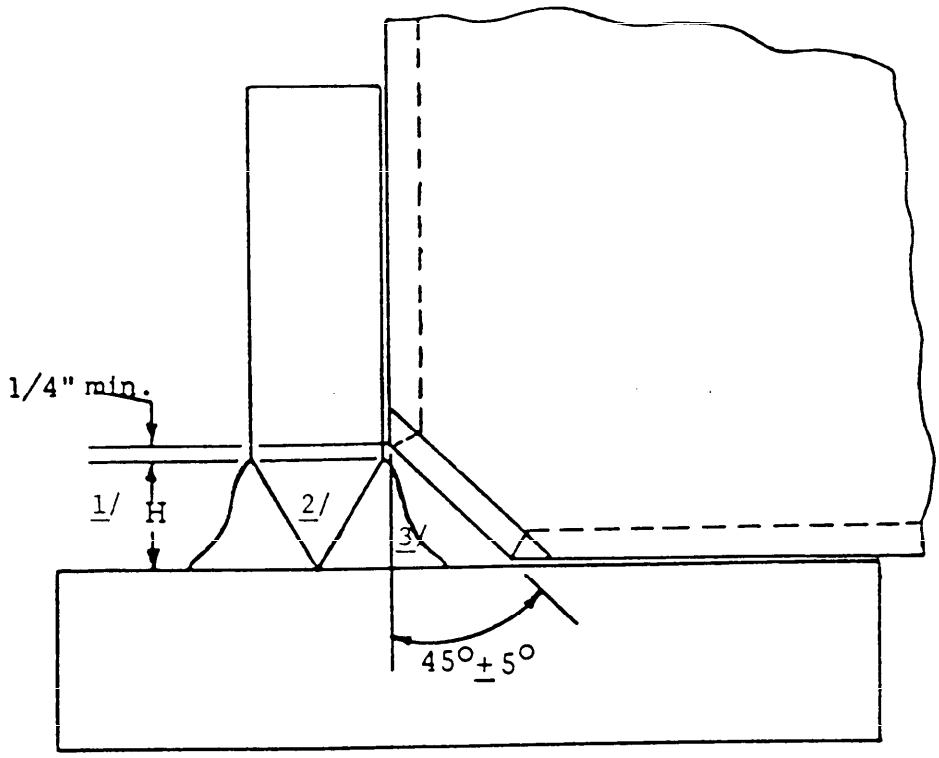
When B is less than 1/2 inch, C =3/4 inch minimum.

1/ Welding is required on side(s) of plating where toe-to-toe dimension is less than "A".

FIGURE 28. Method of welding between adjacent penetrations.

oximately parallel to the d Any single linear indication lying appr

Figure not to scale.



Notes:

1. Height of the snipe (H) shall be such that the corners of the snipe clear the intersecting weld preparation at least 1/4 inch as shown above.

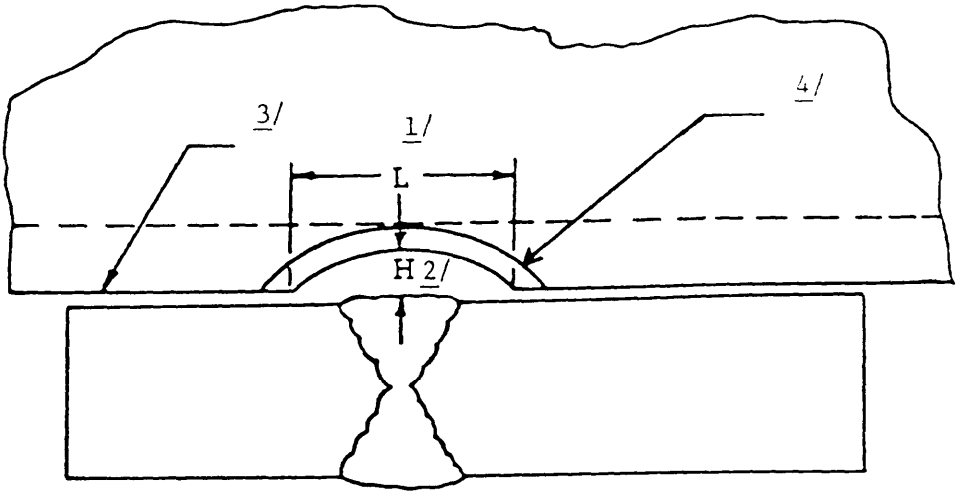
2. The snipe shall be shaped and beveled as required to provide adequate accessibility for welding.

3. All access snipes shall be welded unless otherwise indicated by design requirements. The maximum buildup limitation may be increased to 1-1/2 inches for welding up snipes.

FIGURE 29. Temporary snipe in corner of connecting structural member which intersects two or more other members.

gated to 1/2 inch or less 12) until the indication length is re

Figure not to scale.



Notes:

1. Length of snipe opening (L) shall be at least 1/2 inch longer than width of butt weld which it crosses.

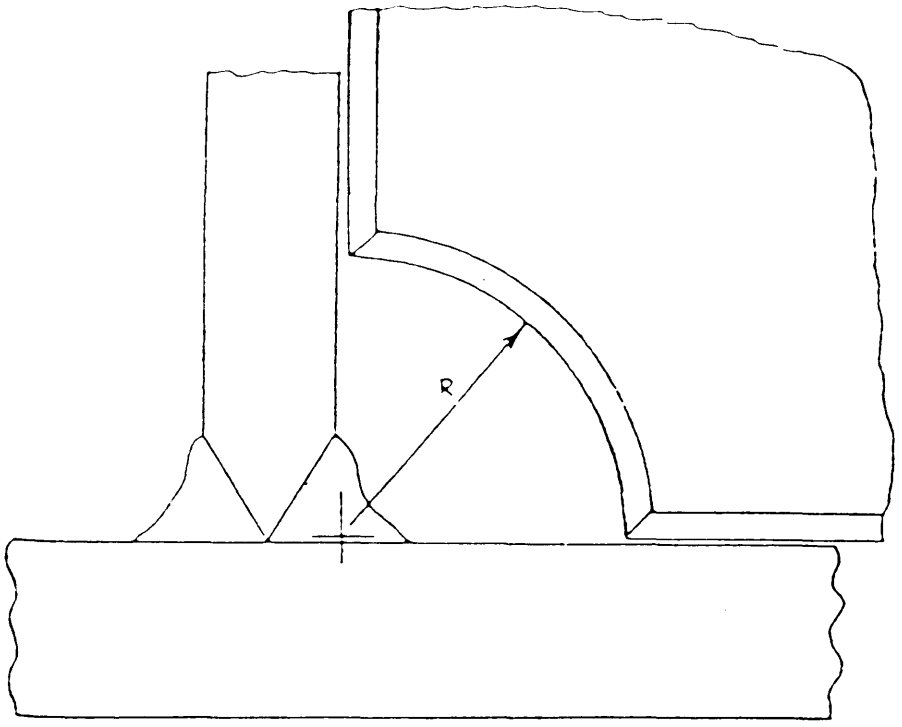
2. Height of snipe opening (H) shall be adequate to provide accessibility for welding but not less than 3/16 inch.

3. When design of the crossing member calls for snipe edge joint preparation, the edges of the snipe shall be beveled as required to provide adequate accessibility to the butt. The edges of the snipe shall be beveled to "fair in" with the plate edge preparation bevel.

4. All access snipes shall be welded unless otherwise indicated by design requirements. The maximum buildup limitation may be increased to 1-1/2 inches for welding up snipes.

FIGURE 30. Temporary snipe in structural member connection crossing a butt weld.

Figure not to scale.



Notes:

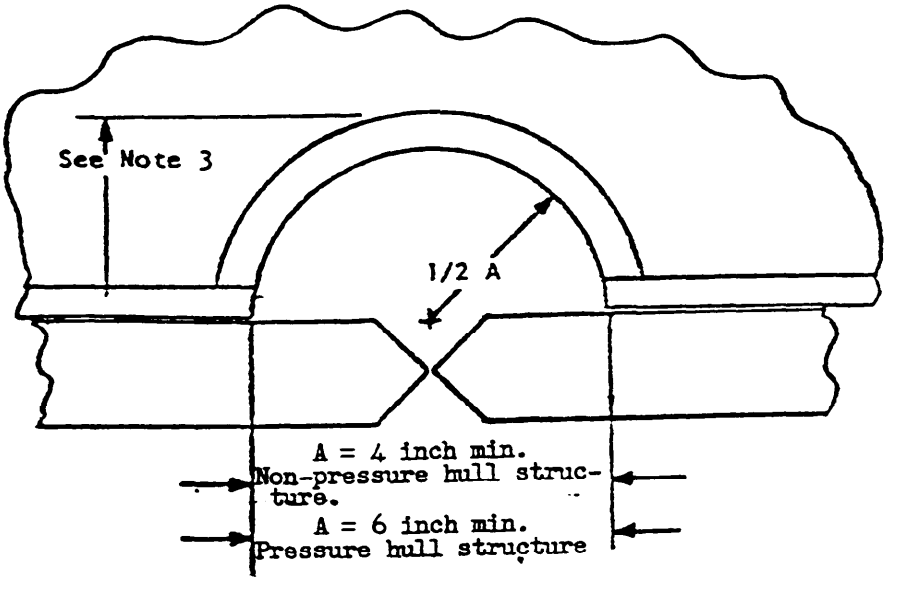
1. The radius of the temporary snipe shall be 2 inch minimum in non-pressure hull structure and 3 inch minimum in pressure hull structure.

2. Regardless of whether design of the sniped member specifies beveled or square edge preparation, the snipe shall be beveled as shown to insure maximum accessibility for welding.

3. The snipe shall be closed during welding of the periphery of the members in which they occur. A patch plate is required.

FIGURE 31. Typical temporary snipe in corner of connecting structural member which intersects two or more other members.

Figure not to scale.



Notes:

1. Temporary snipes shall be used for access for welding equipment where required to permit depositing sound welds in way of intersections.

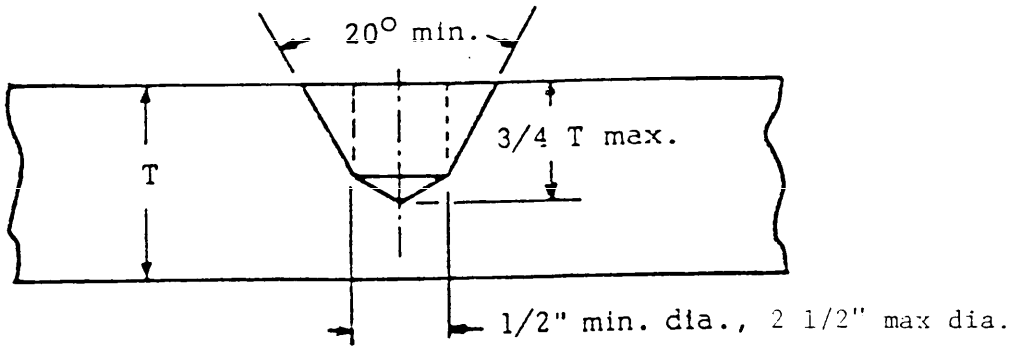
2. Temporary snipes shall be closed by installation of a patch plate. Full penetration welds shall be employed and all welding shall be in accordance with the requirements of section 13.

3. Where added height is required to provide access for the welding process being employed, the temporary snipe may be elongated by maintaining the specified minimum width and the 3 inch minimum radius at the upper end of the hole.

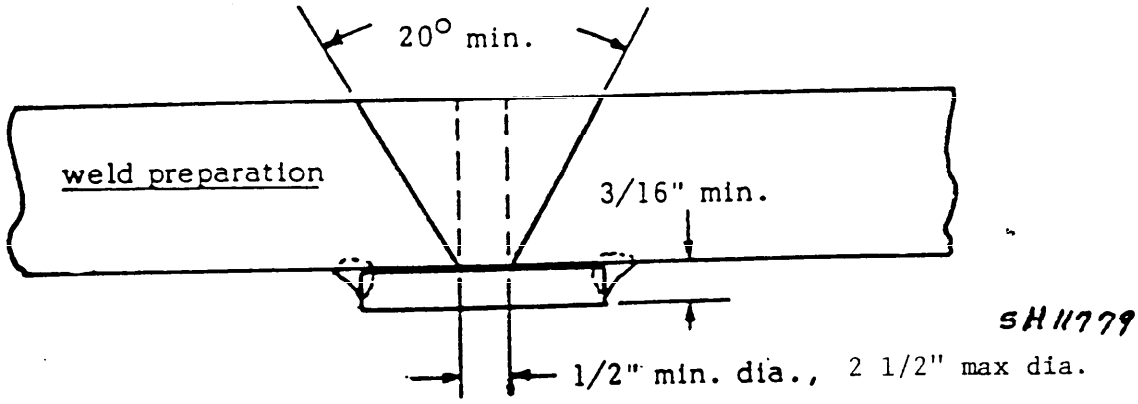
4. NDT for the temporary snipe weld shall be as specified in section 6 as applicable for the member involved.

FIGURE 32. Typical temporary snipe.

Figure not to scale.



Weld Preparation for Repair of Partial Penetration Hole

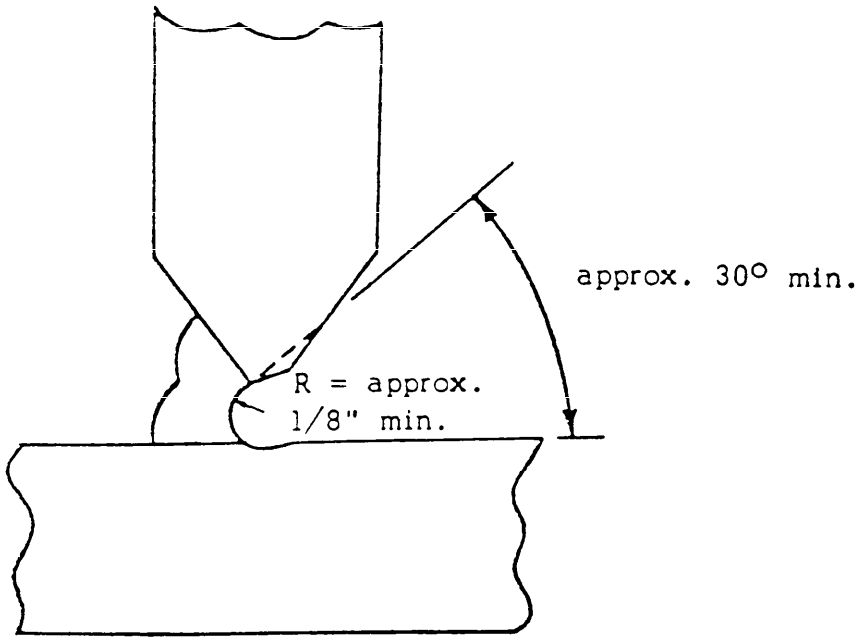


WELD REPAIR OF FULL PENETRATION HOLE

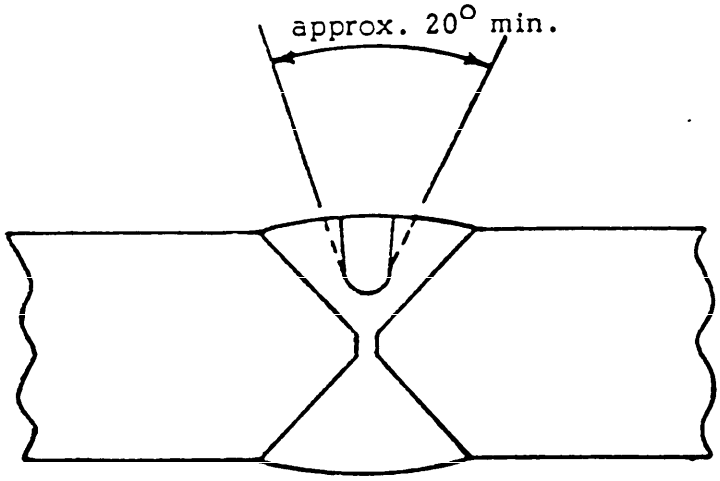
Note:

1. Repair of original hole diameters over 2-1/2 inch diameter shall be in accordance with 13.15.1.

FIGURE 33. Weld repair of holes.



Keyholing resulting from grinding or gouging. Additional metal should be removed as shown by dotted line to permit proper electrode accessibility and manipulation.



Excavation of weld metal for repair. Side walls of groove should be opened as shown by dotted lines before rewelding. Radius at bottom contour = approximately 1/8 inch minimum.

FIGURE 34. Weld root and repair excavation contours.

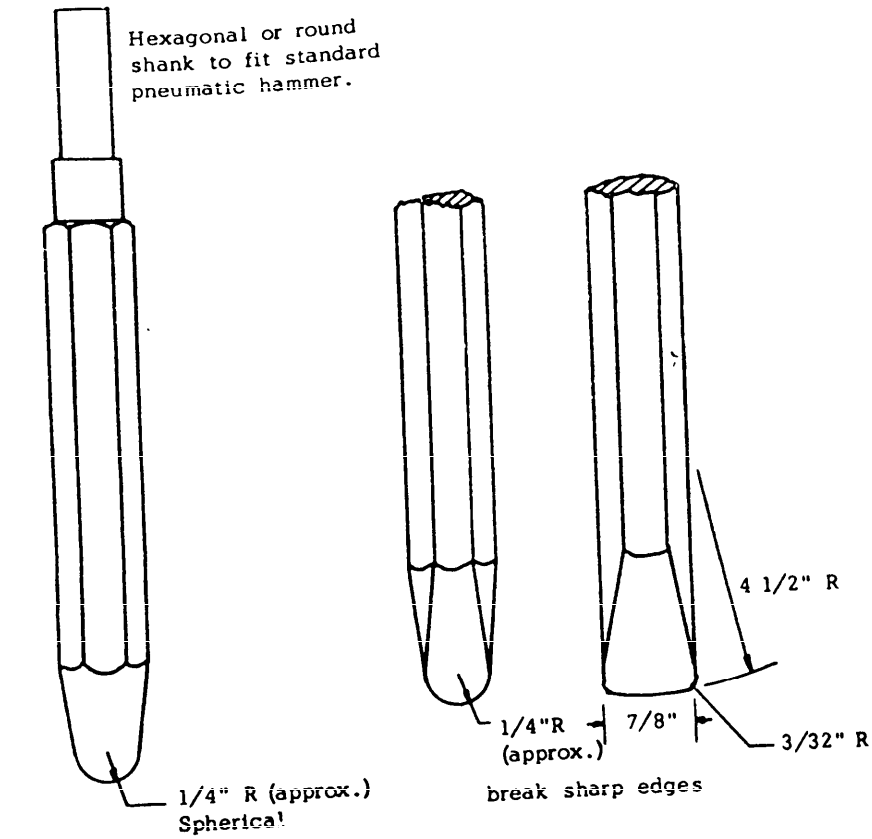


FIGURE 35. Suggested mechanical peening tools.

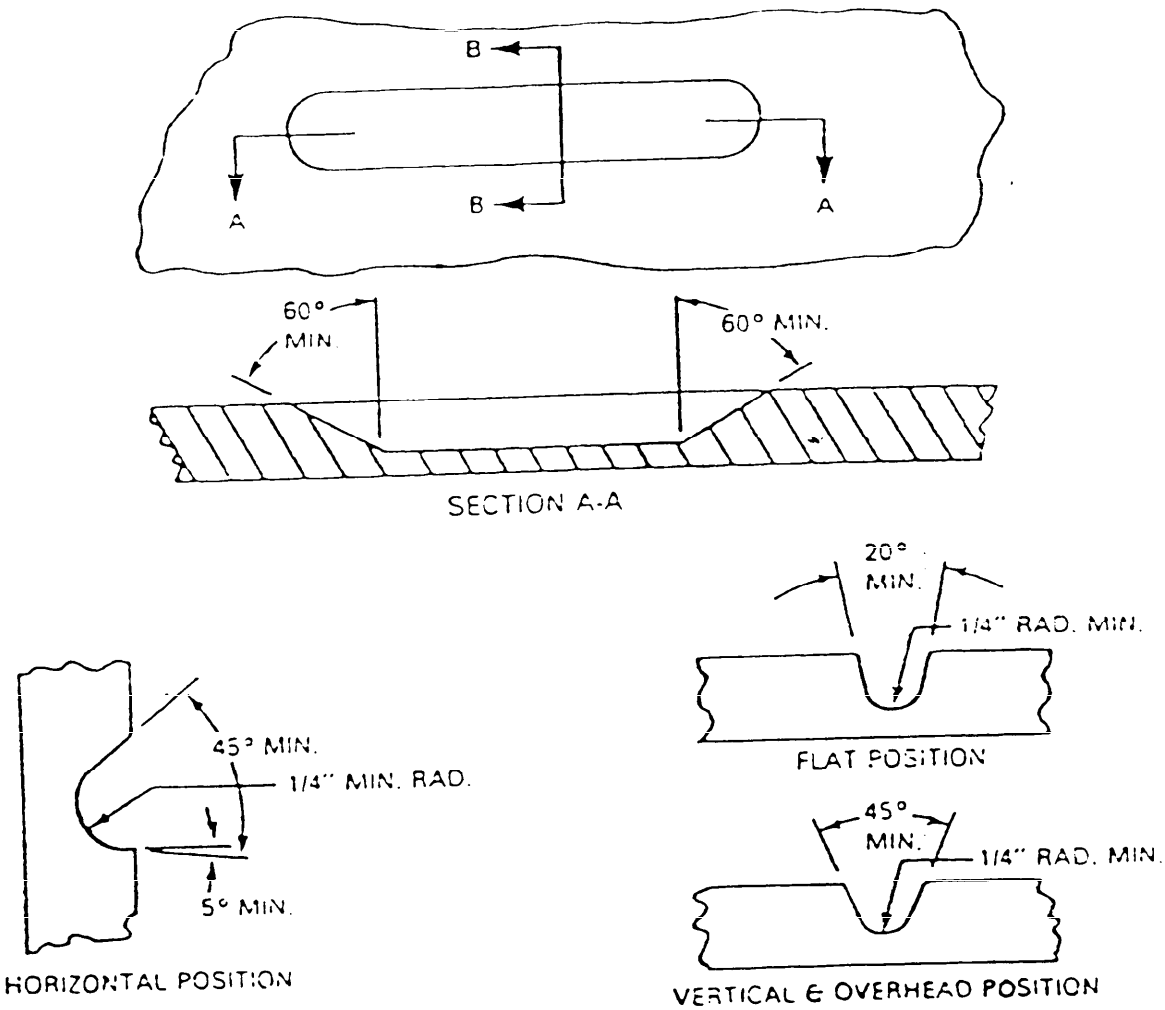


FIGURE 36. Typical weld repair configurations for castings.

inspection, and section 10 for weld

APPENDIX A

CERTIFICATION/DATA REPORT TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers information that shall be included in the certification/data report when specified in the contract or order. This appendix is mandatory only when data item description DI-MISC-80678 is cited on the DD Form 1423.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. DATA REPORT CONTENT

30.1 Circularity inspection. Circularity measurements made as required by 12.6 shall be forwarded to NAVSEA at time of delivery in a format similar to figures 6, 7, and 8.

30.2 Special weld repair of HY-80/100 castings. Requests for approval of any repairs in this category (see 16.5.3.4) shall be accompanied by a suitable sketch or photograph showing complete dimensional details, proposed welding and inspection procedures criteria, and, in addition, shall include a record of all previous repairs except minor repairs.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER	2. DOCUMENT DATE (YYMMDD)
	MIL-STD-1688A(SH)	15 DECEMBER 1990

3. DOCUMENT TITLE
FABRICATION, WELDING AND INSPECTION OF HY-80/100 SUBMARINE APPLICATIONS

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE (Include Area Code) (1) Commercial	(2) AUTOVON
Technical Point of Contact (TPOC) Mr. John Dorn (SEA 51421) PLEASE ADDRESS ALL CORRESPONDENCE AS FOLLOWS	TPOC: 703-602-0205	8-332-0205
c. ADDRESS (Include Zip Code) Commander, Naval Sea Systems Command Department of the Navy (SEA 55Z3) Washington, DC 20362-5101	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	