MARINE MECHANICS HANDBOOK

INT'L. BROTHERHOOD OF
BOILERMAKERS·IRON SHIP BUILDERS·BLACKSMITHS·FORGERS & HELPERS
AFFILIATED—AFL-CIO, CFL

BOILERMAKERS LOCAL #104

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INTRODUCTION

This handbook has been prepared and provided by the Boilermaker's Training Trust and Todd Pacific Shipyard in order to provide the marine mechanic with a ready source of information which can be carried with him/her on the job. It is intended to provide useful information for the marine mechanic as well as apprentices / trainees new to the shipbuilding industry. This handbook is not intended to be a Code or Construction Rules Manual. The use of information in the this handbook may vary with different employers and is subject to change as revisions to codes and/or individual job requirements are made.

1.0
SAFETY

1.1 SAFETY AND HEALTH POLICY FOR TODD PACIFIC SHIPYARD

The purpose of this policy is to develop a high standard of safety throughout all operations of Todd Pacific Shipyards and to assure that no employee is required to work under any conditions which are hazardous or dangerous.

We believe that the individual employee has the right to derive personal satisfaction from their job and the prevention of occupational injury or illnesses of such consequence to this belief that it will be given top priority at all times.

It is our intention at Todd Pacific Shipyards to initiate and maintain complete accident prevention and safety training programs. Each individual from top management to the working person, is responsible for the safety and health of those persons in their charge and co-workers around them. By accepting mutual responsibility to operate safely, we will all contribute to the well being of personnel.

1.2 GENERAL

1.2.1. Todd employees are not permitted to engage in asbestos ripout. Cutting, burning or grinding on materials containing asbestos and/or lead is prohibited unless given specific authorization to do so -- and then only when proper precautionary measures have been taken. If you suspect that the material you are working with contains asbestos and/or lead, notify your supervisor or the Safety Department.

1.2.2. Never enter a closed tank or void until it has been tested and proven safe for entry. Pay particular attention to information on tags and notices posted at entrances to tanks, voids, compartments, etc. Look for -- and read -- the Marine Chemist Certification or Tank Entry Permit.

1.2.3. Safety locks or tags shall be removed immediately, when no longer needed, only by the person who put them in place. Emergency removal may be accomplished under the direction of the employee's supervisor.

1.2.4. If working on a naval vessel, be sure you are familiar with Navy tag out procedures in addition to Todd procedures.

1.2.5. Inert gas (i.e., argon, helium, nitrogen, CO2, etc.) used for testing and purging various ship's systems, displaces oxygen when allowed to escape into closed areas. These gases are odorless and difficult to detect without instruments. Exposure to heavy concentrations of inert gas can bring about unconsciousness and death in a short time. Workers in the vicinities of such inert gas operations should be closely supervised with frequent checks by the lead person. This will minimize the possibility of a casualty in a non-life supporting atmosphere. Access to and use of inert gas shall be restricted to trained, authorized employees. Its use shall be in accordance with current instructions. All inert gas connections should be inspected by a competent person with the appropriate oxygen meter for detecting leaks.

1.3 PERSONAL APPAREL

1.3.1. All employees shall wear clothing suitable for the safe and efficient performance of their work.

1.3.2. Keep work clothing clean. Dirty clothes are a menace to health as well as a fire hazard if oily.

1.3.3. Never put oil-soaked clothing or rags in lockers; they can ignite spontaneously.

1.3.4. All employees should wear shoes with soles and heels in good repair. Shoes worn by employees in the industrial area shall have uppers of substantial leather construction with no cut out areas and heels no higher than medium height. Employees whose duties include climbing ladders should wear shoes with a clearly defined heel. Safety shoes or metal toe caps shall be worn in posted toe hazardous areas. Tennis or deck shoes with canvas or other insubstantial upper portion, or soft leather running shoes, shall not be worn in the industrial area.

1.3.5. Employees exposed to hot sparks or molten metals should wear hard cloth, leather or woolen clothing. Care should be used when selecting clothing made of synthetics. Select a synthetic with a low flammability factor, as some synthetics will burn extremely fast when exposed to hot sparks or molten metals.

1.4 PROTECTIVE EQUIPMENT

1.4.1. Approved hard hats shall be worn by all shipyard personnel working or performing duties aboard ships, in dry-docks, and in all areas of the shipyard.

1.4.2. Approved protective eye wear shall be worn by all employees working aboard all ships, in all production areas of the shipyard, and in posted eye-hazardous areas and piers. Face shields shall be worn in addition to safety glasses when grinding, chipping, or working with chemicals.

1.4.3. Keep goggles clean. Cleaning stations installed at tool rooms are equipped with lens wiping and anti-fog compound.

1.4.4. All persons doing work involving gas welding, burning, silver brazing, or other operations involving exposure to radiation shall wear filter lenses of proper shade. For brief exposure, side shield eye protection fitted with clear lenses normally affords adequate protection to personnel working near or passing by such operations. Do not look at flame when fitted with clear lenses.

1.4.5. Do not breath fumes produced from welding, cutting/burning, or heating metals. Adequate ventilation must be provided as well as proper respiratory protection. This is especially important in enclosed or confined spaces.

1.4.6. Tool room attendants check the fit of your filter cartridge respirator and assign a model and size which best seals to your face. Always use the model and size assigned to you. Be sure the respirator you are wearing is suitable for the specific hazard. Check with your supervisor for information about proper respirator protection for special situations such as acids, gases and ammonia.

(a) Wear a DUST/FUME-type filter cartridge respirator when welding, burning, grinding, handling insulation materials, exposed to sandblasting dust, chipping red lead, etc.

(b) Wear an ORGANIC VAPOR-type filter cartridge respirator when exposed to paint and solvent vapors, tri-chloroethane, and other vapor-producing solvents.

1.4.7. Filter cartridge respirators provide adequate respiratory protection in most shipyard areas where the work area is open and well ventilated. A supplied air respirator may be required for adequate respiratory protection in confined spaces and tanks. Your supervisor will advise you when a supplied air respirator is required.

1.4.8. Never continue to work in a contaminated atmosphere if you suspect that your respirator is not working properly. Inspect the interior of the respirator face piece and the valve seats. Check to be sure that the face piece seals properly to your face by performing the negative and positive pressure check.

1.4.9. Exchange the respirator at least twice weekly; more frequently if you are in a high concentration of fumes or dust.

1.4.10. Remember that all filter-type respirators must fit properly to the face to ensure that they are performing properly. Check with the Safety Inspector or the Tool Room to verify that your respirator seals on your face. Workers with a beard cannot be fit and cannot be assigned in work areas where toxic dusts, fumes and vapors exist.

1.4.11. A safety harness with properly secured lifeline (lanyard) shall be worn while working on hanging staging and at elevations where lack of handrail or other protection presents the hazard of falling. Always check the condition of safety harness before use.

1.4.12. Employees working from gangways, manlifts, manbaskets or similar type working platforms that are suspended from cranes, are required to wear safety harness. The attached safety line (lanyard) must be secured to the railing or to the block above the hook.

1.4.13. Life jackets shall be worn when working in small boats or over water at all times.

1.4.14 . Only employees who have been specially trained and certified to operate hydraulic manlift vehicles will be permitted to do so.

1.4.15. Employees working in posted noise hazardous areas shall wear approved hearing protective devices, i.e. earplugs. Personnel who are passing through such areas or whose duties require only brief exposure are not required to wear hearing protection. Rule of thumb -- ear protection is required when normal speaking voice cannot be heard from a distance of one foot.

(a) Noise hazardous areas and/or occupations requiring ear protection:
   (1) All areas within 50 feet of operations involving chipping, riveting, grinding, caulking, sandblasting, and use of pneumatic tools.
   (2) Ships on which significant non-localized chipping, riveting, caulking, grinding or sandblasting, are taking place, or in areas in which large numbers of ventilation blowers are concentrated.
   (3) All buildings, areas, and equipment designated and posted as NOISE HAZARDOUS.

1.4.16. Safety toe shoes shall be worn by all employees working in posted foot hazard areas.

1.5 LADDERS AND SCAFFOLDS

1.5.1. Stepladders over 6' in length shall be equipped with safety feet.

1.5.2. Don't overreach when working from a ladder. Do not stand with one foot on a ladder and the other foot on a box, bucket, guardrail, bench, etc.

1.5.3. When necessary to place a ladder in front of a doorway, the door shall be locked or guarded.

1.5.4. Items not made for the purpose of standing on (i.e.,, barrels, boxes, chairs, buckets, crates, etc.), shall not be used in place of stepladders or portable steps.

1.5.5. Staging and scaffolding shall be rigged and unrigged only by shipwrights.

1.6. ELECTRICITY

1.6.1. Only qualified persons duly authorized shall make repairs to or work on electrical equipment. Securing regulations shall be observed.

1.6.2. All electrical wires must be considered live until proven they are not.

1.6.3. Be sure proper tag out and/or lock out procedures are followed when working on electrical equipment.

1.6.4. Keep out from behind power panels unless authorized to enter.

1.6.5. Steam, water, or oil leaks near electrical equipment shall be reported immediately to the supervisor.

1.6.6. Working surfaces shall be kept dry when working with or near electrical apparatus.

1.6.7. Electrical equipment or machines with frayed or deteriorated insulation shall not be used.

1.6.8. Material or gear shall not be hung on switchboards, welding machines, transformers or resistors or left near enough to obstruct ready access to this equipment.

1.6.9. All power panels shall be labeled with the voltage and shall be identified as to the equipment being operated.

1.7 COMPRESSED AIR

1.7.1. Use compressed air only for air tools, except when directed by your supervisor.

1.7.2. A stream of compressed air shall never be directed at any part of your body or another employee's body. This could cause a serious or even fatal injury.

1.7.3. When using a stream of compressed air for any authorized purpose, protect your eyes with safety goggles and see that personnel in the vicinity are not endangered.

1.7.4. Always shut off air at the manifold and bleed the air hose at the completion of the job.

1.7.5 Welding, heating, or cutting on a compressed air tank or other pressure vessel is not permitted without specific approval of the Welding Engineer. Pressure vessel work is governed by the ASME Boiler and Pressure Vessel Code.

1.8 EMERGENCY TREATMENT

1. **Check your ABC's**
   A: Airway (Is this person choking?)
   B: Breathing
   C: Circulation (Is this person bleeding, apply pressure as needed)

2. **Get Help**: As you attend the accident victim, send someone for help and make sure you know help is on the way. Also make sure someone can guide EMT to accident scene.

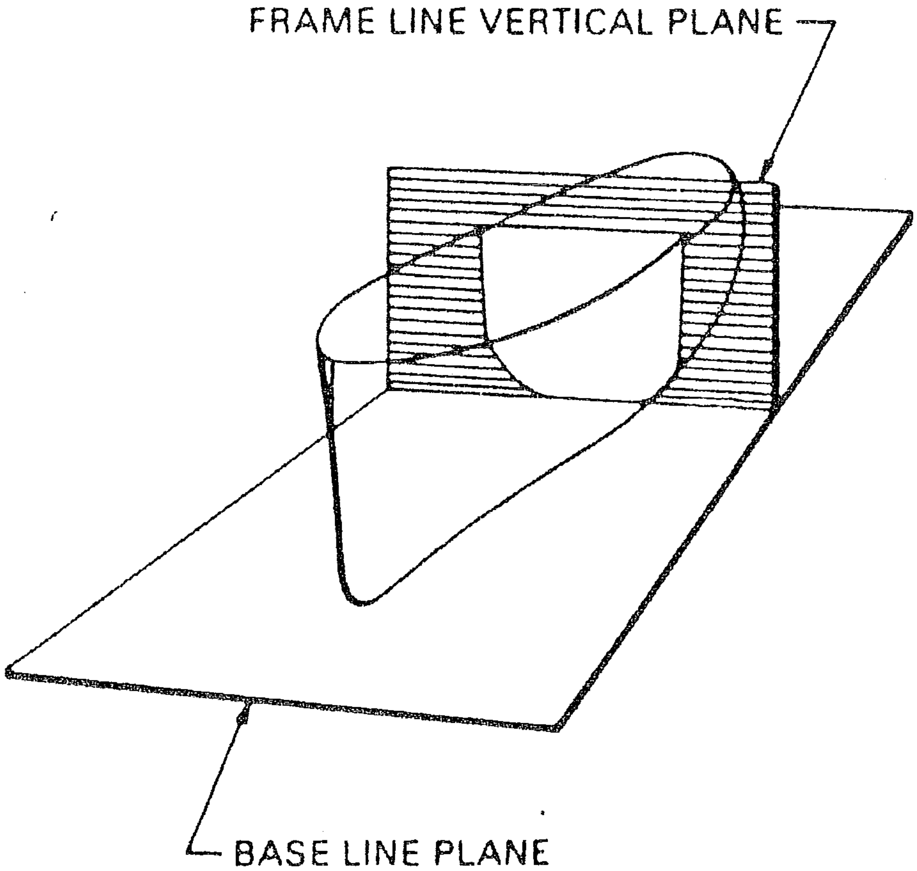
3. **Don't move the victim**!!! Often more serious injury is inflicted by helpful people trying to move the victim. Let EMT personnel move the injured person.

4. **Take a CPR and Industrial First Aid Class**. The Safety Department keeps information available on area classes.

2.0
SHIP'S LINES

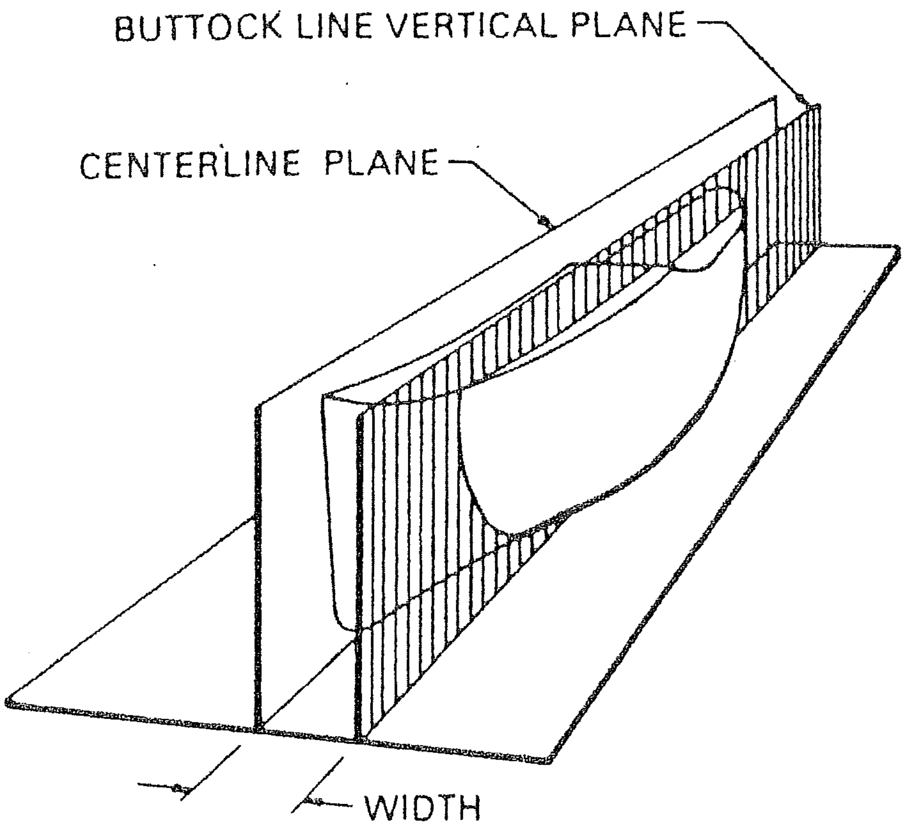
2.1 FRAME LINE

Frame lines are established distances aft of the forward perpendicular. They are vertical planes square to the center line, spaced at regular intervals and numbered consecutively aft. The locations of the frames and bulkheads are determined by the frame lines. Frame lines are used as measuring points for all distances forward and aft. Measurements are usually taken to the nearest frame line.



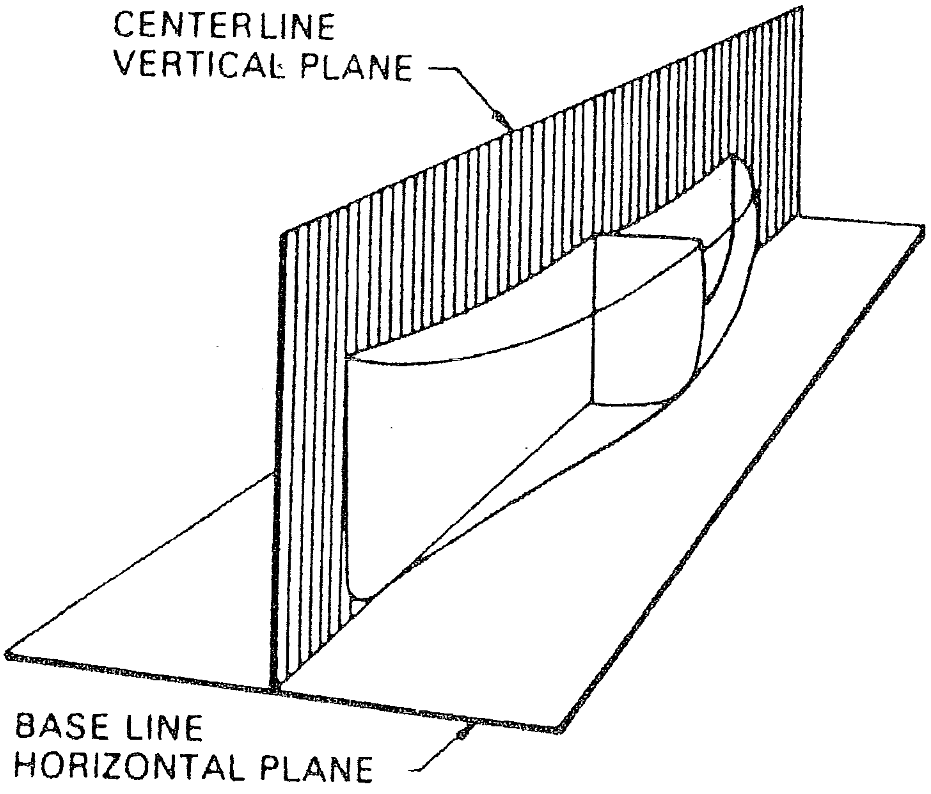
2.2 BUTTOCK LINE

Buttock lines are vertical planes parallel to the center line of the ship. They are auxiliary reference lines for measuring to the center line. A buttock line may be established at any desired distance outboard from the center line. Buttock lines are used for measuring widths where it is inconvenient to measure to the center line.



2.3 CENTER LINE

The center line of the ship is a vertical plane intersecting the ship in the exact center between the two sides. The intersection of this vertical plane with the bulkheads and decks forms the center line as seen on the ship. The center line on a bulkhead is a vertical line, on a deck it is a horizontal line. The center line on the ship will take the slope of the structure upon which it is scribed. It is used for measuring widths or half breadths.

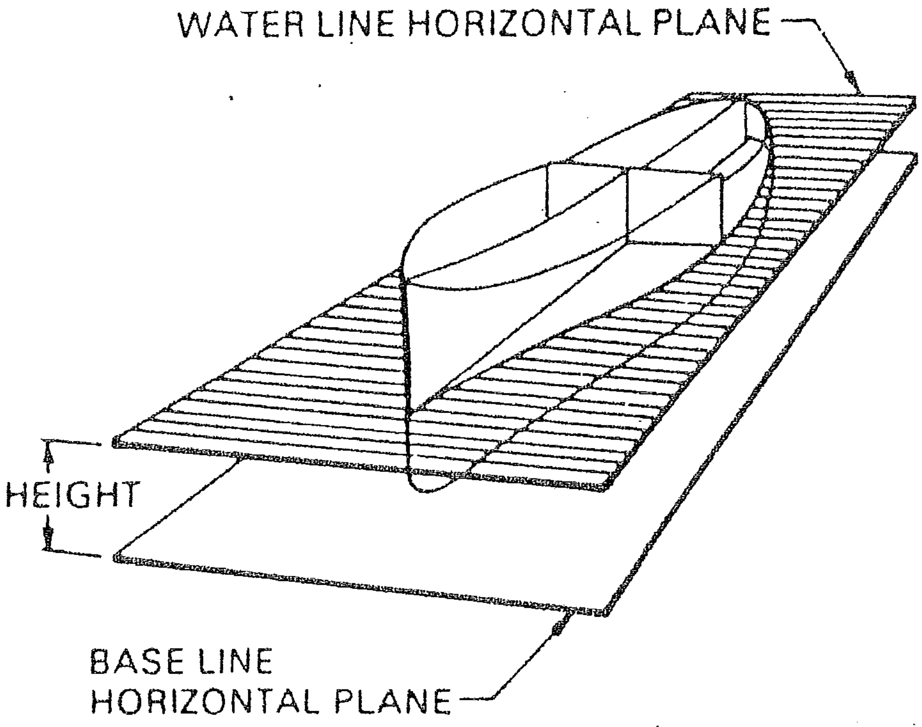


2.4 BASE LINE

The base line is the main reference line for measuring heights. It is a horizontal plane at or near the bottom of the ship. All heights are measured from the base line. All water lines are taken from the base line.

2.5 WATER LINE

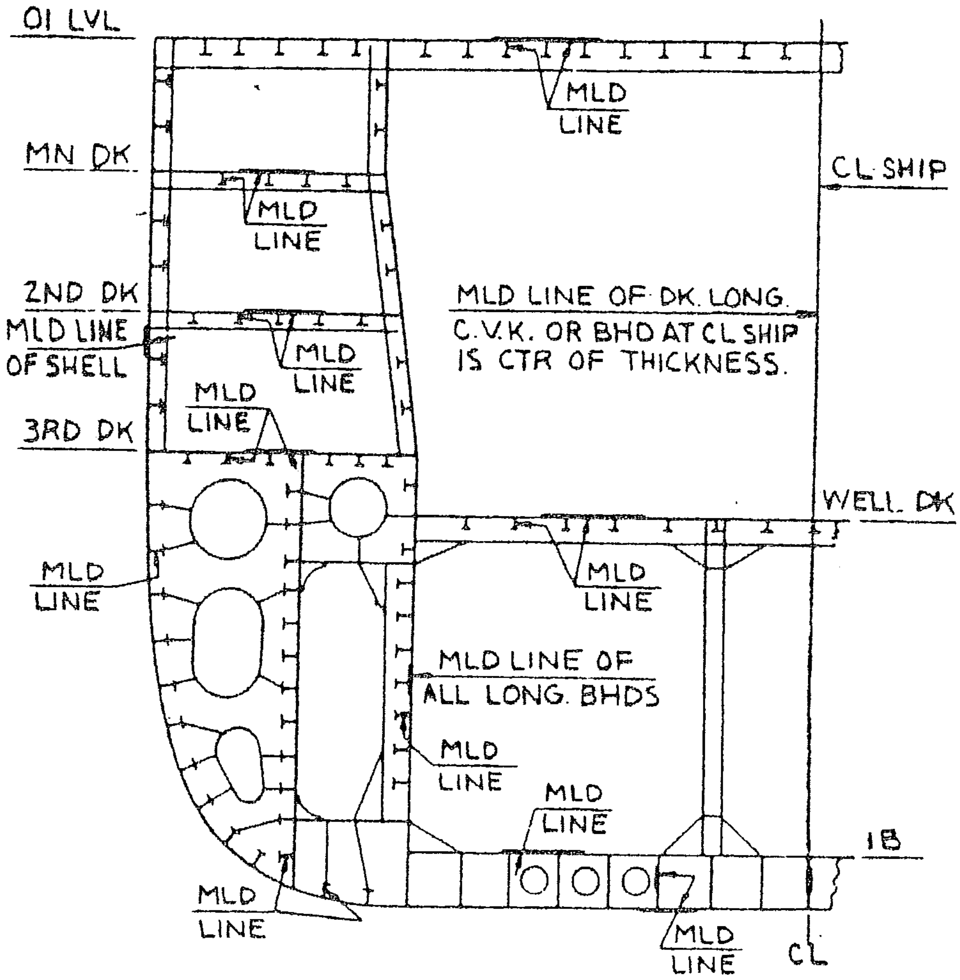
Water lines are auxiliary reference lines for measuring to the base line. A water line is a horizontal plane parallel to the base line plane. A water line may be established any desired distance above the base line. Water lines are used for measuring heights where it is inconvenient to measure to the base line.



2.6 MOLDED LINE

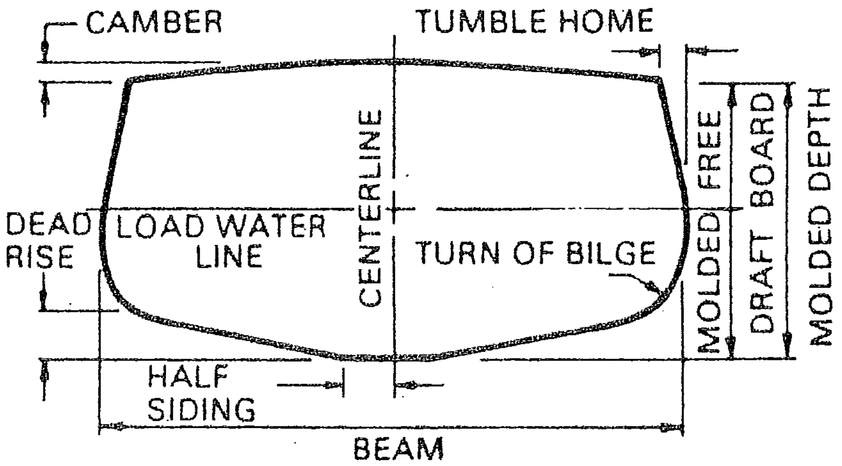
Molded lines are datum or working lines used to guide the structural alignment of a ship in accordance with the design. They may be horizontal and straight as the molded base line, or curved as a molded deck or frame line.

Location of Molded Lines

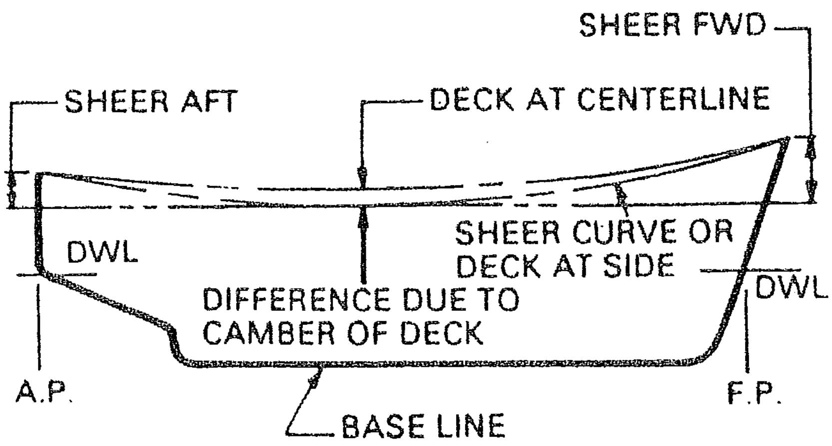


LOCATION OF MOLDED LINES
01 LVL AND BELOW

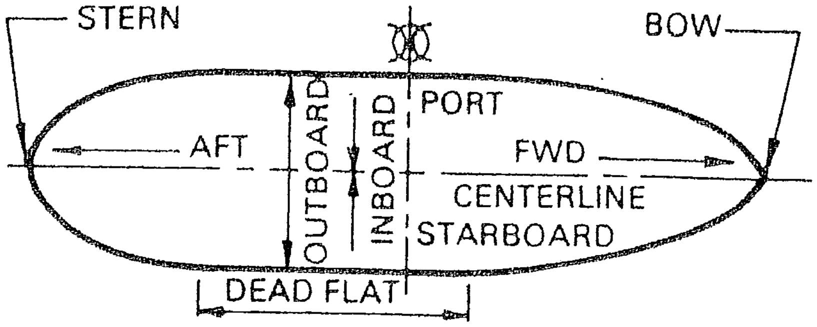
3.0
SHIP'S NOMENCLATURE
3.1 MIDSHIP SECTION



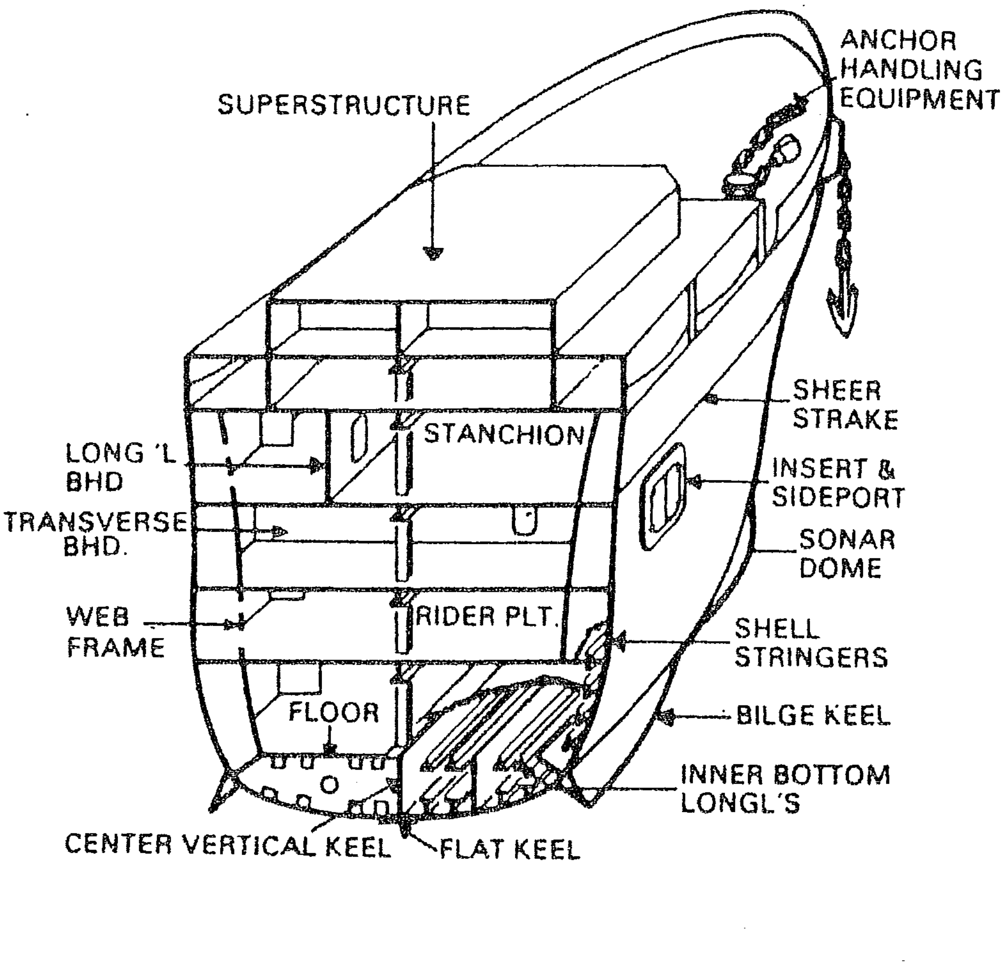
3.2 PROFILE



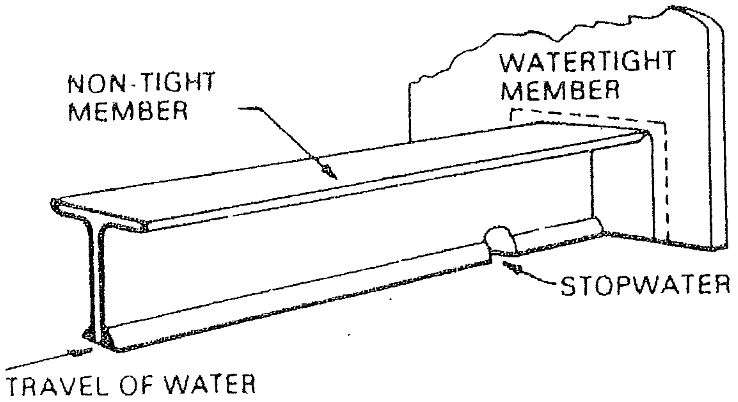
3.3 PLAN

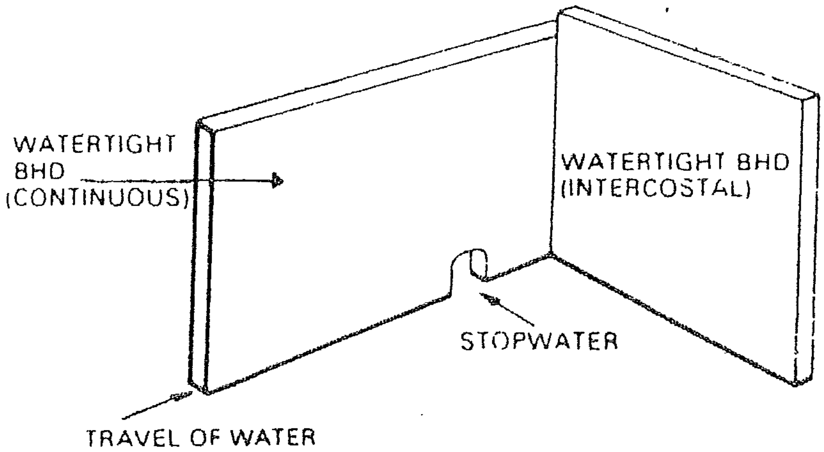


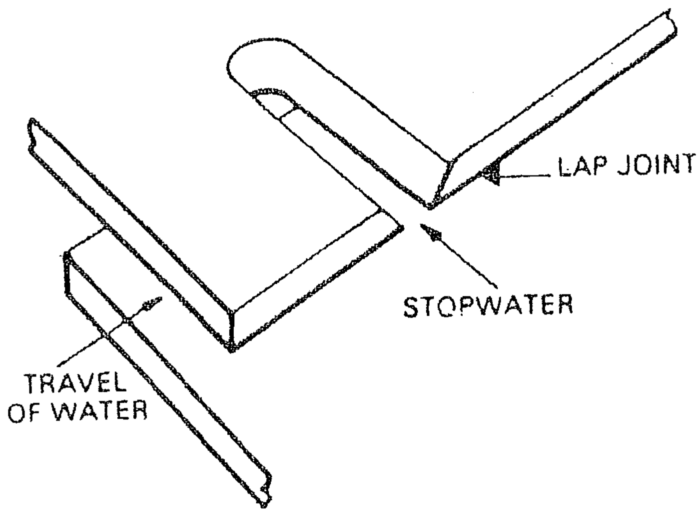
3.4 SECTIONAL VIEW



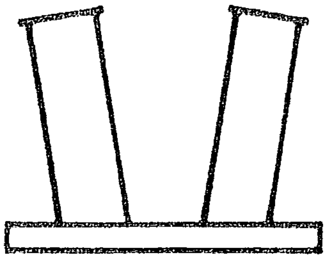
3.5 STOPWATERS (PRACTICAL EXPLANATION)



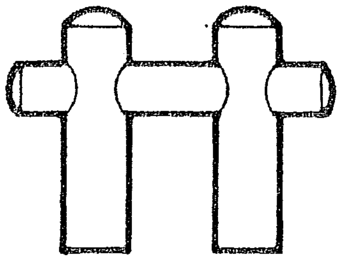




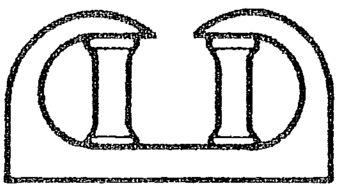
3.6 MOORING FITTINGS



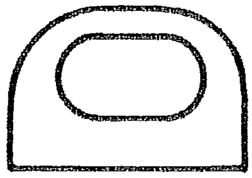
BITT



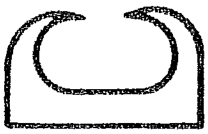
TOWING BITT



ROLLER CHOCK



CLOSED CHOCK



OPEN CHOCK

CLEAT

3.7 NAVY/USCG COMPARTMENT NUMBERING

The compartment number shall consist of four parts, separated by hyphens, in the following sequence:

Deck number
Frame number
Relation to centerline of ship
Use of compartment

3.7.1. Deck Numbering The main deck shall be numbered 1. The first deck or horizontal division below the main deck shall be numbered 2; the second below, numbered 3; and consecutively for subsequent lower division boundaries. The first horizontal division above the main deck is numbered 01; the second above , numbered 02; and consecutively for subsequent upper division boundaries.

3.7.2. Frame Numbering Frames are numbered consecutively aft starting with the forward perpendicular as 0. The frame number shall be the same as the frame number of the forward boundary or the foremost frame within the compartment if the boundary is between frames.

3.7.3. Relations to Centerline of Ship Compartments located so that the centerline passes through them shall be numbered 0. Compartments located completely to starboard of centerline shall be given odd numbers and those completely to port shall be given even numbers. Where two or more compartments have the same deck and frame number and are entirely starboard or entirely port of centerline, they shall have consecutively higher odd or even numbers, as the case may be, numbering from the centerline outboard. In this case, the first compartment outboard of centerline to starboard will be 1; the second 3; etc. Similarly the first compartment outboard of centerline to port will be 2; the second 4, etc.

3.7.4 Compartment Use A capital letter that identifies the assigned primary use of the compartment shall be used in accordance with the following:

A - Stowage spaces
C - Vital ship and fire control spaces (normally manned)
E - Machinery spaces (normally manned)

F - Fuel
G - Gasoline
K - Stowage space for chemicals and semi-safe dangerous materials
L - Living quarters, medical and dental spaces, and passageways
M - For ammunition spaces
Q - For all other spaces (engineering, electrical, and electronics spaces are not normally manned). Also, galley, offices, laundry, pantries, shops, wiring, trunks, and fan rooms.
T - For vertical access trunks
V - For void compartments
W - For water storage compartments

3.7.5 Access Closures Label plates for access closures shall be combined with compartment designation plates. The first line of the inscription shall give the access closure number; the second line, the name of the compartment to which access is provided; and the third line, the compartment number.

3.7.6 Example No. 1,

4-16-2
C.P.O. Storeroom
4-14-2-A

Explanatory Statements:

I. First Line
   1. **4** - Access closure on 4th deck.
   2. **16** - Access of frame 16
   3. **2** - First access on Port side at frame 16.

II. Second Line
   4. Compartment is **Chief Petty Officer's Storeroom**.

III. Third Line
   5. **4** - The compartment has its base on the 4th deck.
   6. **14** - The forward boundary of compartment is frame 14.
   7. **2** - The first compartment on Port side with forward boundary at frame 14.
   8. **A** - Use of compartment is a storeroom.

3.7.7. Example No. 2,

2-51-2
C.P.O. Storeroom
2-51-2-A

Example No. 2 is similar to example No. 1 except it is located on the 2nd deck and has its access located in the forward boundary of the compartment.

3.7.8. Compartment No. 2-118-3-L

2 Deck platform or level

Deck nomenclature starts with the main deck as number 1. All other decks are numbered according to their location above or below. Decks and platforms are numbered consecutively down 2,3,4, etc., and levels numbered consecutively up, 01, 02, 03, etc.

118 Frame number of forward bulkhead.

3 Which side of ship (Port or starboard)
0 - C/L compartment
1 - Starboard (first compartment)
3 - Starboard (second compartment)
5 - Starboard (third compartment)
2 - Port (first compartment)
4 - Port (second compartment)
6 - Port (third compartment)

L Use of Compartment

4.0
STEEL NOMENCLATURE

4.1 TYPES OF MATERIAL
Many different kinds of materials are used in the shipbuilding industry, the most common are structural steels of standard shapes, which are rolled from medium carbon steel.

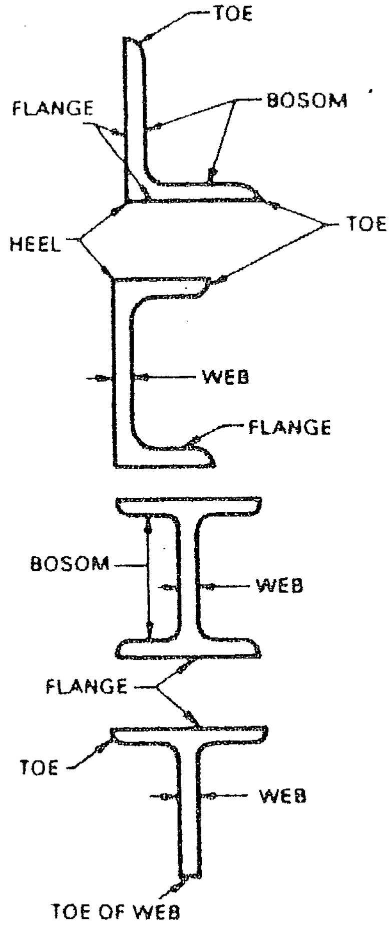
4.2 SHAPES
Steel bars are usually named after the geometric figure or profile of their end views. The thickness of legs, flanges and webs is based on the weight of material per linear foot.

4.2.1 ANGLES - Used for corner connecting members, bulkhead stiffeners, foundations,ribs for ships of light construction, etc.

4.2.2 CHANNELS - Used for longitudinal deck stiffeners, foundations, ribs, shell stiffeners, and bulk-head stiffeners.

4.2.3 S or W BEAMS - Used for centerline deck girders, main support, stanchions for deck supports, and overhead crane tracks, etc.

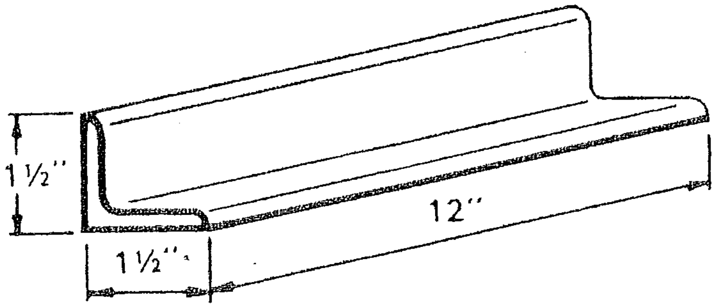
4.2.4 T-BAR - Used for longitudinal shell stiffeners, bulkhead stiffeners, frame work for shells in welded tanks or containers.



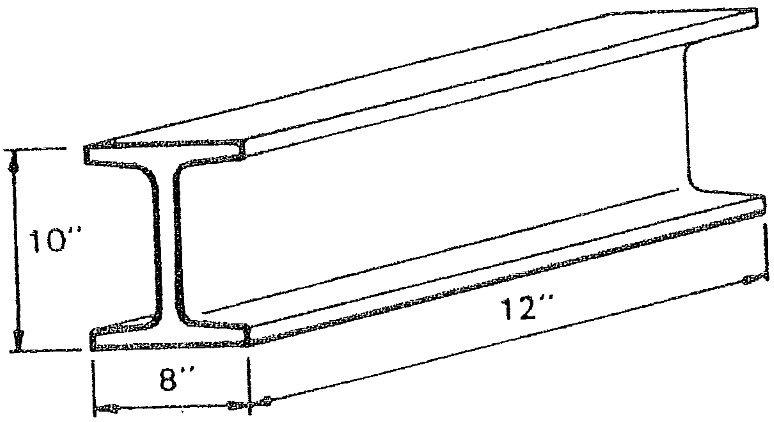
4.3 SIZE

The size of structural steel shapes is determined by the length and height of legs, width of flanges and webs, and weight per linear foot.

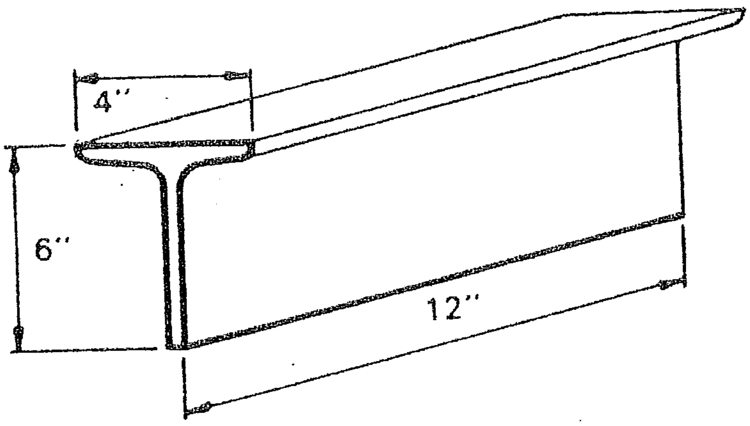
4.3.1 EXAMPLE 1 - The figure illustrates a piece of angle iron written 1-1/2" x 1-1/2" x 1/4" x 12 " long x 2.34#.



4.3.2 EXAMPLE 2 - The figure illustrates a piece of W Beam written as 10" x 8" x 12" long x 39#.



4.3.3 EXAMPLE 3 - The figure illustrates a piece of T Bar written as 6" x 4" x12" long x 15.7#.



4.4 WEIGHT

The thickness of steel plates is based on the weight of plate per square foot. The weight of one cubic foot of steel is the basis for calculating the weight of various plates.

The weight of a cubic foot of steel is 489.6#. As per the illustration, a plate 1" thick and 12" square weighs 40.8# (489.6 divide by 12 = 40.8#)

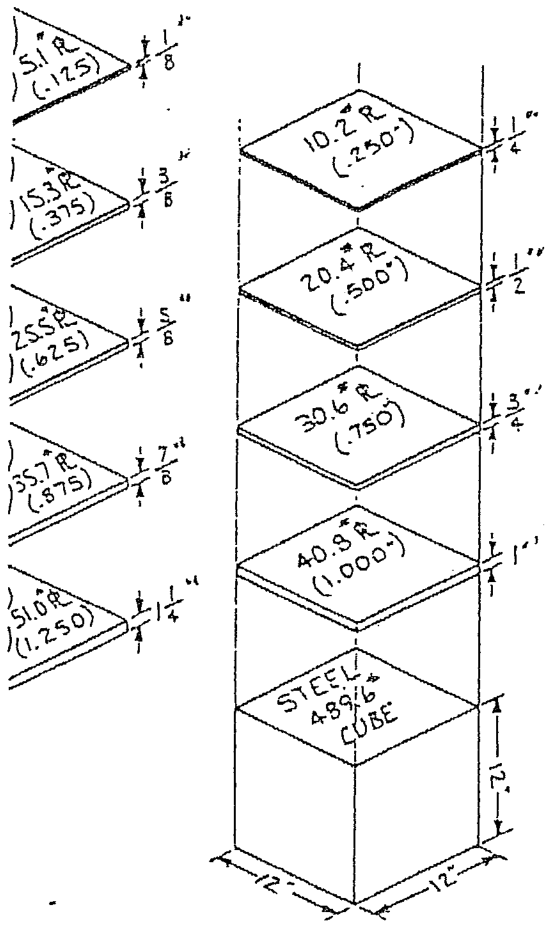
To find the weight of your plate, calculate the square footage of the steel plate and multiply it by the plate poundage. Note: If you have to add inches, divide by 144 to convert to square feet.

<u>Examples</u>

10'-0" x 10'-0" x ½" pl.
= 100 sq. ft. x 20.4# pl.
= 2,040 lbs.

96" x 105 ¾" x ½" pl.
= 10.152 sq. in. divide by 144
= 70.5 sq. ft. x 20.4# pl.
= 1,438.2#

120.25" x 140.3125" x .375" pl.
= 16,872.5 sq ft divide by 144
=117.17 sq ft x 15.3# p.
= 1,724.7#



5.0

HIGH YIELD STEEL

SPECIAL REQUIREMENTS AND INSTRUCTIONS

5.1 SPECIAL CLIPS Use special clips (donut clips or other) for fitting/fairing - do not use tack weld strongbacks and saddles - avoid unnecessary tack welded attachments to HY steel.

5.2 TEMPORARY TACKS If temporary tack welds are unavoidable - remove the temporary welds by scarfing or burning not closer than 1/16" from permanent member (HY) - finish by lightly grinding.

5.3 PREHEATING Use heating coils for HY preheating, using gas/oxy torches is not preferred and shall be limited to temporary tack welds - preheats shall extend 6" beyond weld sites.

5.4 ARC STRIKES Remove evidence of arc strikes on HY by lightly grinding.

5.5 FLAME STRAIGHTENING Flame straightening is not acceptable on HY steel.

5.6 REPAIRS To repair weld undercut and weld edge defects, grinding is preferred method, i.e., for defects to a depth of 1/16" (to a depth of 3/32" for a length of 12" in any 36" length of weld). If welding deposit must be employed, a minimum of two beads are required.

5.7 ADDITIONAL INFORMATION Refer to the chapter for preheat temperatures, preparations, power supply requirements, weld techniques and other weld data.

5.8 COATING REMOVAL Remove all coatings at least 1/2" from edge of weld joint.

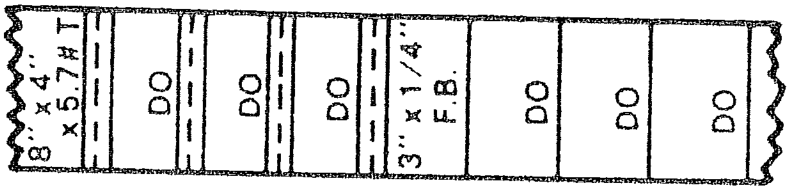
6.0
SYMBOLS AND LINES

6.1 BLUEPRINT SYMBOLS

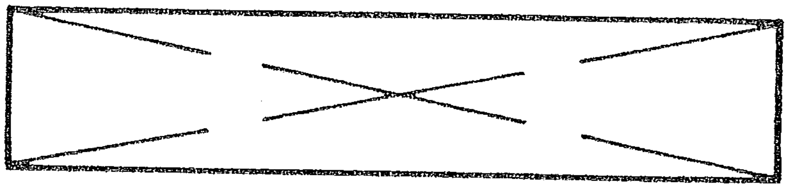
∠	ANGLE BAR		MIDSHIP
[	CHANNEL BAR	Ø	DIAMETER
I	I-BEAM		BASELINE
T	TEE BAR	#	POUNDS OR NUMBER
℄	CENTERLINE	$	SHEAR MARK

○— CONTAINS PIECE MARK

○ □ △ CONTAINS REVISION OR ALTERATION



"DO" DESIGNATES MEMBER SAME AS LAST MEMBER SHOWN



SHOWING OUTER BOUNDARIES OF COMPARTMENTS

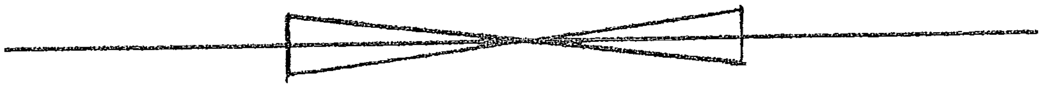
6.2 LINES COMMONLY FOUND ON DRAWINGS

A solid line showing outline or designating material on near side or side shown

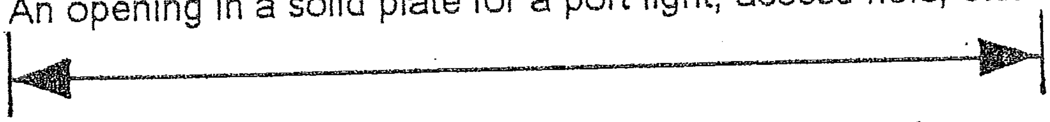
A dotted line shows material on the far or opposite side.

A plate edge or bulkhead on the far or opposite side

A welded butt in a member or a shear line

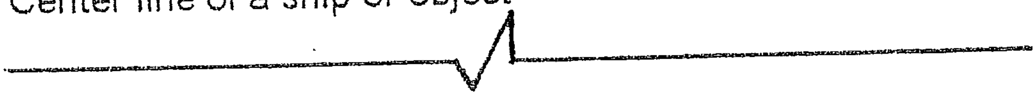


An opening in a solid plate for a port light, access hole, etc.

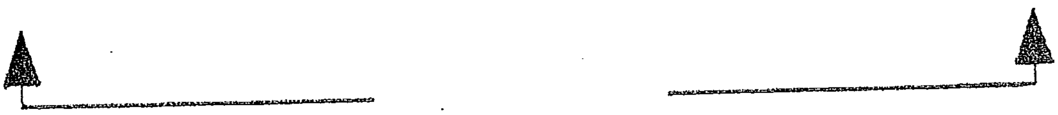


A dimension line showing length between arrows.

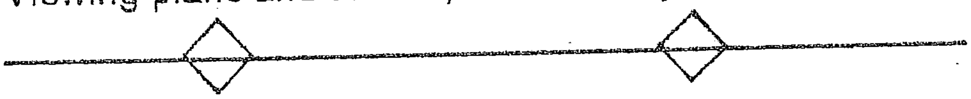
Center line of a ship or object



A broken line showing that all the material is not shown

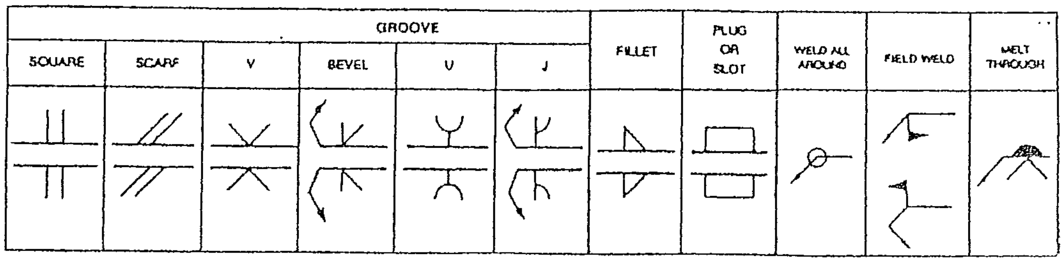


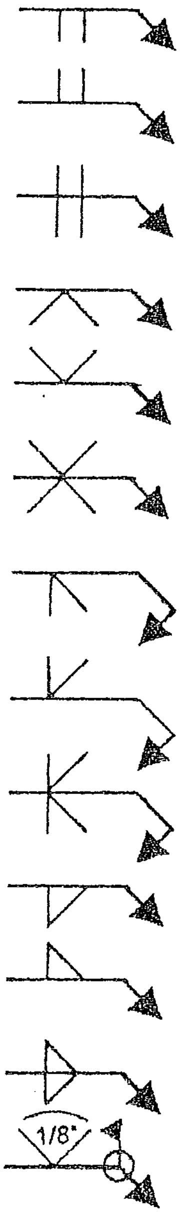
Viewing plane and arrows, for cut away views.



Knuckle or tangent line, for starts and stops of bends.

6.3 WELDING SYMBOLS





SQUARE GROOVE WELD ARROW SIDE

SQUARE GROOVE WELD OTHER SIDE

DOUBLE SQUARE GROOVE WELD

SINGLE V GROOVE WELD ARROW SIDE

SINGLE V GROOVE WELD OTHER SIDE

DOUBLE V GROOVE WELD

SINGLE BEVEL GROOVE WELD ARROW SIDE (broken arrow shows side beveled)

SINGLE BEVEL GROOVE WELD OTHER SIDE

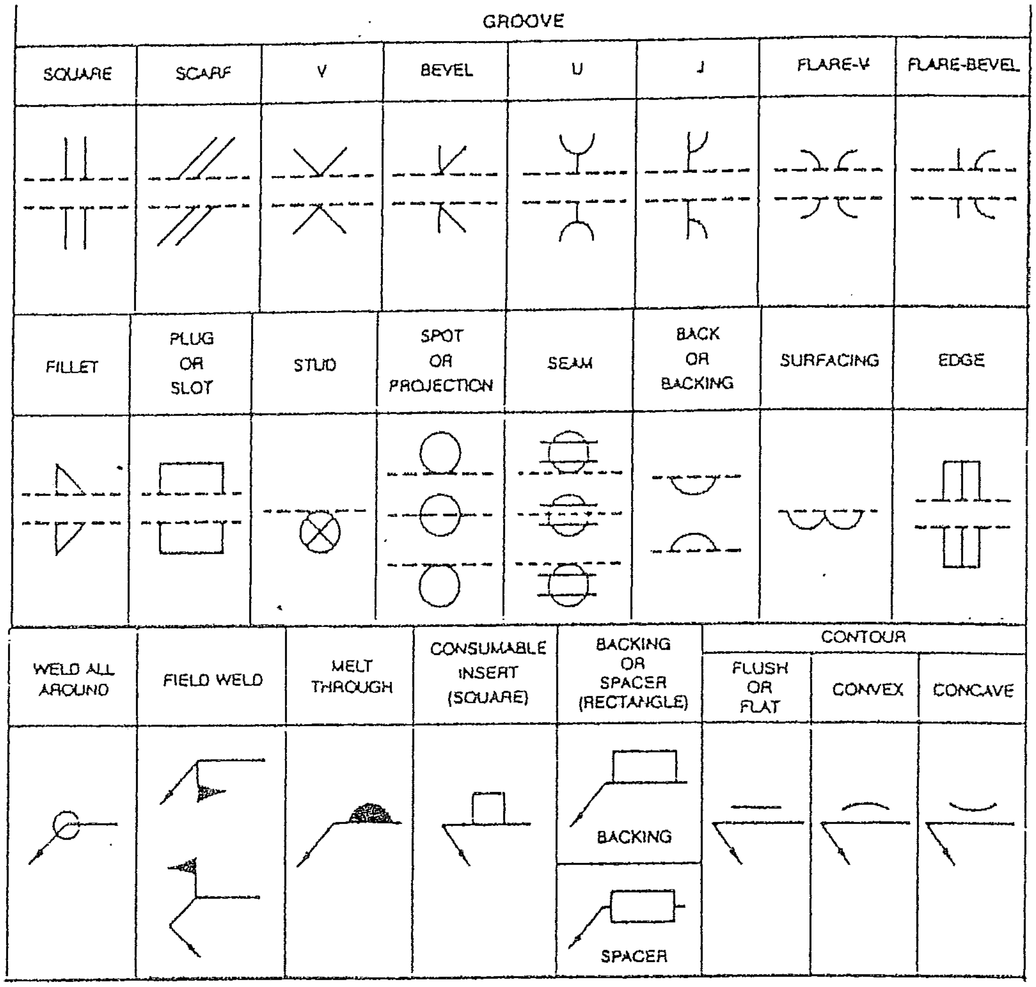
DOUBLE BEVEL GROOVE WELD

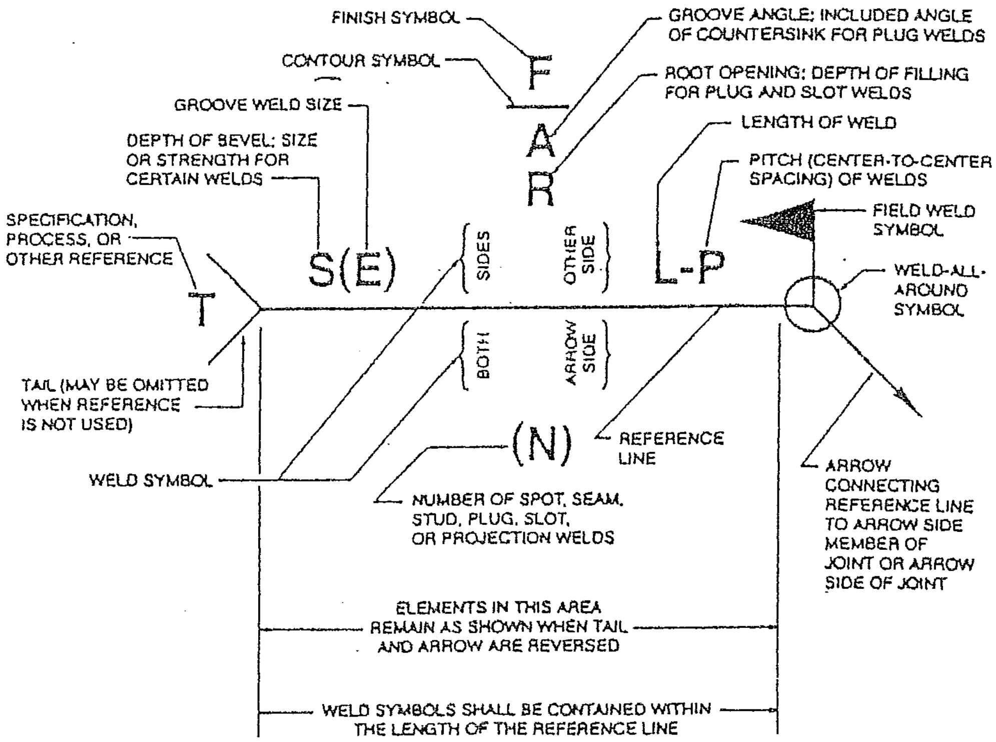
FILLET WELD ARROW SIDE

FILLET WELD OTHER SIDE

FILLET WELD DOUBLE

FIELD WELD ALL AROUND SINGLE V GROOVE OTHER SIDE W/ 1/8" ROOT FACE AND CONVEX FINISH


GROOVE
SQUARE
SCARF
V
BEVEL
U
J
FLARE-V
FLARE-BEVEL
FILLET
PLUG OR SLOT
STUD
SPOT OR PROJECTION
SEAM
BACK OR BACKING
SURFACING
EDGE
WELD ALL AROUND
FIELD WELD
MELT THROUGH
CONSUMABLE INSERT (SQUARE)
BACKING OR SPACER (RECTANGLE)
CONTOUR
FLUSH OR FLAT
CONVEX
CONCAVE
BACKING
SPACER


FINISH SYMBOL
CONTOUR SYMBOL
GROOVE WELD SIZE
DEPTH OF BEVEL; SIZE OR STRENGTH FOR CERTAIN WELDS
SPECIFICATION, PROCESS, OR OTHER REFERENCE
TAIL (MAY BE OMITTED WHEN REFERENCE IS NOT USED)
WELD SYMBOL
GROOVE ANGLE; INCLUDED ANGLE OF COUNTERSINK FOR PLUG WELDS
ROOT OPENING; DEPTH OF FILLING FOR PLUG AND SLOT WELDS
LENGTH OF WELD
PITCH (CENTER-TO-CENTER SPACING) OF WELDS
FIELD WELD SYMBOL
WELD-ALL-AROUND SYMBOL
F
A
R
T
S(E)
SIDES
OTHER SIDE
BOTH
ARROW SIDE
L-P
(N)
REFERENCE LINE
NUMBER OF SPOT, SEAM, STUD, PLUG, SLOT, OR PROJECTION WELDS
ARROW CONNECTING REFERENCE LINE TO ARROW SIDE MEMBER OF JOINT OR ARROW SIDE OF JOINT
ELEMENTS IN THIS AREA REMAIN AS SHOWN WHEN TAIL AND ARROW ARE REVERSED
WELD SYMBOLS SHALL BE CONTAINED WITHIN THE LENGTH OF THE REFERENCE LINE

7.0
USEFUL INFORMATION

7.1 FRACTION AND DECIMAL EQUIVALENTS

7.1.1 TO CHANGE A DECIMAL TO A FRACTION
EXAMPLE: .228

Multiply the decimal portion by the denominator desired.

$$\begin{array}{r} .228 \\ \underline{32} \\ 456 \\ \underline{6840} \\ 7.296 - 7/32 \end{array}$$

.296 dropped since is less than 1/2

or

$$\frac{.228 \times 32}{32} = \frac{7.296}{32}$$

Fraction equivalent of .228 = 7/32

7.1.2 TO CHANGE A FRACTION TO A DECIMAL:
EXAMPLE 25/32

Divide the numerator by the denominator

$$\begin{array}{r|l} & .781 \\ \hline 32 & 25.000 \\ & \underline{224} \\ & 260 \\ & \underline{256} \\ & 40 \\ & \underline{32} \\ & 8 \end{array}$$

Decimal equivalent of 25/32 = .781

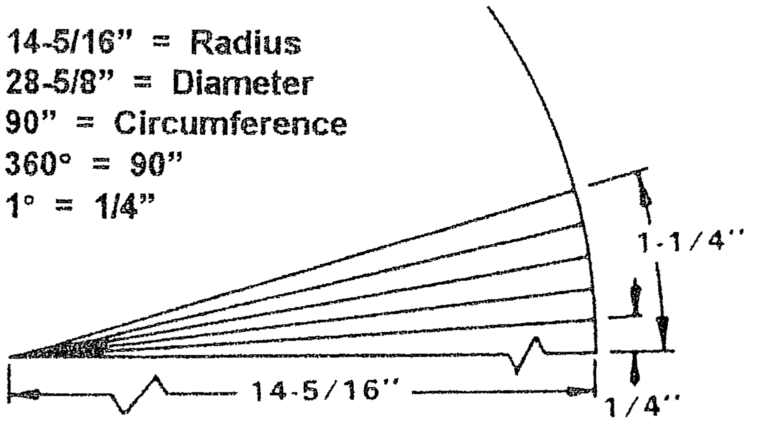
7.2 USEFUL INFORMATION

1. To find circumference of a circle, multiply diameter by 3.1416.
2. To find diameter of a circle, multiply circumference by 3.1831.
3. To find area of a circle, multiply square of diameter by .7854.
4. Area of a rectangle = length multiplied by breadth. Doubling the diameter of a circle increases its area four times.
5. To find area of a triangle, multiply base by 1/2 perpendicular height.
6. Area of ellipse = product of both diameters x .7854.
7. Area of a parallelogram = base x altitude.
8. To find side of an inscribed square, multiply diameter by 0.7071 or multiply circumference by 0.2251 or divide circumference by 4.4428.
9. Side of inscribed cube = radius of sphere x 1.1547.
10. To find side of an equal square, multiply diameter by .8862.
11. Square - a side multiplied by 1.4142 equals diameter of its circumscribing circle.
12. A side multiplied by 4.443 equals circumference of its circumscribing circle.
13. A side multiplied by 1.128 equals diameter of an equal circle.
14. A side multiplied by 3.547 equals circumference of an equal circle.
15. To find cubic inches in a ball, multiply cube of diameter by .5236.
16. To find cubic contents of a cone, multiply area of base by 1/3 the altitude.
17. Surface of frustrum of cone or pyramid = sum of circumference of both ends x 1/2 slant height plus area of both ends.
18. Contents of frustrum of cone or pyramid, multiply area of two ends and get square root. Add the 2 areas and x 1/3 altitude.
19. Doubling the diameter of a pipe increases its capacity four times.
20. A gallon of water (US standard) weighs 8 1/3 lb. and contains 231 cubic inches.
21. A cubic foot of water contains 7 1/2 gallons, 1728 cubic inches, and weighs 62 1/2 lb.
22. To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434.
23. Steam rising from water at its boiling point (212 degrees F) has a pressure equal to the atmosphere (14.7 lb. to the square inch).
24. A standard horse power: the evaporation of 30 lb. of water per hour from a feed water temperature of 100 degrees F into steam at 70 lb. gauge pressure.
25. To find capacity of tanks any size, given dimensions of a cylinder in inches, to find its capacity in US gallons: square the diameter, multiply by the length and by .0034.

26. To ascertain heating surface in tubular boilers, multiply 2/3 the circumference of boiler by length of boiler inches and add to it the area of all the tubes.

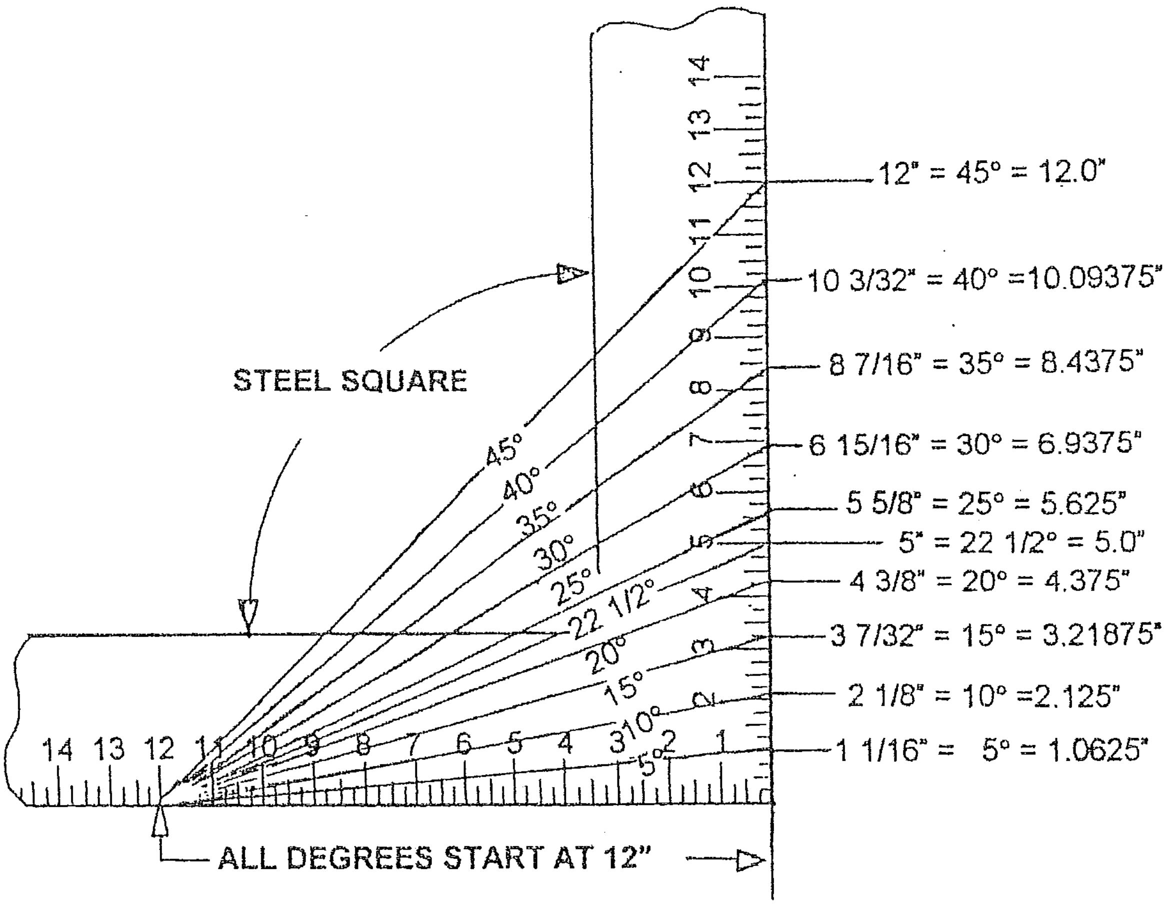
7.3 TO LAYOUT DEGREES WITHOUT A PROTRACTOR

1. Lay out a portion of a circle with a 14-5/16" radius.
2. Mark off 1/4" on the circumference for each degree desired.
3. Any multiples of 14-5/16" and 1/4" can be used (e.g., radius = 28-5/8" with 1/2" increments for 1°).

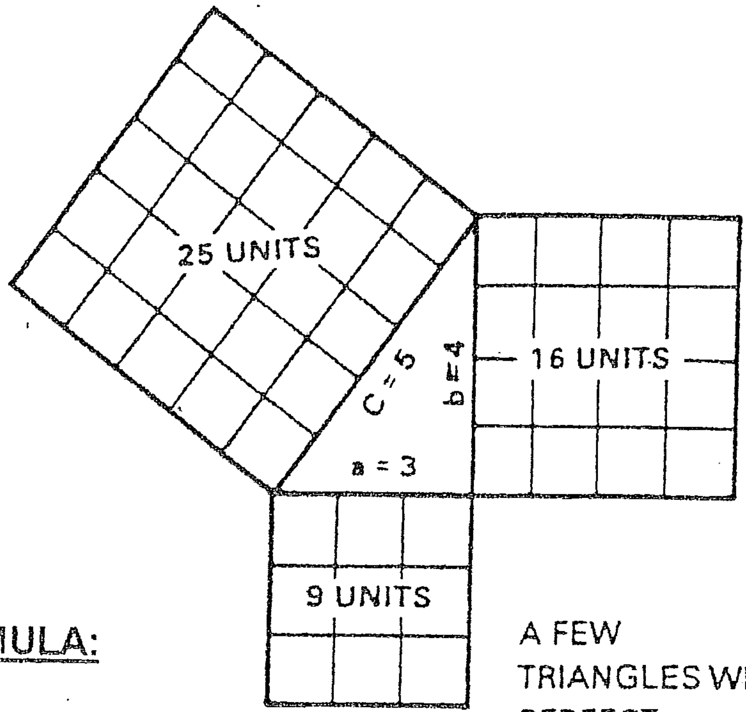


7.4 LAYOUT OF ANY 5° INCREMENT, USING AN ORDINARY 2' STEEL SQUARE (0°- 45°)

1. Draw baseline using horizontal leg, mark at 12".
2. Draw perpendicular line, using the other leg.
3. Mark off the proper measurement for the degree desired.
4. Remove square from work.
5. With a straight edge, connect the two marks for the desired angle.



7.5 SOLUTION OF RIGHT TRIANGLE



FORMULA:

Pythagorean Theorem

SOLUTION:

$a^2 + b^2 = c^2$
$(3x3) + (4x4) = (5x5)$
$9 + 16 = 25$
$\sqrt{25} = 5$

Calculator Steps:

a $\boxed{x^2}$ $\boxed{+}$ b $\boxed{x^2}$ $\boxed{=}$ $\boxed{\sqrt{x}}$ = c

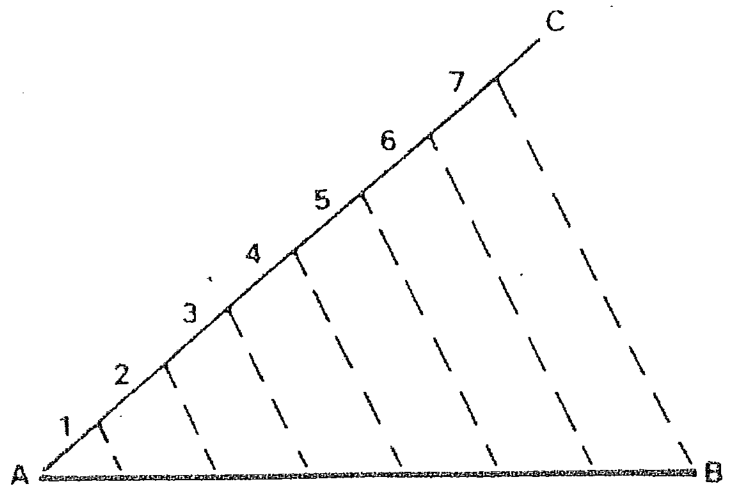
A FEW TRIANGLES WITH PERFECT SOLUTIONS

a	b	c
3	4	5
5	12	13
6	8	10
7	24	25
8	15	17
9	12	15
10	24	26

TO FIND	KNOWN	FORMULA
c	a, b	$c = \sqrt{a^2 + b^2}$
a	b, c	$a = \sqrt{c^2 - b^2}$
b	a, c	$b = \sqrt{c^2 - a^2}$

7.6 DIVIDING A LINE INTO EQUAL PARTS

Problem: Divide line A-B into any given number of equal parts



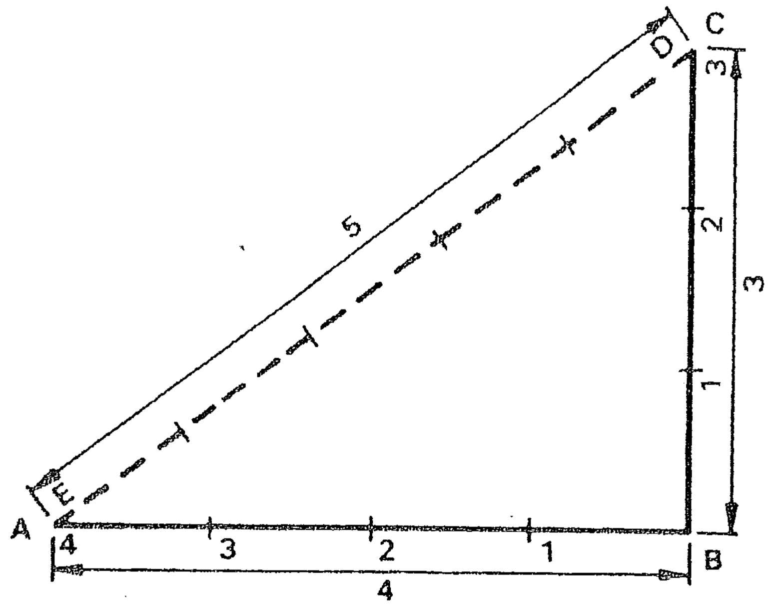
Given: Line A-B.

Let: Number of equal parts be seven.

Steps:
1. Construct line A-C at any angle to line A-B.
2. Divide any length of line A-C into seven equal parts of any convenient length.
3. Connect point seven on line A-C with point B.
4. Construct, parallel to 7-B, lines from points, 6, 5, 4, 3, 2 and 1, intersecting line A-B and dividing line A-B into seven equal parts.

7.7 CONSTRUCTING PERPENDICULARS

7.7.1 Problem: From point B, on line A-B, construct a perpendicular, BC.

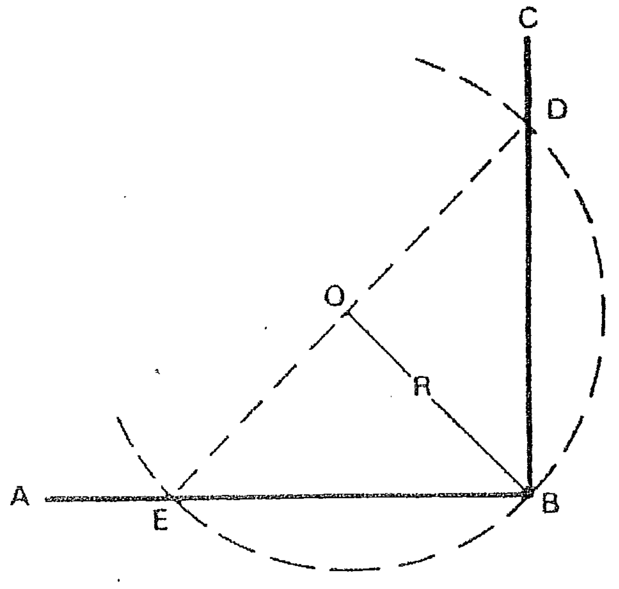


Given: Line A-B of any length.
Postulate: A triangle whose sides are in the radio of 3, 4 and 5 will be a 90° triangle.

Let: Any convenient unit of measurement be used.

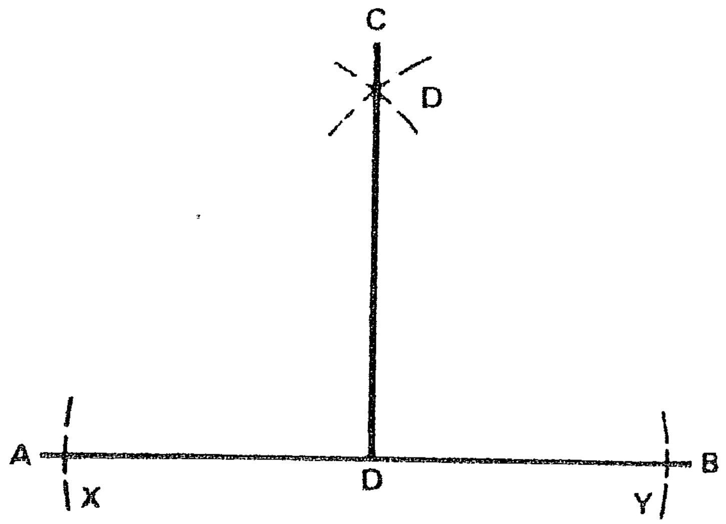
1. From point B, on line A-B, step off 4 units of measurement.
2. From point B, with a radius equal to 3 units of measurement, strike an arc approximately perpendicular to line A-B.
3. With a radius of five units of measurements, from point 4 on line A-B, strike an arc intersecting the 3-unit arc at point D.
4. Erect perpendicular B-C from B through point D.

7.7.2 Problem: From point B, on line A-B, construct a perpendicular BC.



Given:	Line A-B of any length. Postulate: Any triangle inscribed within a semi-circle is a 90° triangle.
Let:	Any convenient radius O-B be used.
Steps:	1. From any convenient point within the estimated angle ABC, locate point O. 2. From point O, with a radius equal to O-B, swing an arc, intersecting line A-B at E and creating at least one-half a circle. 3. From point E on line A-B, construct a line passing through O, and intersecting the arc at point D. 4. Erect perpendicular B-C from B through point D.

7.7.3 Problem: Construct a perpendicular from any point on a straight line.



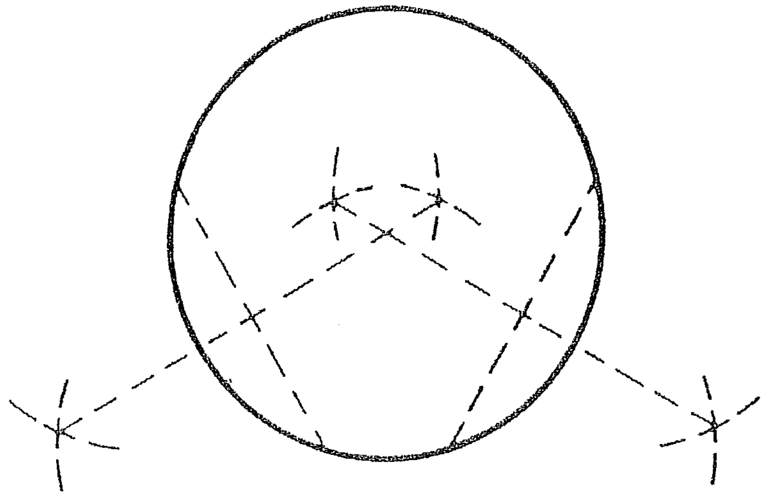
Given: Straight line of any length A-B.
Point D on line A-B

Steps:

1. From given point D on line A-B, and with any convenient radius, swing a semi-circular arc intersecting line A-B at X and Y.
2. From point Y with any radius greater than D-Y, and from point X with the same radius, strike arcs intersecting at point D' (D Prime).
3. From point D, erect perpendicular D-C passing through point D'.

7.8 FIND THE CENTER OF ANY CIRCLE OR ARC

Problem: Find the center of any circle or arc.



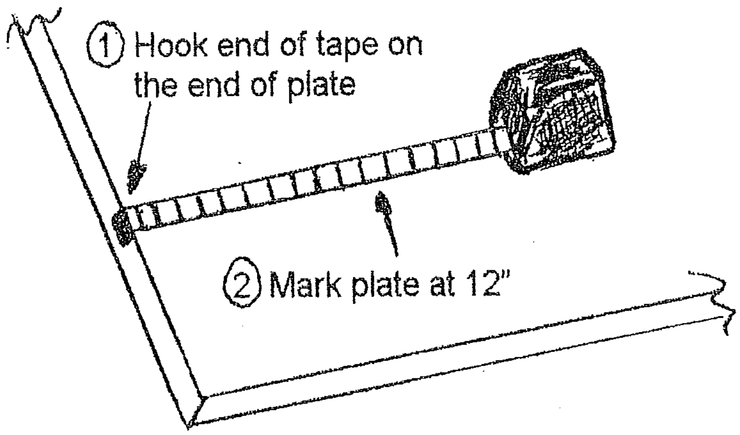
Given: A circle or arc with unknown radius.

Steps:

1. Construct any two chords within circle.
2. Erect perpendicular bisectors to these chords.
3. Center of circle is located where perpendicular bisectors intersect.

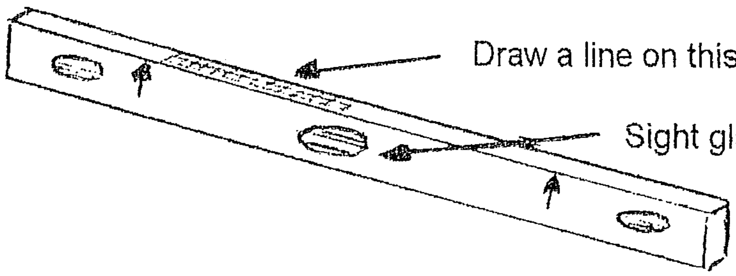
7.9 CHECKING YOURSELF

7.9.1 HOW TO CHECK YOUR TAPE MEASURE



3 Hold 1" of tape on end of plate and look at the 13" mark on the tape. It should line up with your original 12" mark on the plate. Note, if it varies by 1/16" or more try to adjust the tab on the end of the tape or get a new tape from the tool room.

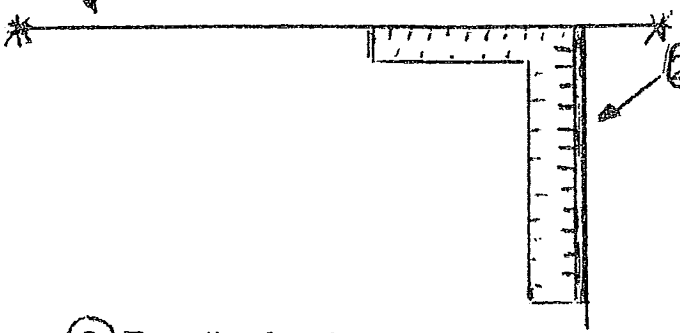
7.9.2 HOW TO CHECK YOUR LEVEL



To <u>check a level</u>, hold it against a wall or bulkhead. "Level" out until the air bubble in the sight glass is centered between the two lines then draw a line. Turn the level around so that the end that was on your left is now on your right and the top side of the level is still on the top. Line the level to the line drawn and then check the air bubble for centering between the lines on the sight glass. Do this same procedure for the side of the level that was on the "bottom" making it now the top side.

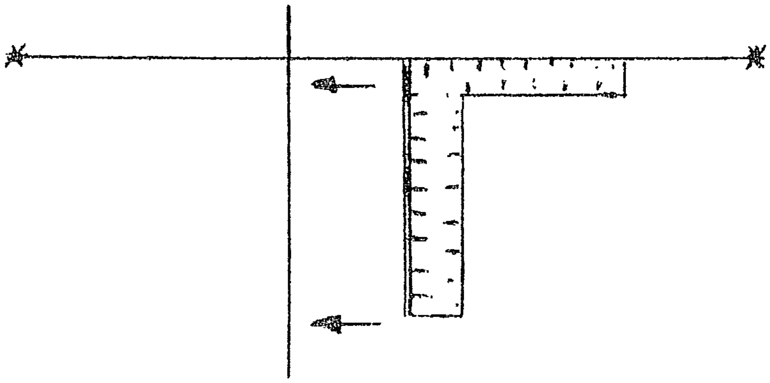
7.9.3 HOW TO CHECK YOUR TWO-FOOT SQUARE

(1) With a straight-edge, draw a straight line on a wall or bulkhead



(2) Check a framing square by holding one edge on the straight line and drawing a second line down the other edge of the framing square.

(3) Turn the framing square over and while holding the top edge to the straight line, move the framing square back to the second line. If the second line does not match up with the edge of the framing square when the top of the framing square is held to the straight line, then the framing square is not 90 degrees and should be returned to the tool room.



8.0
BURNING INSTRUCTIONS

8.1 SAFE USE OF OXYGEN

Always keep **oil** and **grease** away from oxygen cylinders, fittings, and equipment used around oxygen. A violent explosion and/or fire is possible when this rule is not followed.

Never store oxygen cylinders near highly combustible materials.

Never use oxygen to cool off or blow your clothing off.

Never use oxygen to blow out or clean up an area, or to blow out pipes, or to create a head pressure in tanks.

Never use oxygen to operate pneumatic tools.

Never use oxygen to ventilate a confined space.

8.2 PROTECTIVE CLOTHING AND EQUIPMENT

Filter lenses should be used when cutting. Shades range from No. 3 or No. 4 for plate up to about 1 inch, up to No. 5 or No. 6 for heavier plate.

Gloves, jackets, coats, hoods and aprons should be flame resistant.

Wool clothing is better than cotton or synthetic for flame resistance.

Keep your pockets, collars and sleeves buttoned while cutting.

Torn or ragged shirts, coats and pants are dangerous and should not be worn. They catch fire quickly, can get caught in equipment and allow sparks or molten slag in.

Cutting goggles are no substitute for safety glasses. Use both while cutting.

8.3 OTHER SAFE PRACTICES

Make sure the regulators and hoses you are using are meant to be used with the gas you are using. Oxygen equipment has right hand threads and the hose is **green**. Fuel gas equipment has left hand threads and the hose is **red**.

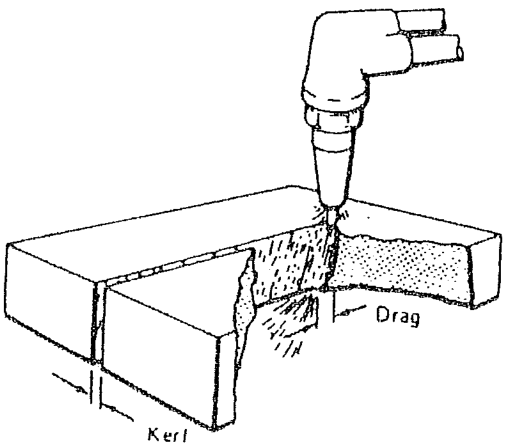
Make sure all connections are **tight** and not **leaking**. Do not try to "get by" with defective equipment.

Flashbacks occur when the flame is burning inside the torch or hoses. It is an extremely dangerous situation and you have to correct it. **Shut** the oxygen off immediately and then the fuel gas. Two common causes of flashback are failure to purge the hoses before lighting and overheating the torch tip.

Tips for use with acetylene are different than natural gas tips. Do not try to use them for both gases.

8.4 KERF AND DRAG

8.4.1 KERF IS THE WIDTH OF THE CUT. Kerf variations can lead to problems when the size of the part needs to be controlled and can cause problems for the welder. Generally the width of the cut can be controlled to 1/64 inch on steel up to 2 inches thick. The things that control kerf are the flow rates of cutting oxygen and pre-heat gases, the speed of cutting, type of tip used and the size of the oxygen port.



8.4.2 DRAG IS THE DISTANCE THAT THE BOTTOM OF THE CUT TRAILS THE TOP OF THE CUT

Cutting speed and oxygen flow control the amount of drag for a given material thickness. Cut quality is usually poorer when a large drag is present. Drag may be reduced by increasing oxygen flow or slowing down cutting speed.

8.5 FLAME ADJUSTMENT

Flame adjustment is critical to making a decent cut. Three types of flames may be obtained by adjusting the torch. A reducing flame using natural gas has a long rounded primary flame cone and is obtained by decreasing oxygen slightly from a neutral flame, is often used to give the best finish to the cut. The neutral flame with natural gas has a short, sharp cone and is the most frequently used type. An oxidizing flame occurs when oxygen is added to the neutral flame. Primary flame cones are longer, less sharply defined and lighter in color. Used for fast, low quality cutting. **PRACTICE MAKES PERFECT**

Care of Cutting Tips - For satisfactory performance, the tips of cutting torches must be clean and in good condition, i.e., the face must be square to the axis of the tip and the holes free of any obstruction.

Cleaning Tip Opening - All tips, new or used, should have the openings cleaned with an appropriate cleaner before use.

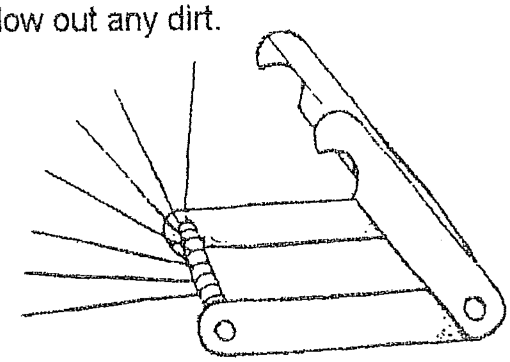
Procedure:

Step 1. Select cleaner needle one size smaller than opening. **Do not force larger cleaner needle into opening.**

Step 2. Open oxygen valve slightly to blow out any dirt.

Step 3. Up and down motion must be straight to prevent flaring the opening.

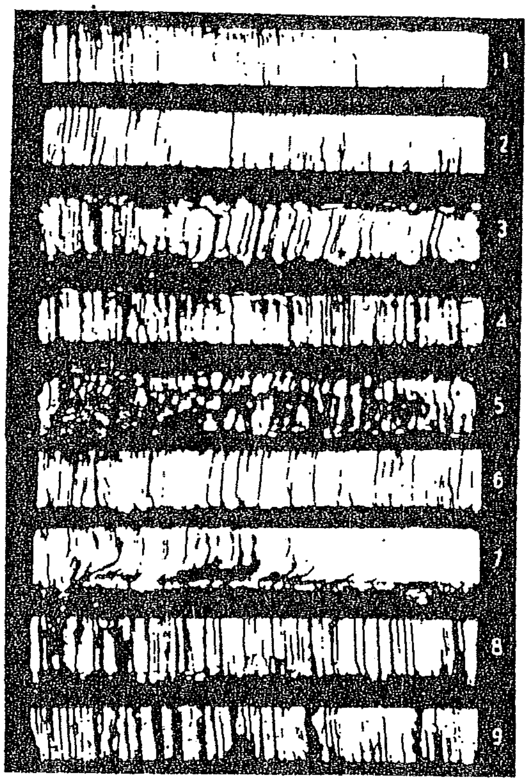
NOTE: Preheat holes and center hole for cutting oxygen are all cleaned.



8.6 CUT SURFACE QUALITY

Cut surface quality depends on many things, most important are:

1. Type, thickness and quality of steel as well as the surface condition of the steel.
2. Intensity of pre-heat flames and pre-heat oxyfuel gas ratio.
3. Condition, side and shape of the tip. Should be clean, flat and proper size/type.
4. Cutting speed.
5. Operator skill and attitude toward doing a good job.



Typical edge conditions resulting from oxyfuel gas cutting operations:

1. Good cut in 25 mm (1 inch) plate -- the edge is square, and the drag lines are essential vertical and not too pronounced.
2. Pre-heat flames were too small for this cut and the cutting speed was too slow, causing bad gouging at the bottom.

3. Pre-heating flames were too long, with the result that the top surface melted over, the cut edge is irregular and there is an excessive amount of adhering slag.
4. Oxygen pressure was too low, with the result that the top edge melted over because of the slow cutting speed.
5. Oxygen pressure was too high and the nozzle size too small, with the result that control of the cut was lost.
6. Cutting speed was too slow, with the result that the irregularities of the drag lines are emphasized.
7. Cutting speed was too fast, with the result that there is a pronounced break in the dragline, and the cut edge is irregular.
8. Torch travel was unsteady, with the result that the cut edge is wavy and irregular.
9. Cut was lost and not carefully restarted, causing bad gouges at the restarting point.

8.7 VICTOR CUTTING TIPS

8.7.1 CUTTING TIP CHART - PROPANE & NATURAL GAS

Metal Thickness	Tip Size	Cutting Oxygen Pressure*** (PSIG)	Pre-Heat Oxygen Pressure* (PSIG)	Pre-Heat Fuel Gas Pressure (PSIG)	Speed I.P.M.	KERF Width
1/8"	000	20/25		3/5	24/28	.04
1/4"	00	20/25		3/5	21/25	.05
3/8"	0	25/30		3/5	20/24	.06
1/2"	0	30/35	S	3/5	18/22	.06
3/4"	1	30/35	E	3/6	15/20	.08
1"	2	35/40	E	3/6	14/18	.09
1 1/2"	2	40/45		4/8	12/16	.09
2"	3	40/45	B	4/8	10/14	.10
2 1/2"	3	45/50	E	5/9	9/12	.10
3"	4	40/50	L	6/9	8/11	.12
4"	5	45/55	O	6/9	7/10	.14
5"	5	50/55	W	6/10	6/9	.14
6"	6**	45/55		6/10	5/7	.17
8"	6**	55/65		8/12	4/6	.18
12"	8**	60/70		10/14	3/4	.41

*NOTE: The above data applies to all torches with the following exceptions:

Torch Series	Pre-Heat Oxygen-PSI	Pre-Heat Fuel-PSI
MT 600N Series	25 PSIG-UP	8 OZ.-UP
STN 2300C Series	N/A	2 PSIG-UP
ST 900C Series	N/A	5 PSIG-UP
ST 1600C/1700C Series	N/A	1 PSIG-UP
ST 1800C/1900C Series	N/A	1 PSIG-UP
MT 200N Series	N/A	8 OZ.-UP
MT 300N Series 000-6	20-55 PSIG	8 OZ.-UP

**For best results use ST 1600C — ST 1900C series torches and 3/8" hose when using tip size 6 or larger.

***All pressures are measured at the regulator using 25'x1/4"hose through tip size 5 and 25'x3/8" hose for tip size 6 and larger.

8.7.2 CUTTING TIP CHART - APACHI, B-PLUS H.P.G. T-9 UCON 96, & VICTORGAS, PROPYLENE

Metal Thickness	Tip Size	IPM	Cutting Oxygen-PSIG	Pre-Heat Oxygen-PSIG	Pre-Heat* Fuel-PSIG	KERF Width
1/8"	000	24/28	20/25	FOR 3—HOSE MACHINE TORCHES ONLY SEE REVERSE SIDE	2/5	.04
1/4"	00	21/25	20/25		2/5	.05
3/8"	0	20/24	25/30		3/5	.06
1/2"	0	18/22	25/35		3/5	.08
3/4"	1	15/20	30/35		3/6	.08
1"	2	14/18	35/40		3/6	.09
1 1/2"	2	12/16	40/45		4/8	.09
2"	3	10/14	40/45		4/8	.10
2 1/2"	3	9/12	45/50		5/9	.10
3"	4	8/11	40/50		6/9	.12
4"	5	7/10	45/55		6/9	.14
5"	5	6/9	50/55		6/10	.14
6"	6	5/7	45/55		6/10	.17
8"	6	4/6	55/65		8/12	.18
10"	7	3/5	55/65		8/12	.34
12"	8	3/4	60/70		10/14	.41
15"	10	2/4	50/70		10/16	—
18"	12	2/3	45/65		—	—

8.7.3 CUTTING TIP CHART - ACETYLENE - GAS PRESSURE FOR CUTTING WITH SUPER STANDARD CUTTING TORCHES AND WELDMASTER CUTTING ATTACHMENT

TIP NO.	THICKNESS OF METAL INCHES	ACETYLENE PRESSURE LBS.	OXYGEN PRESSURE LBS.
L-00	1/8	4	10
L-0	1/4	4	15
L-1	3/8	4	20
L-1	1/2	4	25
L-2	3/4	5	30
L-2	1	5	40
L-2	1-1/2	5	50
L-2	2	5	60
L-3	3	6	70
L-3	4	6	80
L-3	5	6	90
L-4	6	7	100
L-5	8	7	130
L-6	10	8	150

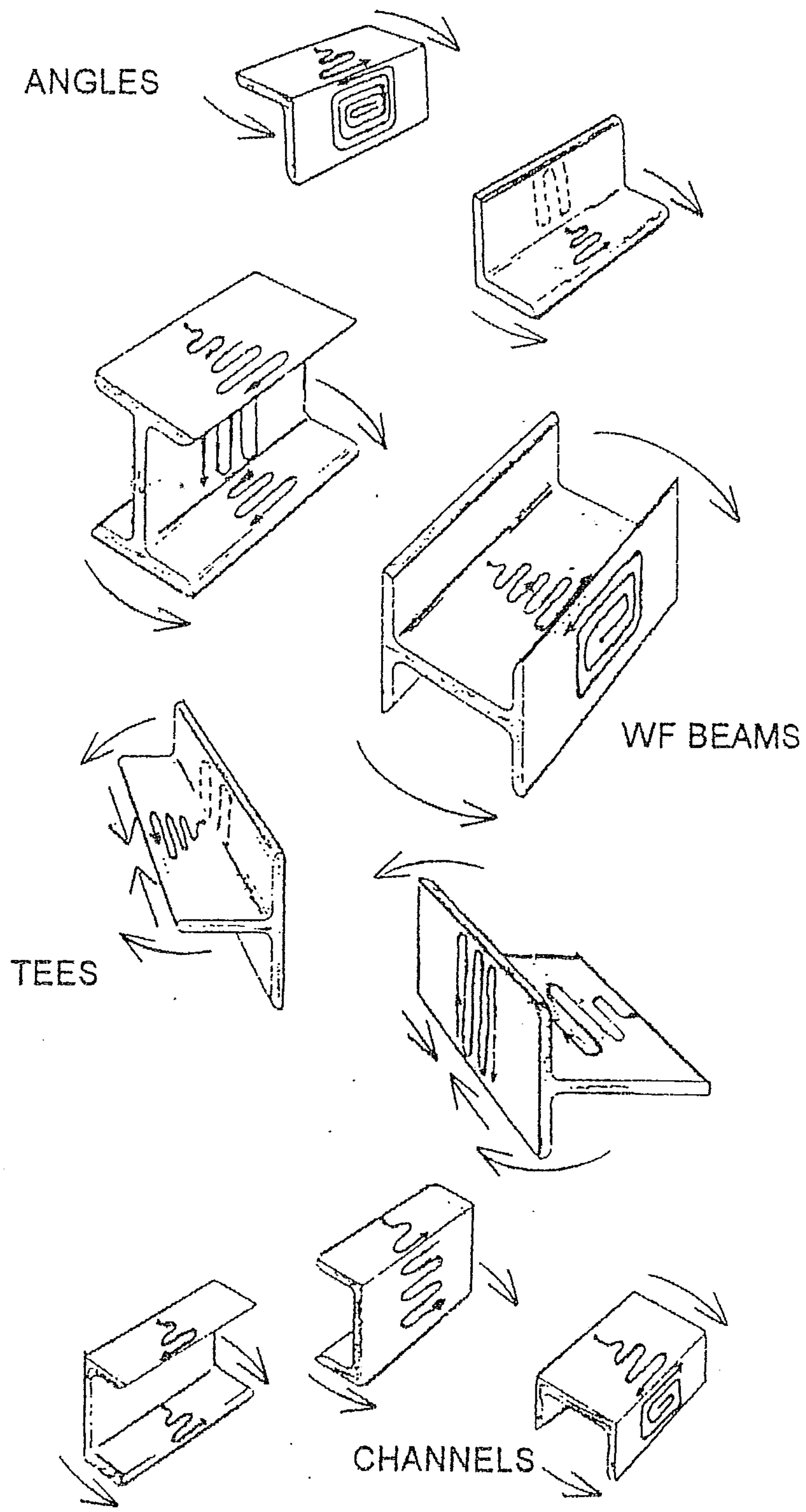
8.8 COLORS OF CARBON STEEL AT VARIOUS TEMPERATURES

Black Red	990° F
Dark Blood Red	1050° F
Dark Cherry Red	1175° F
Medium Cherry Red	1250° F
Full Cherry Red	1375° F
Light Cherry, Scaling	1550° F
Salmon, Free Scaling	1650° F
Light Salmon	1725° F
Yellow	1825° F
Light Yellow	1975° F
White	2220° F

8.9 HEAT FORMING AND STRAIGHTENING

Heat, normally applied by the oxyacetylene torch, can be used to bend or straighten metal parts.

All metals expand when heated and contract when cooled. The amount of expansion depends on the temperature increase, the coefficient of expansion of the metal heated, and size of the heated area. Unrestrained metal expands in all three directions, but metal is normally restrained due to unequal heating.



Application of heat to roll or bend structural shapes.

9.0
BENDING INFORMATION

9.1 BEND PROBLEMS

No exact rules for every type of bend can be formulated, so these general rules are followed>

1. **5 lb**. Through **10 lb**. plate may be flanged 90° without adding material because practically no radius is involved.

2. Plate above 10 lb. cannot be flanged without an appreciable radius being involved at the flange line; consequently, enough material must be added to each bend to compensate for the radius.

3. Whenever possible, flange at 90° to mill roll of plate. If not possible, try flanging a sample plate and if it cracks have the plate annealed prior to flanging.

4. When flanging plate never scribe or punch a flange line when the plate is to be flanged down as it will crack or fracture.

5. When bending or flanging plate it is necessary that there be the following amounts of material on each side of each line of tangency (flange line):

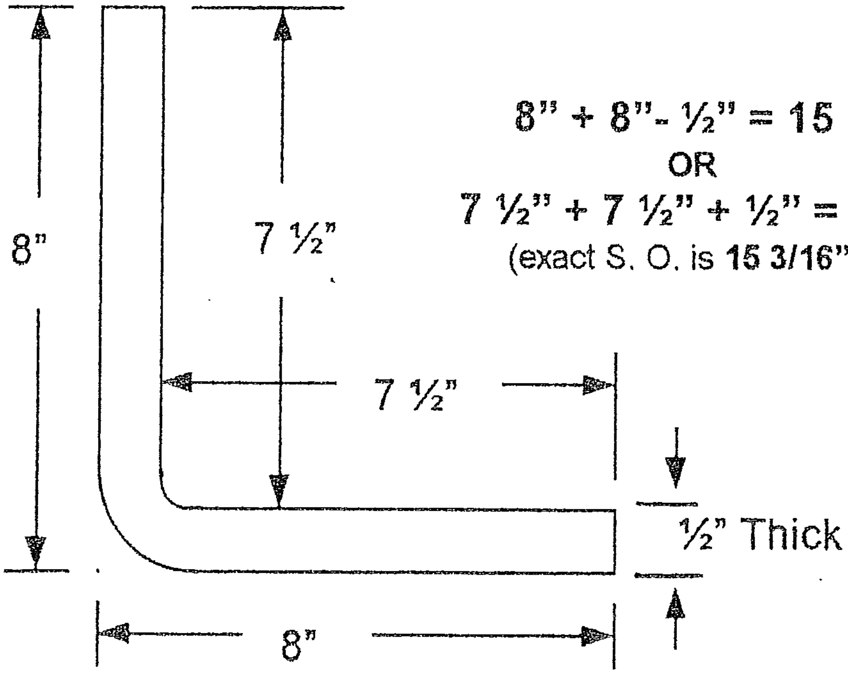
Mild steel	- 4 times thickness	=	1/8"
H.T.S.	- 5 times thickness	=	1/4"
S.T.S., H.Y., CRES	- 6 times thickness	=	1/4"

6. When bending or flanging aluminum do not score the material because it is notch sensitive.

7. When flanging plate up to form a box type corner, the apex should be split prior to flanging to keep the metal from fracturing.

9.2 BEND ALLOWANCE FOR A 90° KNUCKLE FOR REASONABLE ACCURACY

Solve for plate S.O. (stretch out) or O.A.L.
Before the plate is flanged up



8" + 8"- ½" = 15 ½"

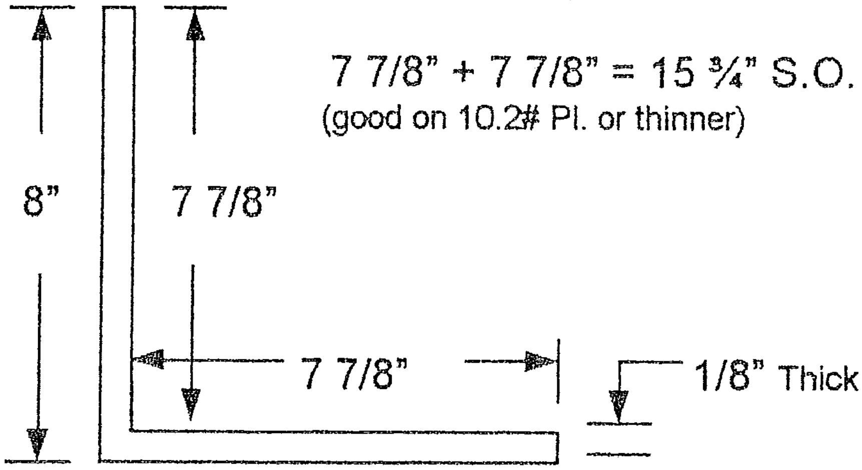
OR

7 ½" + 7 ½" + ½" = 15 ½"

(exact S. O. is **15 3/16"**)

TIGHT BEND FOR LIGHT PLATE 90°

Add inside demensions only for S.O. On compound bends add inside demensions minus corners.

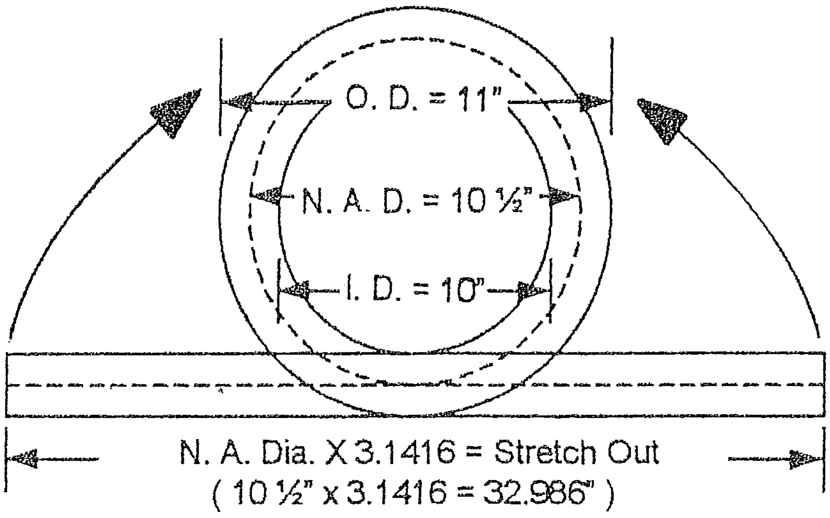


7 7/8" + 7 7/8" = 15 ¾" S.O.

(good on 10.2# Pl. or thinner)

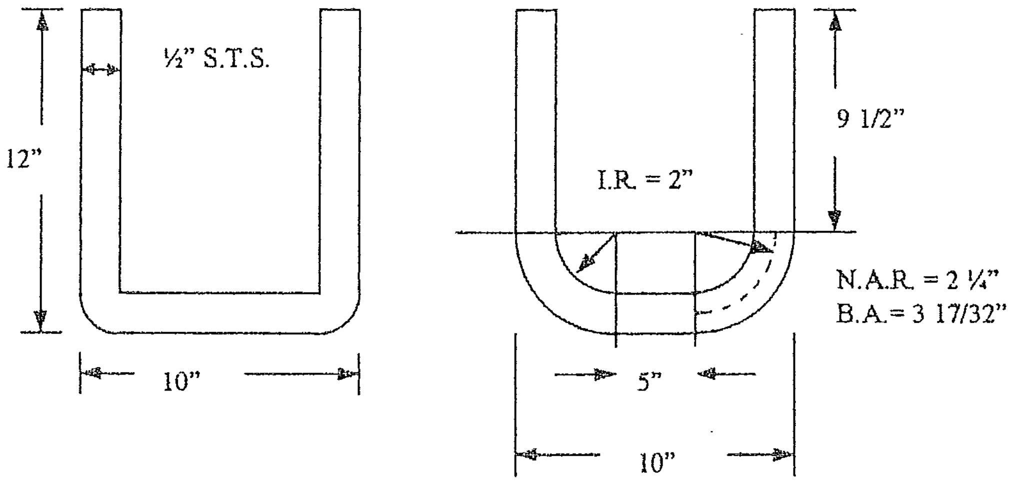
9.3 NEUTRAL AXIS

To calculate the S.O. for a flat pl. being rolled into a cylinder, find N.A. Dia. and multiply by Pi.



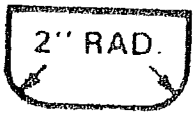
To find N. A. Dia. subtract pl. thickness from O.D. (11" - 1/2" = 10 1/2")
OR add pl. thickness to I.D. (10" + 1/2" = 10 1/2")

9.4 FLANGING WITH A RADIUS



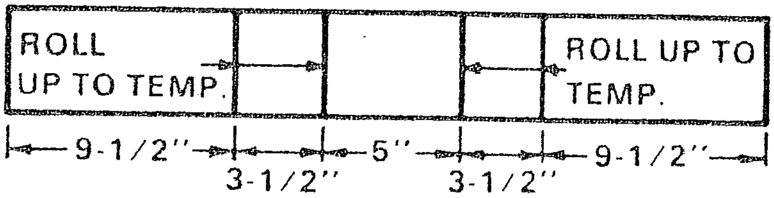
Problem from Blueprint | Sketch - Radius added

Minimum inside radius	=	2" (See chart on next page)
Radius to neutral axis	=	2-1/4"
Neutral axis diameter	=	4-1/2"
Circumference of circle	=	14-1/8"
¼ circumference equals BA	=	3-1/2"+



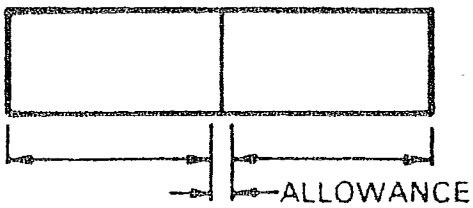
SHAPE TEMPLATE

LAYOUT TEMPLATE



NOTE:

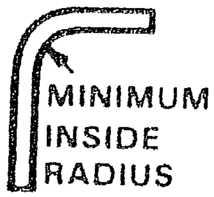
The method shown is used for the larger radii. Although similar problems using smaller
radii may be laid out the same way, it is more practical to lay them out with a single
flange line with one half of the allowance to each side of the line.

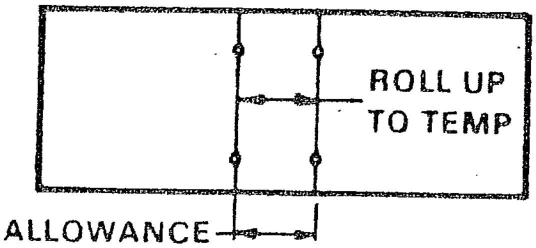


9.5 FLANGING MINIMUM INSIDE RADIUS (IR) AND BEND ALLOWANCE (BA)

These guidelines are for a standard "v" block brake press. The actual minimum inside radius may vary depending on your tooling.

Weight vs Thickness	Mild Steel		High Tensil Steel		Special Tensil Steel	
	IR	BA	IR	BA	IR	BA
10.2# - 1/4"	1/4	19/32	5/16	11/16	1	1-3/4
12.75# - 5/16"	5/16	3/8	13/32	27/32	1-1/4	2
15.3# - 3/8"	3/8	7/8	15/32	1-1/32	1-1/2	2-21/32
17.85# - 7/16"	7/16	1-1/32	35/64	1-3/16	1-3/4	3-1/16
20.4# - 1/2"	1/2	1-3/16	5/8	1-3/8	2	3-17/2
22.9# - 9/16"	9/16	1-5/16	45/64	11-17/32	2-1/4	3-31/32
25.7# - 5/8"	5/8	1-15/32	25/32	1-23/32	2-1/2	4-13/32
28# - 11/16"	11/16	1-5/8	55/64	1-7/8	2-3/4	4-7/8
30.6# - 3/4"	3/4	1-25/32	15/16	2-1/16	3	5-5/16
32.8# - 13/16"	13/16	1-29/32	1-1/64	2-1/4	3-1/4	5-3/4
35.7# - 7/8"	7/8	2-1/16	1-3/32	2-13/32	3-1/2	6-3/16
40.8# - 1"	1	2-3/8	1-1/4	2-9/16	3-3/4	6-5/8
45.9# - 1-1/8"	1-1/8	2-5/8	1-13/32	2-3/4	4	7-1/16
51# - 1-1/4"	1-1/4	2-15/16	1-9/16	3-1/16	4-1/2	7-15/16



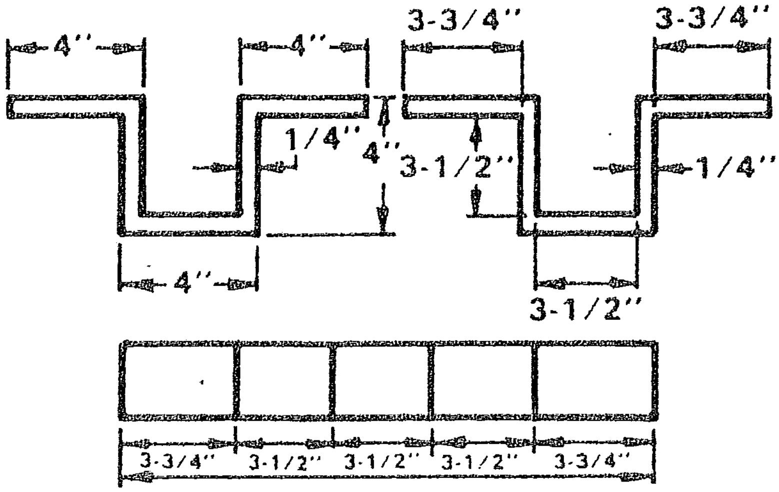


Notes:

Due to the tendencies of steel to fracture under the stress of flanging, only plate under 10 lb. may be flanged without a radius. A list of the minimum allowable radii for plate sizes and types is given with a table of allowances.

The allowance in the above table is the distance between the flange lines and is used to allow enough material for rolling the corner.

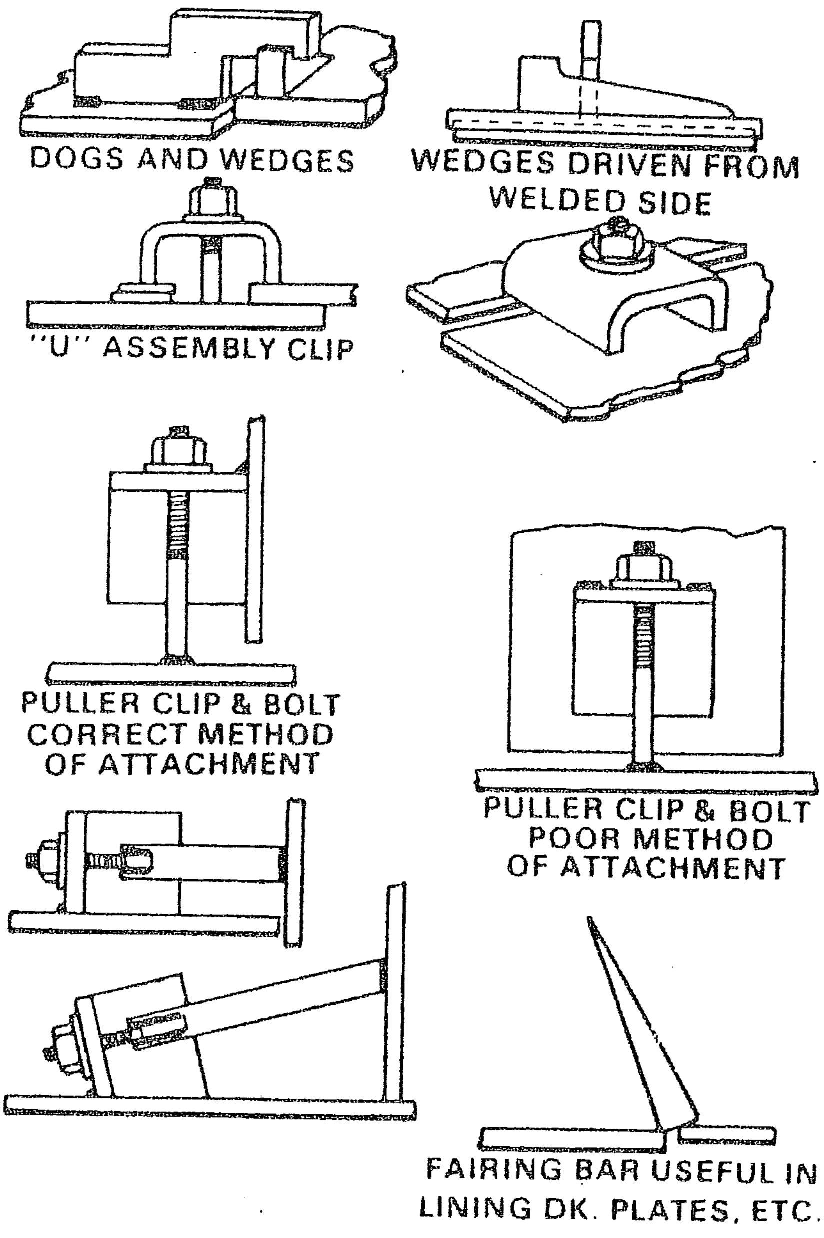
The method used to compute the allowance is shown above.



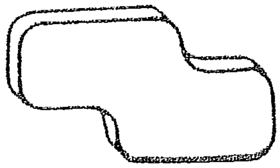
Prior to layout of this type of bend problem, it is necessary to change the dimensions to represent the inside measurements from shear line to flange line, from flange line to flange line, etc., as shown above. This is the only computation necessary whenever square bends are considered as long as the material is under 10 lb. Plate.

10.0
ERECTION AIDS

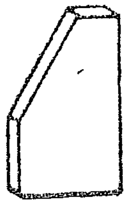
10.1



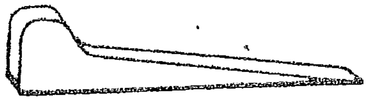
10.2



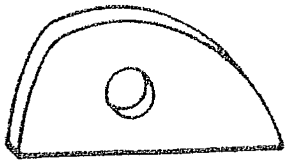
A DOG



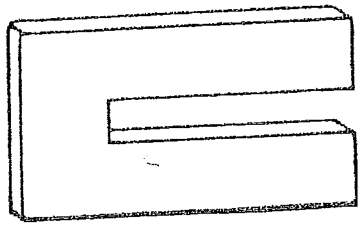
RABBIT EARS



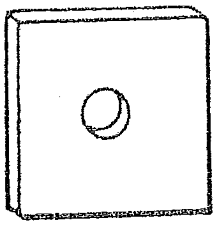
A WEDGE



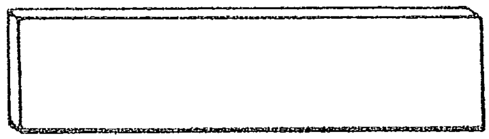
A PAD EYE



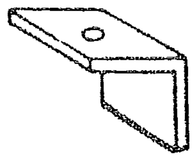
A SADDLE



A BULKHEAD CLIP



A STRONGBACK



A PULLER CLIP

11.0
QUALITY ASSURANCE PROCEDURE

The following Steelwork Production Standards / Quality Assurance Procedures are provided by Todd Pacific Shipyard's Steel and Welding Departments and are acknowledged as such.

11.1 Tolerances of Principle Dimensions & Hull

11.11 **FUNCTION** - The intention of this standard is to define the dimensional tolerances of individual assemblies or unit in relation to principle dimensions and hull form of the completed vessel.

11.12 **SCOPE** - This standard shall apply to all phases of construction involved in ship repair and new ship construction.

11.13 **RESPONSIBILITY** - A) It shall be the responsibility of the Steel Foreman to ensure that all steelwork principle dimensions are maintained within specified tolerances. B) It shall be the joint responsibility of supervisory members of the Steel/Welding and Shipwright Departments to maintain individual component, unit and overall principle dimensions as specified within this standard.

11.14 **PRINCIPLE DIMENSIONS** - A) The overall length between perpendiculars shall be within (+/-0.1%) of ship length. B) The molded breadth amidships shall be within (+/-0.1%) of molded breadth. C) The molded depth shall be within (+/-0.15%) of design molded depth in areas where base line and the keel line are in the same. On rising keels or areas where the keel line and base line differ, the tolerance shall be (2"/100 ft) of the molded depth.

11.15 **HULL FORM** - **A)** Keel deformation (flatness of keel) shall not exceed +/-1 inch for vessels up to 300 ft in length. **B)** Keel deformation (flatness of keel) shall not exceed 2 inch for vessels 300 ft to 500 ft in length. **C)** The maximum permissible hull deformation between two adjacent bulkheads shall not exceed 1/2 inch. **D)** During steelwork construction, keel sights shall be taken routinely and recorded. this information shall be available to the Owners Representation. **E)** The rise of floor amidships taken at the lower turn of the bilge shall be within 1/2 inch of the planned height.

11.2 Dimensional Tolerance of Components, Sub-Assemblies and Units.

11.21 **FUNCTION** - The intention of this standard is to define the dimensional tolerances of individual components sub-assemblies and units or assemblies.

11.22 **SCOPE** - This standard shall apply to all phases of construction involved in Ship Repair and New Ship Construction.

11.23 **RESPONSIBILITY - A)** It shall be the responsibility of the Steel Foreman to ensure that individual tolerances are maintained in such a manner as to achieve the desired principle dimensions and hull form. **B)** It shall be joint responsibility of Supervisory members of the Steel/Welding and Shipwright Departments to maintain individual component, sub-assembly, unit or assembly dimensional tolerances as specified within this standard.

11.24 **INDIVIDUAL COMPONENTS - A)** Relevant piece part and plate dimensions shall be specified in the material preparation standard 11.8. **B)** Overall piece part stiffener and plate relevant dimensions shall be within the limits specified by process below.

N.C. Plasma	+/- 1/16"
N.C. Oxy/Fuel Gas Straight Edge	+/- 1/16"
N.C. Oxy/Fuel Bevel Edge	+/- 1/8"
Manual Preparation	+/- 1/8"
Shearing	+/- 1/16"

C) Component, plate and panel marking shall be within the limits specified below.

Hand Marking	+/- 1/16"
N.C. Powder Marking	+/- 1/16"
N.C. Punch Marking	+/- 1/16"
Centerlines and Waterlines	+/- 1/16"
Scribes	+/- 1/16"

D) Multi-plate panels shall be square within I degree or accurate to within 1/4" on principle dimension. E) Panel frame and stiffener placement shall be accurate to within 1/4" from a general reference point or datum. F) Frame and stiffener attitude to shell or panel surface shall be accurate to within +/-2 degrees of desired angle. G) face plate, rider bars and compensation rings shall be square to member within +/-2 degrees unless specified otherwise.

11.25 **FLAT PLATE BLOCK UNITS OR SUB-ASSEMBLIES** A) Flat plate units or subassemblies shall be accurate to within 1/8" on the principle dimensions. B) Flat plate units or sub-assemblies shall be square within 1/4" over the principle dimensions. C) Twist on flat plate units or sub-assemblies when measured at relevant points on the outer extremities of the unit or sub-assemblies shall not exceed 1".

11.26 **CURVED PLATE BLOCK UNITS OR SUB-ASSEMBLIES**
A) Curved plate units or sub-assemblies shall be accurate to within 1/4" on the principle dimensions. B) Curved plate units or sub-assemblies shall be square to within 1/4" over the principle dimensions. twist on curved plate units or sub-assemblies when measured at relevant points on the outer extremities of the unit or sub-assembly shall not exceed 1" from the norm.

11.27 **SHELL AND PANEL FLATNESS**

FAIRNESS CRITERIA

	MISC BHDS, DK HOUSE SIDES & TOPS, MISC FLATS, FUNNEL & SPOILER				ALL SHELL PLTG INCLUDING F.P.K. & GUARD, CURTAIN PLTG, VEH, PASS & SUN DKS & MN BHDS				
STIFF SPCNG	7.65 lb. (3/16")	10.2 lb (1/4")	12.75 lb (5/16")	15.3 lb (5/16")	7.65 lb (3/16")	10.2 lb (1/4")	12.75lb (5/16")	15.3 lb (3/8")	20.4 lb (1/2")
28"	3/8"	3/8"	3/8"	5/16"	5/16"	5/16"	5/16"	5/16"	5/16"
26"	5/16"	3/8"	5/16"	5/16"	5/16"	5/16"	5/16"	5/16"	5/16"
24"	5/16"	5/16"	5/16"	1/4"	5/16"	5/16"	5/16"	5/16"	1/4"
22"	5/16"	5/16"	1/4"	1/4"	5/16"	5/16"	1/4"	1/4"	1/4"
20"	5/16"	1/4"	1/4"	3/16"	1/4"	1/4"	1/4"	3/16"	-
18"	1/4"	1/4"	3/16"	3/16"	1/4"	3/16"	3/16"	3/16"	-
14"	3/16"	3/16"	3/16"	-	3/16"	3/16"	3/16"	-	-

A) Correction of excessive variance in shell or panel flatness shall be corrected either by re-fairing, flame shrinking or by the addition of extra stiffeners. The specific method shall be decided by the Steel Department Supervisory Staff upon consideration of circumstances and degree or correction required. **B)** All fabrication and erection butt and/or seam joints on shell, decks or panel units such as flats or bulkheads, shall be aligned within 15% of the adjoining plate thickness. **C)** Correction of misalignment beyond 15% of the adjoining plate thickness shall be achieved by splitting the butt or seam in the area to be corrected and re-fairing either by mechanical means or line heating. The specific method shall be decided by the Steel Department Supervisory Staff upon consideration of the material thickness and degree or correction required.

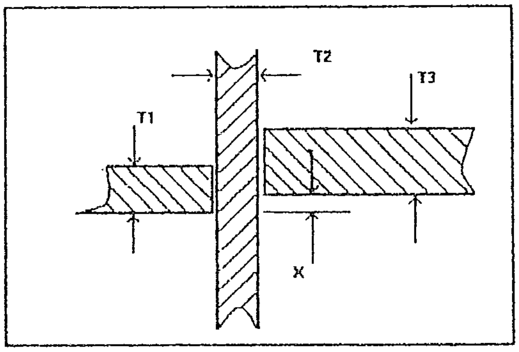
11.3 ALIGNMENT OF COMPONENTS BACKING-UP OR BACKED-UP BY ANOTHER COMPONENT

11.31 **FUNCTION** - The intention of this standard is to define the limit of misalignment and corrective action required for fitting of steelwork members or components which either back up or are backed up by another member or component.

11.32 **SCOPE** - This standard shall apply to the fitting accuracy and alignment of brackets, tripping brackets, intercostal girders, webs, longitudinals, etc., on ship repair and new ship construction.

11.33 **RESPONSIBILITY** - **A)** It shall be the responsibility of the Steel Foreman to ensure that all fitting and/or corrective action comply with this standard. **B)** It shall be the responsibility of all Steel Supervisors to ensure that all work complies with the limits or tolerances as specified in this standard.

11.34 **MAXIMUM MISALIGNMENT**



A) On primary structure, "x" may be equal to, but not greater than (1/2 of T1) where T1 is the thinnest of the backing up sections. **B)** To compensate for misalignment as specified in 11.34 A, the weld size on both backing up sections must be increased by amount equal to the misalignment. **C)** On secondary structure "x" may be equal to, but not greater than (1/2 of T3) up to a maximum of (3//4 of T1) where T1 is the thinner of the backing up sections and T3 is the thicker of the backing up sections. **D)** If T3 is the same thickness as Y1, standard 11.34 C, the weld size must be increased by an amount equal to the misalignment.

11.35 **CORRECTION** - **A)** Misalignment beyond the tolerance specified in 11.34 A must be còrrected by releasing section and realigning over 1 frame space or length equal to 50 "x". **B)** Misalignment beyond tolerance specified in 11.34 C must be corrected by either releasing section and realigning over 1 frame space or a length equal to 50 "x". Or backing up the structure, using a lap plate lapped onto out-of-alignment section and fillet welded.

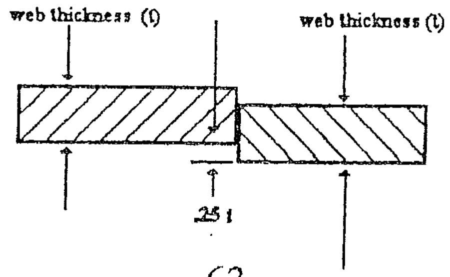
11.4 MISALIGNMENT OF STRUCTURAL COMPONENTS

11.41 **FUNCTION** - The intention of this standard is to define the limit of misalignment and corrective action required for the fitting of steelwork longitudinals and transverse frames.

11.42 **SCOPE** - This standard shall apply to the fitting accuracy and alignment of longitudinals and transverse frames on ship repair and new construction.

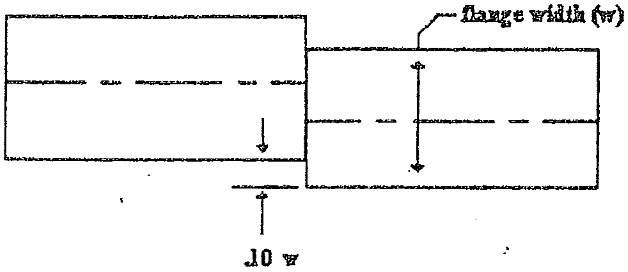
11.43 **RESPONSIBILITY** - **A)** It shall be the responsibility of the Steel Foreman to ensure that all fitting and/or corrective action complies with this standard. **B)** It shall be the responsibility of all Steel Department Supervisors to comply with the limits or tolerances as specified within this standard.

11.44 **WEB** - **A)** Alignment of web portion of longitudinal or transverse frame shall be within 25% of the thinnest web section up to a maximum of 1/4".



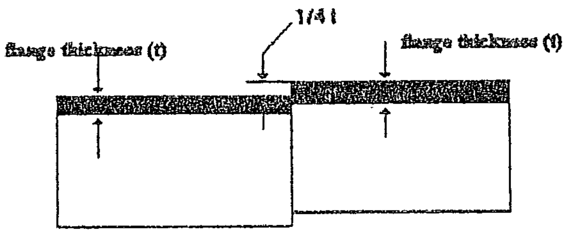
B) Misalignment beyond that allowed in 11.44 A, shall be corrected by releasing and realigning over a distance of one frame space or (50 x the amount of correction required).

11.45 **FLANGE MISALIGNMENT - A)** Alignment of the flange portion of "T" style longitudinals or stiffeners shall be within 10% of the flange width up to a maximum of 1/4".

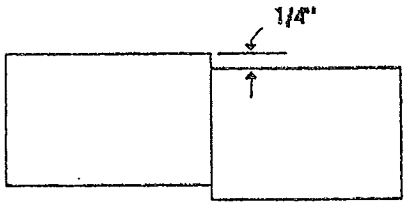


B) Misalignment beyond that allowed in 501 shall be corrected by releasing the misaligned portion of the flange from the web for a distance of (50 x the amount of misalignment) and refairing.

11.46 **LONGITUDINAL HEIGHT MISALIGNMENT - A)** Misalignment of longitudinal or stiffener height shall not exceed 25% of the flange thickness up to a maximum of 1/4".



B) Height misalignment of longitudinals or stiffeners of the flat bar style shall not exceed 1/4".



C) Misalignment beyond that allowed in 601 and 602 shall be corrected by releasing the misaligned portion of the longitudinal, stiffener or transverse frame by an amount consistent with achieving proper alignment.

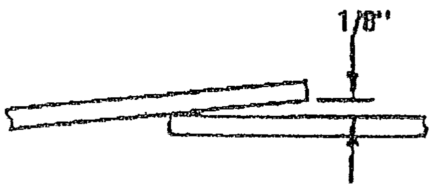
11.5 MISALIGNMENT OF LAPPED STRUCTURE

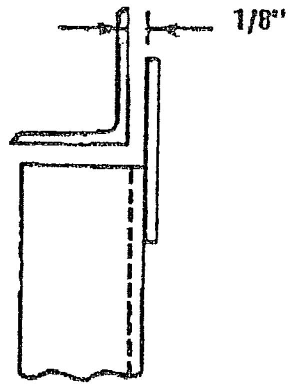
11.51 **FUNCTION** - The intention of this standard is to define the limit or degree of misalignment and corrective action required for the fitting of steelwork components which lap onto adjoining structure.

11.52 **SCOPE** - this standard shall apply to the fitting accuracy and alignment of lap components on ship repair and new ship construction.

11.53 **RESPONSIBILITY** - **A)** it shall be the responsibility of the Steel Foreman to ensure that all fitting and/or corrective action complies with this standard. **B)** It shall be the responsibility of all Steel Department Supervisors to comply with the limits or tolerances as specified within this standard.

11.54 **LAP MISALIGNMENT** - **A)** The maximum gap allowable between lapping structure shall not exceed 1/8".





B) Excessive gap shall be corrected by increasing the weld size to compensate for gaps in excess of 1/16" but less than 1/4". **C)** gaps in excess of 1/4" shall be corrected by realignment of lapping structure or bracket.

11.6 STRUCTURAL INSERTS

11.61 **FUNCTION** - the intention of this standard is to define the type, size and method of installing inserts.

11.62 **SCOPE** - **A)** This standard shall apply to inserts fitting into new or existing structure on new ship construction and ship repair. **B)** This standard shall apply to inserts resulting from access openings, steelwork repairs or construction errors.

11.63 **RESPONSIBILITY** - **A)** It shall be the responsibility of the supervisory staff of the Steel/Welding Departments to comply with the method and sequence of insert installation and size. **B)** It shall be the responsibility of the Steel Foreman to authorize the size and location of all temporary openings required for access, ventilation or services.

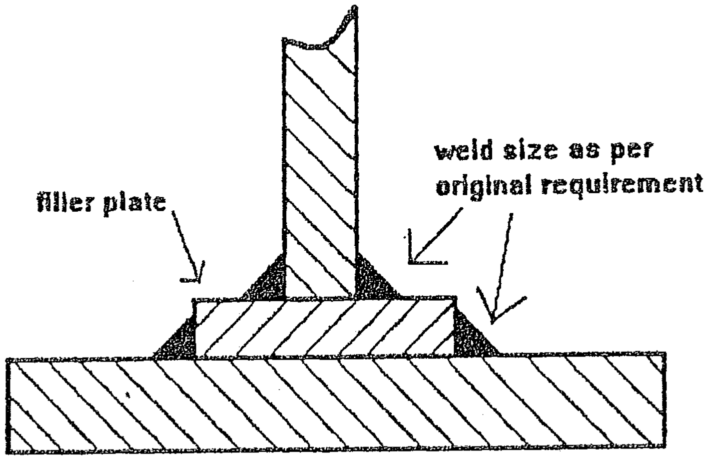
11.64 **TEMPORARY OPENINGS FOR ACCESS, VENTILATION OR SERVICES** - **A)** The minimum size insert allowable for temporary openings shall not be less than 12" without prior consultation with the ABS/Coast Guard or Owners Representative. **B)** All inserts shall have corner radii of not less than 2", unless the insert location corresponds with an existing butt/seam intersection. **C)** Where possible, inserts shall not be located within 12" of an existing butt or seam weld. **D)** Inserts may be fitted with a steel backup strip, which may be left in place on structure with a Class 3 or 4 finish as outlined in 11.86 or 11.87, provided that the backup strip is continuously welded to either the insert or to the surrounding plate. **E)** Inserts may be fitted with a steel backup strip, which may be left in place on structure with a Class 2 finish as outlined in 11.85, provided that the backup strip is welded continuously to both the insert and the surrounding plate. **F)** Inserts may be fitted with a steel backup strip, which must be removed by chipping, arc-air gouging and grinding on structure with a Class 1 finish as outlined in 11.84. **G)** All inserts fitted with steel backup strips shall have a minimum root opening of 1/4". Where included joint angle is less than 60 degree root opening must be increased to allow proper root access. **H)** All inserts 1/2 inches or thicker shall be welded with a basic or low hydrogen type electrode or wire approved for the grade of material involved. **I)** In instances where an existing butt and/or seam form part of the insert connection, the existing welded connection in the butt and/or seam must be cut back or released for a distance of 6" maximum beyond the insert opening. **J)** In instances where framing or support structure attach to or form part of the inserted area, framing or structure shall be released for a distance of 6" beyond the inserted section if the structure or framing crosses the insert connection. **K)** Welding sequence for all inserts shall be as illustrated in 11.65 A.

11.65 **MATERIAL REPLACEMENT INSERTS - A)** The minimum size insert allowable shall not be less than the following without prior consultation with the ABS/Coast guard or Owners Representative.

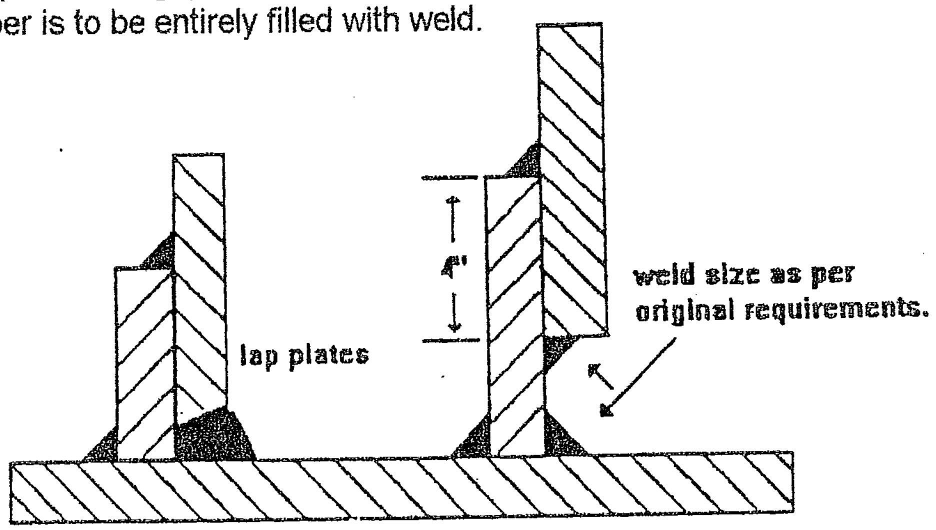
- 12 inches wide on strip inserts
- 12 inches minimum dimension on shell inserts
- 12 inches length on longitudinal, frame or stringer inserts

B) On occasions whereby the conditions as outlined in 11.65 A are unable to be adhered to, the size shall be determined by the Steel Forman or Superintendent in consultation with the Owner Representative and the ABS/Coast Guard Inspector along with other relevant parties. **C)** The root gap opening for all inserts shall not exceed the maximum specified opening as stipulated within the appropriate welding procedure specification and edge preparation standard. **D)** Inserts shall not be located within 12 inches of an existing butt or seam weld without prior consultation with the owner representatives and the ABS/Coast Guard Inspector. **E)** The first two layers on all inserts fitted with or without steel or ceramic backup, shall be welded using a back-step technique. **F)** All inserts 1/2" or thicker, shall be welded with a basic or low hydrogen type electrode or wire, approved for the grade of material being welded. **G)** All inserts 7/8" or thicker shall have a corner radii of not less than 3", unless the insert location corresponds with an existing butt/seam intersection. **H)** All inserts 7/8" shall have a corner radii of not less than 2", unless the insert location corresponds with an existing butt/seam intersection. **I)** In instances where an existing butt and/or seam form part of the insert connection, the existing welded connection in the butt and/or seam must be cut back or released for a distance of 6" beyond the insert opening. **J)** In instances where framing or support structure attach to or form part of the inserted area, framing or structure shall be released for a distance or 6" beyond the inserted section, if the structure or framing crosses the insert connection. **K)** Welding sequence for all inserts shall be as illustrated.

11.66 **FILLET CONNECTION FILLER PLATE AND LAP PLATES - A)** Fillet connection filler plates shall not be used without prior agreement from owners and ABS/Coast Guard Inspectors. **B)** Fillet connection filler plates shall not be used in instances where attaching members are loaded in a tensile manner. **C)** Fillet connection filler plates shall not be less than 1-1/2" wider than the perpendicular attaching member. **D)** Filler plates should not be used where attaching members are loaded in a tensile manner.



E) Fillet connection lap plates shall not be used without prior agreement from the owners and ABS/Coast Guard Inspectors. **F)** Lap plates shall not be less than 4" wide, and fitted in such a manner as to leave a minimum gap between the plate to be lapped and the adjoining member of 4" , for welding access, unless the lap plate is to be utilized as a backup and the gap between the plate being lapped and the adjoining member is to be entirely filled with weld.



G) Weld sizes on filler and lap plates be the same as specified in the original structure.

11.7 MATERIAL PREPARATION USING OXY/FUEL GAS, PLASMA OR SHEARING

11.71 **FUNCTION** - The intention of this standard is to define the requirements of material preparation methods regarding finish, cut quality and accuracy.

11.72 **SCOPE** - **A)** This standard will apply to all New Ship Construction, Ship Repair and Industrial Work. **B)** This standard will define the finish, dimensional accuracy and general cut quality of all material cuts completed using either plasma, oxy/fuel gas techniques or shearing. **C)** This standard will define corrective measures to be utilized in the repair of cut surfaces which are unacceptable to this standard.

11.73 **RESPONSIBILITY** - **A)** It shall be the responsibility of the Steel Foreman to ensure that all material preparation is carried out in accordance with this standard. **B)** It shall be the responsibility of the Steel/Welding Department Foreman to ensure that all preparation work is carried out by individuals with the necessary training, skill and ability.

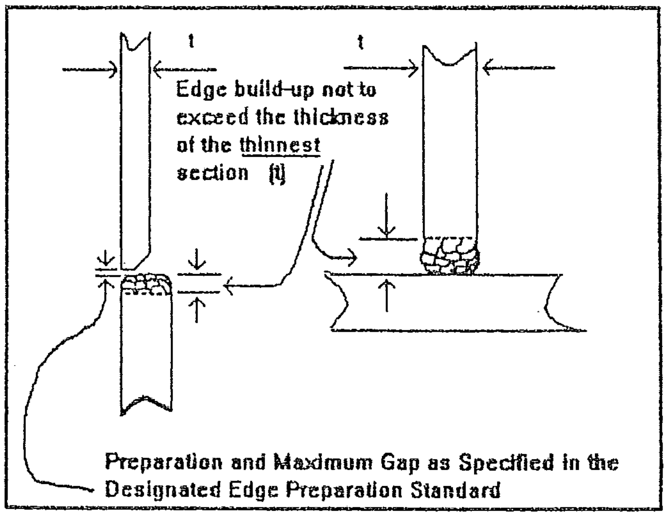
11.74 **CRITERIA - OXY-FUEL CUTTING** - **A)** Cut surface roughness level shall be judged in accordance with the visual example levels illustrated on the A.W.S. C4.1.77 Standards Gauge. **B)** All machine or mechanized cuts either on beveled edged or square cuts shall not be of a level lower than 3 in comparison with the A.W.S. C4.1.77 Standards Gauge. **C)** All hand or manual cuts on either beveled edges or square cuts which form part of a welding preparation shall not be of a level lower than 2 on the A.W.S. C4.1.77 Standards Gauge. **D)** All hand or manual cuts on square cuts not forming part of a welding preparation shall not be of a level lower than 1 on the A.W.S. C4.1.77 Standards Gauge. **E)** All automatic or machine cuts shall not exceed 1/16" from the desired cut path. **F)** All hand or manual cuts shall not exceed 1/8" from the desired cut path. **G)** All automatic or machine bevel cuts shall not exceed +/- 3 degrees of the required bevel angle. **H)** All manual or hand bevel cuts shall not exceed +/- 5 degrees of the required bevel angle. **I)** All burning slag shall be removed at time of cut.

11.75 **CRITERIA - PLASMA CUTTING** - **A)** Cut surface roughness level shall be judged in accordance with the visual example levels illustrated on the A.W.S. C.4.1.77 Standards gauge. **B)** All plasma cuts shall not be of a level lower than 3 in comparison with the A.W.S.

C.4.1.77 Standards Gauge. **C)** All plasma cuts shall be square within +/- 3 degrees. **D)** All plasma cuts shall not exceed 1/16" from the desired cut path. **E)** All burning slag shall be removed at time of cut.

11.76 **CRITERIA - SHEARING** - **A)** All sheared plate edges to be square within +/- 1 degree. **B)** Shearing deformation or roll shall not exceed 1/32", **C)** Any sharp edges or slivers which present a potential safety hazard shall be dressed smooth. **D)** All shear cuts shall not exceed +/- 1/16" from the desired path.

11.77 **DEFECT REPAIR** - **A)** Isolated burning gouges with a depth greater than 1/8" will be corrected by melding and grinding. **B)** Isolated burning gouges with a depth less than 1/8" will remain unless by their location are deemed to jeopardize the structural integrity or welding quality. **C)** Repairs to surface discontinues beyond the acceptable roughness level in comparison with A.W.S. C.4.1.77 Standards Gauge, shall be ground to within the roughness level applicable. **D)** Welded defect repairs will be completed using E-7018 electrode. **E)** Plate lamination shall be repaired either by grinding or arc-air gouging and welding or by inserting the laminated area, depending on the size of lamination and location within the structure. Where the dimensional extent of the lamination is unknown, ultrasonic inspection shall be used to determine the area size and boundaries. The repair method shall be at the discretion of the Steel Foreman or Superintendent after consultation with the design office, owners representative and the ABS/Coast Guard surveyor. **F)** Material preparation cuts beyond the tolerance specified in Section 11.7 may be corrected either at the material preparation stage or at the material fit-up stage by building up one or both of the abutting edges to a maximum built-up thickness equal to the thickness of the thinner of the adjoining plates.



11.8 STEELWORK FINISHING STANDARDS

11.81 **FUNCTION** - **A)** The intention of this standard is to define the class of surface finish as dictated by good shipbuilding practice, appearance and regulatory requirements. **B)** The removal of lugs, fairing aids and temporary pieces along with the welding of scars and grinding shall be the responsibility of the Steel Foreman or Superintendent.

11.82 **SCOPE** - **A)** This standard will apply to all New Ship Construction, Ship Repair and Industrial Work. **B)** This standard will define the grade or class of acceptable finish, along with the appropriate method of attaining the required finish.

11.83 **RESPONSIBILITY** - **A)** The class or grade of finish for each project shall be determined and identified by area or zone by the Project Superintendent in consultation with the Technical Director and Steel Foreman or Superintendent. **B)** It is the responsibility of the Steel Foreman to assure conformance to this standard and that surface repairs are carried out in accordance with specified procedures.

11.84 **SPECIFICATIONS - CLASS 1 - A)** A Class 1 finishing shall apply to all areas or zones requiring good appearance. typical areas such as hull exterior, exposed deck, painted bulkheads in machinery rooms and walkways, bulwarks, fairleads and bollards. **B)** **Criteria** 1. All lugs, temporary fairing aids, studs, etc. to be removed completely and finished by chipping or grinding. 2. Weld repairs such as undercut or unacceptable bead contour shall be welded and ground to an acceptable contour free of sharp edges and irregularities. 3. All plate scars to be welded with consumables approved for the grade of plate involved then ground flush. 4. Welding spatter and slag shall be removed prior to painting, all burning slag shall be removed from cut edges, light adhering dross shall not be removed. 5. Sharp plate edges from burning or shearing shall be lightly ground. **C)** All exterior hull welds shall be in accordance unless the construction or repair contract, a specialized hull coating, or welds which are located within a specific proximity to sonar equipment require a weldment finish in excess of that attained using normal hull welding processes and techniques.

11.85 **SPECIFICATIONS - CLASS 2 - A)** A Class 2 finishing standard shall apply to all areas or zones requiring an acceptable finish. Typical areas such as cargo holds, exposed machinery space, deckheads, seachests and seabays, locker spaces and general stores. **B)** **Criteria** 1. All staging and lifting lugs to be continuously welded and left in place unless they directly constitute an operational or safety hazard. 2. Staging and lifting lugs which do constitute an operational or safety hazard shall be cut off flush with the top of the attaching fillet welds and the cut surface ground free of any sharp edges or irregularities. 3. All irregular projections such as fairing-aid tack melds shall not be access of 1/8' and smooth bead welded only. 4. All plate scare to be welded with consumables approved for the grade of plate involved. 5. All loose welding spatter and slag shall be removed prior to painting. 6. All burning slag shall be removed from cut edges, light adhering dross shall not be removed. 7. Steel backup strips fitted in accordance with 11.6 may be left in place, provided that the backup strip is welded continuously to both the insert and the surrounding plate.

11.86 **SPECIFICATIONS - CLASS 3 - A)** A Class 3 finishing standard shall apply to all areas or zones not requiring a good finish. Typical areas such as void spaces, fuel tanks, covered decks. **B)** **Criteria** 1. All staging and lifting lugs to be continuously welded and left in place. 2. All plating scars shall be welded with consumables approved for the grade of plate involved. 3. All irregular projections such as fairing aid tacks shall be smooth bead welded only. 4. All burning slag shall be removed from cut edges, light adhering dross shall not be removed. 5. All loose welding spatter and slag shall be removed. 6. Steel backup strips fitted in accordance with 11.6 may be left in place, provided that the backup strip is welded continuously to either the insert or the surrounding plate.

11.87 **SPECIFICATIONS - CLASS 4 - A)** 1. A Class 4 finishing standard shall apply to all areas or zones covered with insulation, ceiling panels or bulkhead linings or panels. 2. Staging and lifting lugs shall remain in place. 3. Any protrusions which hinder the installation of the covering shall be cropped to a suitable size and left in place. 4. Only plating scars deemed to jeopardize the structural integrity shall be welded with consumables approved for the grade of plate involved. 5. Slag shall be removed from cut edges, light adhering dross shall not be removed. 6. All loose welding spatter and slag shall be removed. 7. Steel backup strips fitted in accordance with 11.6 may be left in place, provided that the backup strip is welded continuously to either the insert or the surrounding plate.

11.9 HOSE AND PRESSURE TESTING OF STRUCTURAL AREAS AND ACCESSES

11.91 **FUNCTION** - The intention of this standard is to define the method of testing and the requirements for hose and pressure testing of structural areas and accesses.

11.92 **SCOPE** - This standard shall apply to all new ship construction and ship repair.

11.93 **RESPONSIBILITY** - **A)** It shall be the responsibility of the Steel Foreman to ensure that testing is carried out in accordance with this standard. **B)** It shall be the responsibility of the Steel Department through its tank testing supervisor to carry out the tests in accordance with this standard. **C)** It shall be the responsibility of the Steel and Welding Foreman supervising the steelwork erection and welding of the area to be tested, to notify the tank testing supervisor upon completion of steelwork survey. **D)** It shall be the responsibility of the Superintendent to notify the tank testing supervisor upon completion of all outfitting work within the area to be tested which could affect the integrity or validity of a test on that area or tank. **E)** It shall be the responsibility of the Foreman or Assistant Foreman supervising the tank test crew, to organize a proof test and schedule through Todd Quality Assurance Department or Craft Quality Control Inspector, a time whereby the governing classification agency, government regulatory bodies and owner representatives can, if they wish, witness the integrity of the tank, area or access in question.

11.94 **TESTS** - **A)** Hose or pressure testing of an area or access shall not be carried out until the visual steelwork inspection has been completed, unless specifically agreed to by the Steel Foreman or Superintendent in consultation with the surveying agencies. **B)** Hose, air and hydrostatic tests must be carried out in an organized and scheduled manner, and timed as conveniently as practical, with regards to the overall production schedule of the vessel, the efficient operation of the tank test crew, as well as the availability of the representatives of the classification agency, government regulatory bodies and owner representatives. The notification of test witness time will, whenever possible, be scheduled the previous afternoon for morning tests and before 9:00 a.m. for afternoon tests. However, due to the nature and set-up required for these tests, exceptions will arise. **C)** Appropriate tank test survey forms are to be completed and signed by the

Inspecting Authorities indicating compliance for the whole or partial area tested. All deficiencies or non-conforming items are to be noted on this form. (Todd Forms TS649C Rev 5/6/86). **D)**All deficiencies or non-conforming items noted during the tank test survey are to be clearly marked. A list of these deficiencies will be forwarded as soon as practical through the appropriate Supervisor for corrective action. Upon completion of these deficiencies, the Surveying Authorities are to be advised and verification of deficiency correction arranged where necessary. All deficiencies and non-conforming items must be corrected and signed off by Surveying Authorities before final acceptance of hose or pressure test.

11.95 **AIR JET AND WATER HOSE TESTING** - **A)** Hose testing shall be carried out on and in accordance with the specified areas and rules as outlines in Applicable ABS/Coast Guard Rules. **B)** Area subject to hose testing: mounted watertight doors, watertight bulkheads, tunnels, flats and recesses, bow, side and stem doors, weathertight doors and other weathertight appliances, weathertight steel hatch covers, weather decks and waterways, windows and sidelights, and exterior structures. **C)** Test requirements: air pressure (80 psig), nozzle distance (as close as possible), water pressure (30 psig), and nozzle distance (5 feet).

11.96 **AIR OR LEAK TESTING** - **A)** Leak testing shall be carried out on and in accordance with the specified areas and rules as outlines in ABS/Coast Guard Rules. **B)** Areas subject to air or leak testing: 1. Air or leak testing is normally carried out routinely as a pre-hydrostatic proof check at the discretion of the builder. Air or leak testing may however, be substituted for an area or tank hydrostatic test in accordance with the applicable ABS/Coast Guard rules. 2. Prior approval relative to the above rules and provisions must be attained in writing in order to assure test validity. **C)** Test Requirements: 1. A soapy water solution is applied to the tank boundaries while the tank is subjected to a pressure of 2 psig. 2. Air or leak testing is normally carried out before boundaries are coated with protective coatings.

11.97 **HYDROSTATIC TESTING** - **A)** Pressure testing shall be carried out on and in accordance with the specified areas and rules as outlined in ABS/Coast Guard Rules. **B)** Areas and pressure or head requirements subject to hydrostatic testing: 1. Deep tanks, bunker and peak tanks including closing arrangements (8 feet) above highest point of tank excluding hatchway or to the top of the vent pipe, whichever is greater. 2. Water ballast tanks (8 feet) above highest point of tank excluding hatchway or to the top of the vent pipe, whichever is greater. 3. Double plated rudders (8 feet) with rudder laid on its side or to be a head equal to the vertical height of the rudder, whichever is greater. 4. Cargo tanks, cofferdams, void spaces (8 feet) above the highest point of tank excluding hatchways or to the top of the vent pipe, whichever is greater. 5. Double bottom tanks to top of evenflow.

11.98 **LEAK REPAIR** - **A)** All minor leaks on void tanks, found during an air or leak test or during a hydrostatic test shall be repaired by peening or bobbing, or by welding or a combination of both. Repairs carried out with tank under pressure must be peened or peened first, then welded. **B)** All minor leaks on oil or water tanks, found during an air or leak test or during a hydrostatic test, shall be repaired by peening or bobbing and welding. repairs carried out with the tank under pressure may be peened to stop the leak, but must be permanently repaired by welding. **C)** Major leaks shall be repaired by lowering tank pressure and carrying out the appropriate repair from either inside or outside of tank or area. **D)** On hatches, doors or other watertight appliances, leak repairs shall be carried out as required.

12.0
GENERAL SHIPFITTING ABBREV.

ABL	Above Base Line
ALUM	Aluminum
AMM	Ammunition
A.O.	Access Opening
A.P.	Aft Perpendicular
A.P.	Airport
A.T.	Air Tight
A.T.D.	Air Tight Door
A.T.Q.A.D.	Air Tight Quick Acting Door
AUX.	Auxiliary
A.V.H.C.	Air Vent Hose Connection
B.A.	Bulb Angle
B.C.	Bolt Center/Bolt Circle
BET.	Between
BEV.	Bevel
BEV.PN.	Bevel Plane
B.H.	Breast Hook
BHD.	Bulkhead
BK	Bilge Keel
BKT.	Bracket
B.L.	Base Line
BM.	Beam
B.M.	Bolted Manhole
B/M	Bill of Material
BOT.	Bottom
B. P.	Bevel Plane
B.P.	Breather Plug/Bolted Plate as in FL OT BP MH
BR.	Bridge
BRG.	Bearing
BRS.	Brass
B.S.	Butt Strap

BUTT.	Buttock
B.W.	Butt Weld
BZ.	Bronze
C-C or C to C	Center to Center
C.BORE	Counter Bore
CH.	Channel
CIR.	Circumference/Circle
C.L. or C	Center Line
CL.	Collar
CLK.	Caulk
C.M.	Check Marks or Check Measure
CMG. Or COAM.	Coaming
COFF.	Cofferdam
COL.BH.	Collision Bulkhead
COMP.	Composition/Composite
COMP'T	Compartment
COND.	Condenser
CONT.	Continuous/Continued
CRES.	Corrosion Resisting Steel
C.R.S.	Cold Rolled Steel
CSK.	Countersink
CTRS.	Centers
CU.FT.	Cubic Feet
C.V.K.	Center Vertical Keel
D. Or DIA.	Diameter
DBL.	Double or Doubler
D.C.	Dead Cover or Damage Control
DET.	Detail
DIAG.	Diagonal
DISCH.	Discharge
DK.	Deck
DN	Down
DR.	Drill
DWG.	Drawing
D.W.L.	Designated Water Line
DWT.	Deadweight
ELEC.	Electrical

ELEV.	Elevation
E.M.	Expanded Metal
E.R.	Engine Room
E.S.	Escape Scuttle
EXP.	Expanded
F.A.T.H.	Flush Air Tight Hatch
F.B.	Flat Bar
FDN.	Foundation
F.K.	Flat Keel
F.L.	Folding Line
FL.	Floor
FLG.	Flange
F.L.W.T.B.P.A.V.H.C.	Flush Water Tight Bolted Plate Air Vent Hose Connection
F.N.T.H.	Flush Non Tight Hatch
F.O.	Fuel Oil
FOSCLE	Forecastle
F.O.T.M.H.	Flush Oil Tight Man Hole
F.P.	Forward Perpendicular
FR	Frame
FT.	Feet
F.T.	Fume Tight
FWD.	Forward
F.W.T.	Fresh Water Tank
F.W.T.H.	Flush Water Tight Hatch
F.Z.	Fire Zone
GALV.	Galvanize
GAR.STR.	Garboard Strake
GIRD.	Girder
GRTG	Grating
GWL.	Gunwale
H.	H Beam or Heel
HGT.	Height
H.P.	High Pressure
H.R.	Half Round
H.T.	Heat Treat
H.T.S.	High Tensile Steel

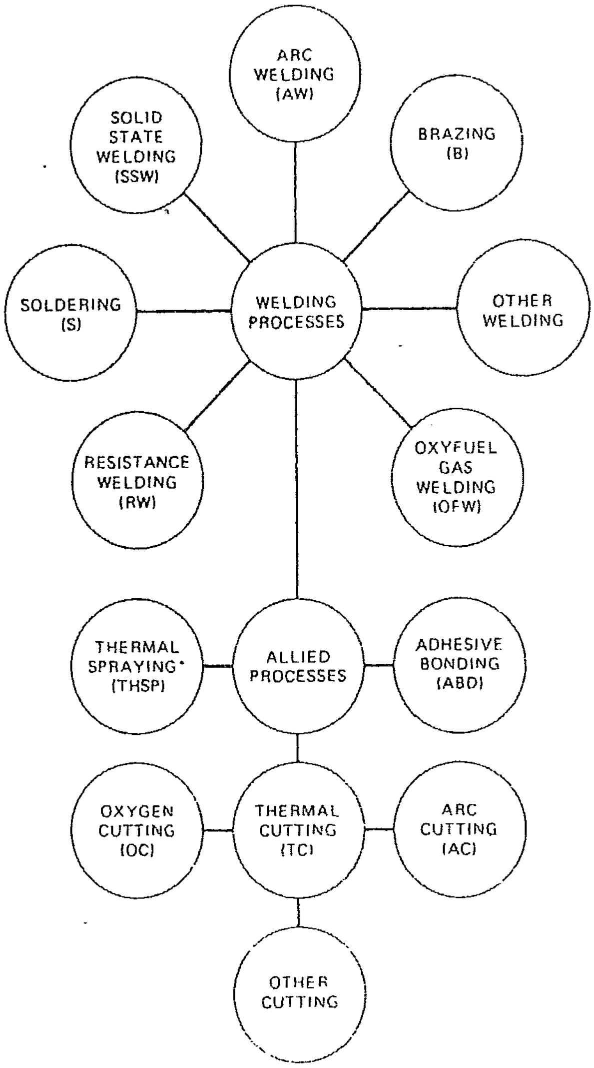
I	I-Beam
I.B.	Inboard/Inner Bottom
I.D.	Inside Diameter
INS.	Insulation
INTERC.	Intercostal
JOG.	Joggle
J.O.	Job Order
K.B.	Knee Brace/Knee Bracket
KN.	Knot
KNU.	Knuckle
K.P.	King Post
L.	Ângle or Left
L.B.P.	Length between perpendiculars
LBS.	Pounds
LDG	Landing
LG.	Length
L.H.	Left Hand
L.O. or LUB OIL	Lubricating Oil
L.O.A.	Length Over All
LONG.	Longitudinal
L.P.	Low Pressure
LTD.	Lightened
LTG.H.	Lightening Hole
L.W.L.	Load Water Line
MACH.	Machine
MAG.	Magazine
MAT'L	Material
MAX.	Maximum
M.DK.	Main Deck
M.E.	Molded Edge
MIN.	Minimum
M.J.D.	Metal Joiner Door
M.J.D.D.	Metal Joiner Dutch Door
M.K.	Mark
M.L.	Molded Line
MLD.	Molded
M.S.	Mild or Medium Steel

M.T.	Flame Tight
N	Near
N.C.	National Coarse
N.D.T.	Non-Destructive Testing
N.F.	National Fine
N + F	Near and Far
NPS	Nominal Pipe Size
N.T.	Non Tight
N.T.D.	Non Tight Door
N.T.S.	Not to Scale
O.B.	Outboard
O.C.	On Center
O.D.	Outside Diameter
OPP.	Opposite
ORD.	Ordinance
O.S.	Otherside or Outside
O.S.U.	Other Side Up
O.T.	Oil Tight
P.	Port
PANT.STRGS.	Panting Stringers
PAR.	Parallel
PASS.	Passage
PC. MK.	Piece Mark
PCS.	Pieces
PERP.	Perpendicular
PLATF.	Platform
PLT. Or PL.	Plate
PLTG.	Plating
PNL.	Panel
PROJ.	Projective
P + S or P/S	Port and Starboard
P.S.I.	Pounds per Square Inch
P.T.	Pipe Thread/Plenum Tight
Q.A.	Quality Assurance
Q.A.D.	Quick Acting Door
Q.A.S.	Quick Acting Scuttle
Q.A.W.T.	Quick Acting Water Tight

QTRS	Quarters
R.	Right
RAD.	Radius
REF.	Reference
REQ.	Required
R.F.W.	Reserve Feed Water
R.H.	Right Hand
RIV.	Rivet
R.OT.M.H.	Raised Oil Tight Manhole
R.W.T.H.	Raised Water Tight Hatch
S.	Shear is always an "S" on the line
S.A.	Shaft Alley
SECT.	Section
SPA.	Spacing
SPEC'S	Specifications
SQ.	Square
STA.	Station
STAN.	Stanchion
STBD.	Starboard
STD.	Standard
STG.	Straight
STGR.	Stringer
STIFF.	Stiffener
STK.	Strake or Stock
STL.	Steel
S.T.S.	Special Treatment Steel
S.W.	Stop Water
S.W.	Salt Water
SYM.	Symetrical
T.	Tee Bar
TAN.BKT.	Tangency Bracket
TEMP.	Template or Temporary
TIL.BKT.	Tilt Bracket
THD.	Thread
THK.	Thickness
T.L.	True Length
TOL.	Tolerance

TRANS.	Transverse
T.S.	This Side
T.S.U.	This Side Up
T.T.	Tank Top
TYP.	Typical
U.S.S.	United States Standard
V.	Void
VENT	Ventilation
V.K.	Vertical Keel
V.L.	Vertical Ladder
W.	Width
W.E.R.P.	Welded Equipment removal Plate (Hard Patch)
W.L.	Water Line
W.R.	Wash Room
WT.	Weight
W.T.	Water Tight
W.T.D.	Water Tight Door
W.T.Q.A.D.	Water Tight Quick Acting Door
Y.S.	Yard Stock
Z.	Zee Bar

13.0
WELDING PROCESSES AND GROUPING



AWS master chart of welding and allied processes.

14.0
WELDING PROCEDURES

SECTION 14.1 STEEL WELDING ELECTRODE AND PROCESS SELECTION CHART

BASE METAL	MILD STEEL	HTS	HY 80	HY 100	PROCESS
	6011	7018	7018	7018	SMAW
	7018				
MILD	705-3	705-3			GMAW-S
STEEL	E71T1	E71T1	E71T1	E71T1	FCAW
	EM12K	EM12K/761	100S-1/709-5	100S-1/709-5	SAW
	70S-2		70S-2		GTAW
		7018	11018	12018	SMAW
HTS		70S-4			GMAW-S
		81T1-Ni2	81T1-Ni2	81T1-Ni2	FCAW
		EM12K/761	100S-1/709-5	100S-1/709-5	SAW
		70S-2			GTAW
			11018	12018	SMAW
HY 80			E91T1-K2		FCAW
			100S-1/709-f	100S-1/709-5	SAW
				12018	SMAW
				120S-709-5	SAW

Process Abbreviations:

SMAW - Shielded Metal Arc Welding (Stick)
FCAW - Flux Cored Arc Welding (Dual Shield)
GTAW - Gas Tungsten Arc Welding (heliarc or TIG)
GMAW-S - Gas Metal Arc Welding (Short Circuiting)
SAW - Submerged Arc Welding

SECTION 14.2 STAINLESS STEEL ELECTRODE AND PROCESS SELECTION CHART

BASE METAL	304	304L	316	316L	321	347	309	310
304	308							
304L	308	308L						
316	308	308	316					
316L	308	308L	316	316L				
321	308	308L	316	316L 347	347			
347	308	308L	316 347	316L 347	347	347		
309	309	309	310	310	309	309	309	
310	310	310	310	310	310	310	310	310

Processes include:

SMAW (Stick) 3XX-16 Electrode
GMAW (MIG) E3XX Electrode and 98-2 Gas
GTAW (TIG) ER3XX Electrode and Argon Gas

SECTION 14.3 DISSIMILAR METALS ELECTRODE AND PROCESS SELECTION CHART

BASE METAL	MS/HTS	HY80/100	CuNi	MONEL	ALUMINUM	PROCESS
CRES 3XX	309-16	309-16	N/A	N/A	N/A	SMAW
	310-16	310-6				
	309	309	RN82(1)	RN82(1)	N/A	GTAW
	310	310				
CuNi	9N10	9N10	CuNi	9N10	N/A	SMAW
	RN60	RN60	RN67	RN60	N/A	GTAW
MONEL	9N10	9N10	9N10	9N10	N/A	SMAW
	RN60	RN60	RN60	RN60	N/A	GTAW
BRONZE (2)	CuA1-A2					SMAW

(1) - Limited applications approved, contact welding engineers for detailed instructions.

(2) - Weldable grades of aluminum bronze only.

SECTION 14.4 ALUMINUM WELDING ELECTRODE SELECTION CHART

BASE METAL	5052	5083	5086	5454	5456	6061 (1)	1100, 3003 (1)
5052	5356	5356	5356	5356	5356	4043	4043
5083		5356 5556	5356 5556	5356 5556	5356 5556	4043	4043
5086			5356 5556	5356 5556	5356 5556	4043	4043
5454				5356 5556	5356 5556	4043	4043
5456					5356 5556	4043	4043
6061						4043	4043
1100,3003							1100 (2) 4043 (3)

(1) This base metal not to be used for structural applications
(2) Better color match
(3) Least cracking tendency

14.5 WELDING GENERAL INFORMATION - SMAW

14.5.1. 6011
Base Metal A M.S.
Base Metal B M.S.
Thickness: 3/16 through 7 inches
Polarity: DC Reverse or AC for 6011
Preheat: 32°F for 1 inch and less Interpass: 450°F
Preheat: 60°F for over 1 inch Interpass: 450°F

	Amperage			
	All Position		Flat & Horizontal	
	3/32	1/8	5/32	3/16
6011	50-90	80-130	120-180	150-200

Cleaning: Remove rust, scale,. slag, grease, paint from within 1/4 inch of the expected weld toe. Weld through primer or a light bloom of rust is acceptable.

Techniques: Maintain medium-long arc length. Manipulate electrode to control bead shape. Whipping is recommended.

Weld Joints: See weld joint procedure. Back gouge second side of all full penetration welds.

Power Supplies: Constant current; motor generator, rectifier or grids; Heliarcs without hi-freq. For AC.

14.5.2. 7018

Base Metal A	M.S.	M.S.	HTS
Base Metal B	M.S.	HTS	HTS

Thickness: 3/16 through 7 inches
Positions: All
Polarity: DCRP
Preheat:: 32°F for 1 inch and less
60°F for over 1, up to 3 inches
125°F for over 3, up to 4 inches
200°F for 4 inches and over
Interpass: 450°F maximum

Cleaning: Remove rust, scale, slag, paint, grease from within 1/4 inch from the expected weld toes; weld through primer or a light bloom of rust is permitted.

Techniques: Use stringer beads, minimum weave. Maintain the shortest possible arc length. No whipping is permitted. All vertical welding shall be up. Remove all slag between passes by picking, wire brushing or grinding.

Weld Joints: See weld joint procedure, back gouge second side of all full penetration welds.

Power Supplies: Constant current; motor generator, receivers or grids.

RECOMMENDED SETTINGS

	All Position			Flat and Horizontal		
Electrode diameter	3/32	1/8	5/32	1/8	5/32	3/16
Amperage	70-110	110-135	120-180	125-145	135-180	170-250

14.5.3. 11018

Base Metal A	M.S.	HTS	HY 80	HY 100	HY 100
Base Metal B	HY 80	HY 80	HY 80	HY 80	HY 100

Thickness: 3/16 through 1-3/4 inches
Polarity: DCRP

Thickness	Pre-Heat	Interpass	Arc Gouge
1 inch or less	125°F	300°F	60°F
Over 1 inch	200°F	300°F	125°F

Cleaning: Remove rust, scale, slag, paint, primer and grease from within 1/4 inch of the expected weld toes; weld through primer is not permitted.

Techniques: Use stringer beads, minimum weave. Maintain the shortest possible arc length. No whipping is permitted. All vertical welding shall be up. Remove all slag between passes by picking, wire brushing or grinding.

Heat input: Heat input must be controlled to maintain the base metal strength and toughness. Thicker plate can be welded with higher heat input. Under 1/2 inch, use 45,000 joules/inch. 1/2 inch and over, 55,000 joules/inch are permitted. Use the thinner base metal for heat input limits when welding different thicknesses.

Use the following table as a guide to control heat input. The right hand column shows the shortest allowable bead when the whole 14 inch electrode is consumed. (Weaving makes the beads shorter and raises heat input.)

Plate Thickness	Electrode Diameter.	Min.Bead Length (in.)
less than 1/2"	3/32	3
	1/8	4
	5/32	5-3/8
	3/16	8
	3/32	2-3/4
1/2" and up	1/8	3-3/8
	5/32	4-3/8
	3/16	6-1/4

	RECOMMENDED SETTINGS					
	All Position			Flat and Horizontal		
Electrode diameter	3/32	1/8	5/32	1/8	5/32	3/16
Amperage	70-110	110-135	120-180	125-145	135-180	170-250

Temper beads: Temper bead technique is required for HY 80. See Section 4.16.

Weld Joints: See weld joint procedure; back gouge second side of all full penetration welds. MT of the back gouge is required.

14.5.4 12018M-1
Base Metal A HY 100
Base Metal B HY 100
Thickness: 3/16 through 2 inches
Polarity: DCRP
Preheat: 150°F
Interpass: 300°F

Arc Gouge: 60°F

Cleaning: Remove rust, scale, slag, paint and primer from within 1/4 inch of the expected weld toes. Weld through primer is not permitted.

Techniques: Use stronger beads, minimum weave. Maintain the shortest possible arc length. No whipping is permitted. All vertical welding shall be up. Remove all slag between passes by picking, wire brushing, or grinding.

Heat Input: Must be controlled to maintain the base metal strength and toughness. Thicker plate can be welded with higher heat input. Under 1/2 inch, use 45,000 joules/inch. 1/2 inch and over, 55,000 joules/inch are permitted. Use the thinner base metal for control when welding differing thicknesses. Use the following table as a guide to control heat input. The right hand column shows the shortest allowable bead when the whole 14 inch electrode is consumed. (Weaving makes the beads shorter and raises heat input.)

Plate Thickness	Electrode Diameter	Min.Bead Length (in.)
Less than 1/2"	3/32"	3
	1/8	4
	5/32	5-3/8
	3/16	8
	3/32	2-3/4
1/2 and up	1/8	3-3/8
	5/32	4-3/8
	3/16	6-1/4

Temper Beads: Temper bead technique is required for HY 100. See Section 4.16.

Weld Joints: See weld joint procedure; back gouge second side of all full penetration welds. MT of back gouge is required.

	RECOMMENDED SETTINGS					
	All Position			Flat and Horizontal		
Electrode diameter	3/32	1/8	5/32	1/8	5/32	3/16
Amperage	70-110	110-135	120-180	125-145	135-180	170-250

14.5.5. 3XX-16 (308.16, 309-16, etc.)

Base Metal A	CRES	CRES	See 14.2 & 14.3
Base Metal B	CRES	Steel	

Thickness: 1/8 through 1-1/2 inches
Positions: All
Polarity: DCRP
Preheat: 32°F
Interpass: 350°F

Cleaning: Remove oxide, scale, slag, paint, grease from within 1/4 inch of the expected weld toes; weld through primer or rust is not permitted.

Techniques: Use stringer beads, minimum weave. Maintain short arc length. No whipping is permitted. All vertical welding shall be up. Remove all slag between passes by picking, wire brushing or grinding.

Weld Joints: See weld joints procedure, back gouge second side of all full penetration welds.

Power Supplies: Constant current; motor generator, rectifiers, or grids.

	RECOMMENDED SETTINGS					
	All Position			Flat and Horizontal		
Electrode diameter	3/32	1/8	5/32	1/8	5/32	3/16
Amperage	60-90	90-120	120-160	90-120	120-160	160-240

14.5.6. CuNi

Base Metal A	CuNi	See 14.3
Base Metal B	CuNi	

Thickness: 1/8 through 1-1/2 inches
Positions: All
Polarity: DCRP
Preheat: 32°F
Interpass: 350°

Cleaning: Remove oxide, scale, slag, paint, grease from within 1/4 inch of the expected weld toes; weld through primer or rust is not permitted.

Techniques: Use stringer beads, minimum weave. Maintain short arc length. No whipping is permitted. All vertical welding shall be up. Remove all slag between passes by picking, wire brushing or grinding.

Weld Joints: See weld joint procedure, back gouge second side of all full penetration welds.

Power Supplies: Constant current; motor generator, rectifiers, or grids.

	RECOMMENDED SETTINGS					
	All Position			Flat and Horizontal		
Electrode diameter	3/32	1/8	5/32	1/8	5/32	3/16
Amperage	60-90	90-120	120-160	90-120	120-160	160-240

14.5.7. 9N10

Base Metal A	CuNi	MONEL	See 14.3
Base Metal B	MONEL	MONEL	

Thickness: 1/8 through 1-1/2 inches
Positions: All
Polarity: DCRP
Preheat: 32°F
Interpass: 350°F

Cleaning: Remove oxide, scale, slag, paint, grease from within 1/4 inch of the expected weld toes; weld through primer or rust is not permitted.

Techniques: Use stringer beads, minimum weave. Maintain short arc length. No whipping is permitted. All vertical welding shall be up. Remove all slag between passes by picking, wire brushing or grinding.

Weld Joints: See weld joint procedures, back gouge second side of all full penetration welds.

Power Supplies: Constant current; motor generator, rectifiers, or grids.

	RECOMMENDED SETTINGS					
	All Position			Flat and Horizontal		
Electrode diameter	3/32	1/8	5/32	1/8	5/32	3/16
Amperage	60-90	90-120	120-160	90-120	120-160	160-240

14.6 WELDING PROCEDURE

14.6.1. E3XX (E308, E309, etc.)

Base Metal A	CRES	See 14.2	CRES	See 14.3
Base Metal B	CRES		Steel	

Thickness: 1/8 through 1-1/4 inches
Polarity: DCRP
Preheat: 32°F
Interpass: 350°F
Positions: Flat, vertical and horizontal.

Cleaning: Remove all oxide, scale, slag, paint and other contaminants from within 1/4 inch of the expected weld toes. Weld through primer is not permitted.

Shielding Gas: A 1025 (90% Helium, 7.5% Argon, 2.5% CO_2)

Electrode Diameter: 1/16th inch maximum.

Slope: Affects the amount of current that flows while the wire is shorted to the puddle. Too much slope will keep the arc from re-igniting. Increasing slope generally softens the arc.

Inductance: Increasing inductance increases the fluidity of the puddle and decreases spatter. Too much inductance will make starting difficult.

Voltage: Is used to control arc length, set high enough to prevent stubbing, low enough to keep short circuiting. Too much voltage will give globular transfer.

	Recommended Settings		
Position	Vert. & Horiz.	Vert. & Horiz.	Flat
Electrode Diameter	.035	.045	1/16
Amperage	90-170	120-220	160-240
Voltage	16-24	17-26	19-28

14.7 WELDING PROCEDURE -- GMAW (SPRAY ARC)

14.7.1. 70S-3 (Linde 82)
70S-4 (Linde 85)
Base Metal A M.S. M.S.
Base Metal B M.S. HTS
Thickness: 3/16 through 3-1/2 inches
Position: Flat
Polarity: DCRP

Thickness	Preheat	Interpass
1 inch or less	32°F	450°F
over 1 up to 2 inches	60°F	450°F
over 2 up to 3 inches	125°F	450°F
over 3 inches	200°F	450°F

Cleaning: Remove rust, scale, slag, paint, grease from within 1/4 inch of the expected weld toes; weld through primer or a light rust is permitted.

Shielding Gas: 98-2 (98% Argon, 2% Oxygen) or 95-5 (95% Argon, 5% CO2)
Slope: Has very little affect in spray transfer.

Inductance: Has very little affect in spray transfer.

Voltage: Is used to adjust arc length; raise the voltage above short circuiting.

Wire Feed/Amperage: Amperage must be above the globular/spray transfer transition for the wire/gas combination. Raise the wire feed to raise amperage, until the drop size decreases and becomes spray, and the end of the wire is pointed.

	Recommended Settings	
Electrode Diameter	.045	1/16
Amperage	200-300	270-400
Voltage	22-28	25-32

14.7.2. E3XX (E308, E309, etc.)

Base Metal A	CRES	See 14.2	CRES	See 14.3
Base Metal B	CRES		Steel	

Thickness: 1/8 to 1-1/4 inches
Polarity: DCRP
Preheat: 32°F
Interpass: 350°F
Position: Flat

Cleaning: Remove all oxide, scale, slag, paint and other contaminants from within 1/4 inch of the expected weld toes. Welding through primer is not permitted.

Shielding Gas: 98-2 (98% Argon, 2% Oxygen)
Electrode Diameter: 1/16th inch maximum
Slope: Has very little effect in spray arc.
Inductance: Has very little effect in spray arc.
Voltage: Is used to control arc length; set high enough to prevent stubbing, high enough to keep from short circuiting.

Wire Feed/Amperage: Controls the "heat" and mode of transfer. Increase wire feed until the wire is pointed and no globular transfer is seen. Increase voltage to maintain the arc length as the wire feed is increased.

	Recommended Settings	
Position	Flat	Flat
Electrode Diameter	.045	1/16
Amperage	120-220	160-240
Voltage	24-29	26-32

14.7.3. 5556
5356

Base Metal A Aluminum - see Table 4.6
Base Metal B Aluminum
Thickness: 3/16 through 1 inch
Polarity: DCRP
Preheat: Preheat is only required if moisture is present. If so, heat to 200°F to dry and let cool to 150°F or below to weld.

Interpass: Temperatures of 150-400°F should be avoided in welding alloys 5086 and 5456, to prevent sensitization to corrosion.

Positions: All

Cleaning: Remove oxide by grinding, chipping or filing. Wherever possible acid etch with chemical cleaner. Use stainless steel power wire brush to clean tacks and between passes. Joints must be welded within 8 hours of clearing, to prevent oxide from building up.

Electrode Diameter: 035, 3/64, 1/16

RECOMMENDED SETTINGS

	All Position		Vert.	Hor. Overhead	
Electrode Diameter	3/64	1/16	.035	3/64	1/16
Amperage	200-240	250-300	110-140	180-220	230-270
Voltage w/Argon	23-26	23-26	16-19	22-25	23-26
Voltage w/He-Argon	24-27	28-32	17-20	23-26	24-27

Power Supplies: Constant voltage; SVI-600 with Cobra push/pull wire feeder, or with Westing-Arc spool guns, Gilliland with standard wire feeder. Constant current; receivers with Westing-Arc spool guns.

Techniques:

Constant voltage: Voltage controls arc length; set voltage high enough to prevent short circuiting.

Amperage/Wire Feed: Controls "heat" and transfer. Increase wire feed to get spray transfer, increased deposition and decreased spatter.

Constant current: Amperage setting on the power supply controls "heat"; set to the proper range to get spray transfer.

Wire Feed: Controls arc length. Set high enough to get wire down into the weld joint, low enough to avoid short circuiting.

Weld Joints: See weld joint procedure; backchip or grind second side of all full penetration welds.

14.8 WELDING PROCEDURE - GMAW-P

14.8.1 5556
5356

Base Metal A	Aluminum - see 14.4
Base Metal B	Aluminum

Thickness: 3/16 through 1 inch
Polarity: DCRP
Preheat: Preheat is only required if moisture is present. If so, preheat to 200°F to dry and let cool to 150°F to weld.
Interpass: Temperatures of 150-400°F should be avoided in welding alloys 5086 and 5456, to prevent sensitization to corrosion.
Positions: All.

Cleaning: Remove oxide by grinding, chipping or filing. Wherever possible acid etch with chemical cleaner. Use stainless steel power brush to clean tacks and between passes. Weld joints must be welded within 8 hours of cleaning to prevent oxide from building up.
Shielding Gas: Helium-Argon (75% Helium-25% Argon)

Electrode: 1/16th

Power Supply: Airco PA-3A with Cobra push/pull feeder, or with push feeder.

Voltage: On setting voltage for pulsed spray Gas Metal Arc, two voltage settings are required, peak and background.

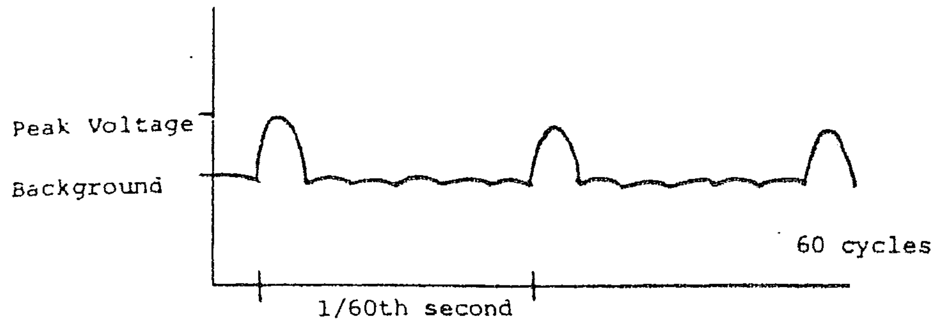
Peak: Sets the high pulse voltage. This should be set at 69-70 by holding the voltage test switch on peak and turning the pulse peak knob. Adjust up or down as needed to get enough peak to go to spray transfer during the high pulse, eliminating globular transfer.

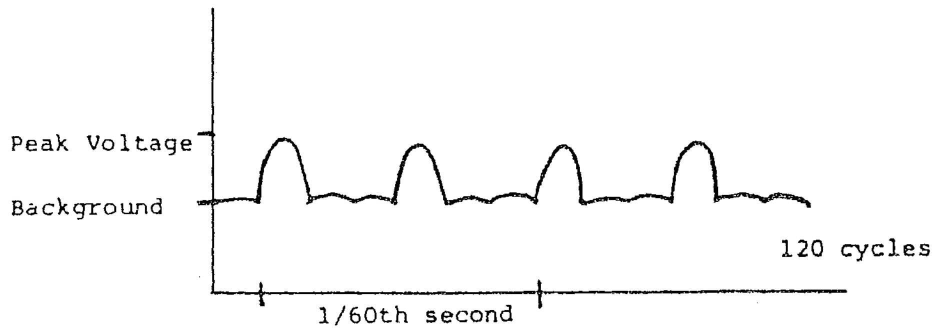
Background: Controls the wetness of the puddle by chilling the heat during the low pulse. Hold the voltage test switch to background and set by increasing or decreasing background reading to 28-30.

Pulse Rate: Set at 120 PPS.

Wire Feed: Controls arc length. Set at 220 inches per minute to get started, then adjust to fine tune the arc length.

Figure 14.8-1 Wave Form





14.9 WELDING PROCEDURE -- FCAW

14.9.1 E81T1-Ni2 (Dual Shield 8000)

Base Metal A	M.S.	HTS	HTS
Base Metal B	M.S.	M.S.	HTS

Thickness: 1/8 through 1-1/2 inches

Polarity: DCRP

Positions: All

Thickness	Preheat	Interpass
1 inch or less	32°F	450°F
over 1 inch	60°F	450°F

Shielding Gas: C-25 (75% Argon, 25% CO_2)

Electrode Diameter: 1/16 maximum

Voltage: Controls arc length; set voltage high enough to prevent short circuiting. Too much voltage causes undercut.

Amperage/Wire Feed: Controls "heat" and transfer. Increase wire feed to get spray transfer, increased deposition and decreased spatter. User lower heat, slightly globular for horizontal cover passes.

Slope and inductance: Have very little affect on flux cored arc welding.

	Settings					
Position	Flat			Vert.	Horiz.	Overhead
Electrode Diameter	.045	.052	1/16	.045	.052	1/16
Amperage	220	290	275	175	220	250
Voltage	29-31	29-31	31-34	23-26	24-27	24-28

Weld Joint: See weld joint design procedure and ceramic tape procedure. Back gouge second side of all full penetration welds.

14.9.2 E81T1-Ni2 (Dual Shield 8000 with low hydrogen)

Base Metal A	HY 80	HY 80
Base Metal B	M.S.	HTS

Thickness: 3/16 through 1-1/2 inches

Polarity: DCRP

Positions: All

Cleaning: Remove all slag, scale, paint, primer, rust, grease and other contaminants; weld through primer is not permitted.

Thickness	Preheat	Interpass
1 inch or less	125°F	300°F
over 1 inch	200°F	300°F

Shielding Gas: C-25 (75% Argon, 25% CO_2)

Electrode Diameter: 1/16 maximum

Voltage: Controls arc length; set voltage high enough to prevent short circuiting. Too much voltage causes undercut.

Amperage/Wire Feed: Controls "heat" and transfer. Increase wire feed to get spray transfer, increased deposition and decreased spatter. Use lower heat, slightly globular for horizontal cover passes.

Slope and Inductance: Have very little effect on flux cored arc welding.

	Settings					
Position	Flat			Vert.	Horiz.	Overhead
Electrode Diameter	.045	.052	1/16	.045	.052	1/16
Amperage	220	290	375	175	220	250
Voltage	24-27	25-29	27-32	21-24	22-25	24-28

Heat Input: Must be controlled to maintain the base metal strength and toughness. Thicker plate can be welded with higher heat input. Under 1/2 inch, use 45,000 joules/inch maximum. 1/2 inch and over, 55,000 joules/inch are permitted. Use the thickness of the HY 80 for heat input limits.

Use the following formula to calculate heat input:

$$\text{Heat input (joules/inch)} = \frac{\text{Volts x Amps X 60}}{\text{Travel Speed (IPM)}}$$

Moisture Control: Exposure of 81T1-Ni2-HY must be controlled to prevent moisture pickup, similar to control of 11018. Spools must be marked with the date and time removed from the rod shack. All the wire must be used in 24 hours, or shall be returned to the rod shack and marked "for Mild Steel Only".

Weld Joints: See weld joint design procedure. Back gouge second side of all full penetration welds. MT of back gouge is required.

14.9.3 CERAMIC TAPE (3M-SJ8071X)
(3M-SJ8074X)
(Refrac-T-Back)
(Kuder)

Base Metal A	M.S.	M.S.	M.S.	HTS	HTS
Base Metal B	M.S.	HTS	HY 80	HTS	HY 80

Thickness: 1/8 through 1-1/2 inches
Positions: Flat, Vertical and Horizontal

Process: FCAW with either 81T1-Ni2 or 81T1-Ni2-HY electrode dependent on base metal combination; use the 81T1-Ni2-HY for all combinations with HY 80.

Ceramic Tapes: Use part no. 9100-0000 (white squared tape) or 9110-0000 (yellow square tape) for butt welds on steel 5/16 and over. Use no. 9101-0000 (brown tape with small groove) for butt welds on steel 1/4 and under. Use 9111-0000 (round tape) for corners and tees.

Joint Design: Weld joints for ceramic tape are shown in the structural joint design procedure; B1V.8 for butts, T1V.8 for normal tees, T1(S)V.8 for skewed tees, and C1V.8 for corners.

Application of Ceramic: The ceramic must be centered over the groove and held tightly in place; adhesive backed aluminum foil should be rolled or pressed to prevent the ceramic from lifting away from the steel surface. Restraining bars or other holding devices may also be used. The surface of the steel behind the ceramic must be clean to avoid contamination of the weld and where the adhesives are used to restrain the ceramic, the surface to which it will be applied must also be free of contamination.

Technique: To obtain proper backside bead contour, the arc must be maintained directly on the leading edge of the puddle and drawn straight ahead (without manipulation) using a slight backhand angle. When the wire is too far back on the puddle the back side will appear blocky with a rough contour. When the wire is ahead of the puddle, stubbing may occur or excessive penetration.

	Root Pass Ceramic Tape Settings				
Position	Flat	Vertical		Horizontal	
Electrode Diameter	.052	.045	.052	.045	.052
Amperage	190	160	180	170	180
Voltage	23-25	19-21	20-22	19-21	20-22

Defects at stops and starts: When starting a pass the arc must be initiated on the side of the groove, on a starting pad, or on a previously placed bead which has been tapered to insure a good tie-in on the backside. At the terminus of beads, two defects are common: 1)Centerline tearing 2) Diagonal slag pocket.

Conventional crater filling techniques will not eliminate these problems, and will often worsen them. Tears always will appear on the top surface of the bead if they are present and will extend approximately 2/3 through the bead. The diagonal slag pocket will cause a slight depression in the top and bottom surface of the bead and will extend through the entire thickness. Although it cannot necessarily be detected without grinding into the crater, it will invariably exist. When one bead ties into another bead, incomplete penetration can occur, causing an inconsistency in the backside bead.

Preventing Defects: Rub continuously without stopping from a run-on tab to a run-off tab whenever possible. Put ceramic on the stiffened side of plate where interruptions will be minimized. Use an elongated rat-hole to accommodate the ceramic.

Tie-ins: Where interruptions are necessary, plan the stop and start locations so that they are accessible to an angle grinder. Before starting a second bead which will overlap a first, taper each end of the first bead which will require a tie-in, removing all defects as follows: 1) Use a dish tape where start is on a bead, running off the bead onto ceramic. 2) Use a diamond taper where the end is on a bead, running off the ceramic onto the bead.

Use strongbacks to maintain alignment; do not tack in the joint. If tack welds are absolutely necessary, they must be ground flush prior to applying the ceramic to obtain a tight fit between it and the steel. The tacks must be completely removed prior to welding to avoid rework of the back side, as they will not be burned out during welding.

Where tears have been found in the root pass, or tie-ins were not properly prepared, the following weld/NDT back side repair will be necessary. After completion of the weld from the flat side, locate the defective areas on the other side by finding the tie-in area. Carbon-arc scarf 3" minimum on each side of the tie-in to a depth of 1/4" to remove all defects from the root pass. MT or 5X visual the removal areas for sound metal. Re-weld the excavation with 7018 (for MS/HTS) or 11018 (for HY 80).

NDT: MT or 5X magnification 100% of all root passes welded into ceramic backing.

Preheat/Interpass for M.S./HTS

Thickness	Preheat	Interpass
1 inch and less	32°F	450°F
over 1 inch	60°	450°F

Preheat/Interpass for MS/HY 80 or HTS/HY 80

1 inch and less	125°F	300°F
over 1 inch	200°F	300°F

14.10 WELDING PROCEDURE - SAW

14.10-1 (Single Arc)
EM 12K (Linde 81)
Flux (Linde 231)

Base Metal A	M.S.	HTS	HTS
Base Metal B	M.S.	M.S.	HTS

Thickness: 3/16 through 1-1/2 inches

Polarity: DCRP

Thickness	Preheat	Interpass
1 inch or less	32°F	450°F
over 1 inch	60°F	450°

Thickness	Recommended Settings 1st Side Amps	Volts	Travel	2nd Side Amps	Volts	Travel
3/16	375	32	30	400	32	25
	400	33	32	425	33	
1/4	400	33	27	450	33	24
	425	34	30		34	
5/16	450	33	25	550	33	32
	475	34			34	
3/8	500	33	25	575	33	22
	525	34			34	
7/16	525	34	25	625	33	20
	550	35			34	
1/2	575	34	23	675	34	19
	600	35			35	
9/16	600	35	16	700	37	15
		36			38	
5/8	650	35	15	700	37	13
		36			38	
3/4	700	36	15	750	40	12
		40			42	

Cleaning: Remove rust, scale, slag, grease, paint from within 1/4 inch of the expected weld toes. Weld through primer is permitted.

Electrode Diameter: 3/32, 1/8, 5/32

Weld Joints: See weld joint procedure. Square groove is permitted through 5/8 inch. Single Vee is used over 5/8 through 7/8 inch, double Vee over 7/8 inch.

Maximum Gap is as follows:

Plate Thickness	Gap
1/8 - 7/16	0-1/32
1/2 and up	0-3/64

Excessive gaps should be seal welded and then require back gouge to assure penetration. 'Back gouge of the second side is not normally required, but a skim cut may be used to improve cover configuration.
Tacking: Tack welds may be deposited by any approved carbon steel welding procedure. Cracked or broken tacks or those of poor quality shall be removed and not incorporated in the final weld.

Flux Flow: Flux flow shall be regulated to the minimum necessary to obtain quiet arc action with no spark through.

Electrode Alignment: For butt welding, the electrode shall be positioned directly over the joint centerline and 90 ° to the work; for fillet welding an offset in wire alignment of 1/2 the wire diameter in the horizontal direction and lateral tilt of 24-45 from the vertical is recommended.

14.10.2 (Tandem Arc)

EM 12K	(Linde 81)	(95-3912-1560)	
Flux	(Linde 231)	(95-7231-0000)	
Base Metal AM.S.		HTS	HTS
Base Metal BM.S.		M.S.	HTS

Thickness: 3/16 through 1-1/2 inches
Polarity: DCRP

Thickness	Preheat	Interpass
1 inch or less	32°F	450°F
Over 1 inch	60°F	450°F

Cleaning: Remove rust, scale, slag, grease, paint from within 1/4 inch of the expected weld toes. Weld through primer is permitted.

Electrode Diameter: 5/32

Weld Joints: See weld joint procedure. Square groove is permitted through 5/8 inch. Single Vee is used over 5/8 through 7/8 inch, double Vee over 7/8 inch. Maximum root gap is as follows:

Plate Thickness	Gap
1/8 - 7/16	0 - 1/32
1/2 and up	0 - 3/64

Excessive gaps should be seal welded, and then require back gouge to assure penetration. Back gouge of the second side is not normally required, but partial gouge may be used to improve cover configuration.

Tacking: Tack welds may be deposited by any approved carbon steel welding procedure. Cracked or broken tacks or those of poor quality shall be removed and not incorporated in the final weld.

Flux Flow: Shall be regulated to the minimum necessary to obtain quiet arc action and prevent spark through.

Electrode Alignment: The electrodes shall be aligned directly over the centerline of the joint. The lead electrodes should be 90 to the work, and the trail electrode should be 60-70 to the work and to 1-1/4 inches back from the lead.

Settings: See the panel line welder foreman for recommended settings.

14.10.3 100S-1

Flux	(Lincoln 880)				
Base Metal A	HY 80	HY 80	HY 80	HY 100	HY 100
Base Metal B	M.S.	HTS	HY 80	HY 80	HY 100

Thickness: 3/16 through 1-1/4 inches

Note: HY 100 to HY 100 only through 1/2 inch

Polarity: DCRP

Thickness	Preheat	Interpass	Arc Gouge
1 inch or less	150°F	300°F	60°F
Over 1 inch	200°F	300°F	125°F

Post Weld Heat: Whenever possible, soak at 200°F for 8 hours after welding HY 80 over 1/2 inch or after welding HY 100.

Cleaning: Remove rust, scale, slag, grease, paint, primer from within 1/4 inch of the expected weld toes. Weld through primer is not permitted.

Electrode Diameter: 5/32

Weld Joints: See weld joint procedure. Square groove is permitted through 1/4 inch on HY 80/HY 100. No back gouge is required through 1/2 inch if full penetration is proven by UT, X-ray or gouging. All full penetration joints over 1/2 inch shall be back gouged. MT of back gouge is required. Excessive gaps should be seal welded.

	Recommended Settings							
Thickness	1st side				2nd side			
	Amps	Volts	Travel	Joules	Amps	Volts	Travel	Joules
3/16	375	30	30	25600	425	30	25	32640
	400	32	32			32		
1/4	400	30	27	30222	450	30	25	34560
	425	32	30			32		
5/16	450	30	25	36480	550	30	24	44000
	475	32				32		
3/8	500	30	25	40320	560	30	24	44800
	525	32				32		
7/16	525	30	25	42240	560	30	24	44800
	550	32				32		
1/2	575	30	23	50087	600	30	21	54857
	600	32						

Over 1/2 inch - Multi-pass Required, 55,000 joules/inch permitted.

Amps	Volts	Travel	Joules/Inch
600	32-34	23-25	55,000

Temper Beads: Temper technique is required for HY 80/HY 100: see Section 14.14.

Heat Input: Must be controlled to maintain the base metal strength and toughness. Thicker plate can be welded with higher heat input. Under

1/2 inch, use 45,000 joules/inch. 1/2 inch and over, 55,000 joules/inch are permitted. Use the thinner base metal for heat input limits when welding different thicknesses. Use the following formula to calculate heat input:

$$\text{Heat input (joules/inch)} = \frac{\text{Volts x Amps X 60}}{\text{Travel Speed (IPM)}}$$

14.11 WELDING PROCEDURE -- GTAW

14.11.1 70S-1

Base Metal A	M.S.	M.S.	HTS
Base Metal B	M.S.	HTS	HTS

Thickness: 1/8 to 3/4 inch
Polarity: DCSP
Preheat: 60°F
Interpass: N/A
Positions: All

Electrode: Use 2% thoriated electrode; AWS EWTh-2 (Red).
Sharpen the electrode to about a 60 degree included angle; this will be a bevel about as long as two times the diameter.

Gas Cup Size: This depends on the amount of draft, the size of the bevel, and the technique used. Use the largest cup which still allows adequate manipulation and visibility. Minimum cup size is no. 6.

Cleaning: Remove rust, scale, slag, grease and paint from within 1/4 inch of the expected weld toe. Weld through primer or a light bloom of rust is not permitted.

Purging: Purging is only required on carbon steels in pipe when the system requires absolute freedom from scale and the pipe will not be pickled in the pipe shop. This is generally only required on lube oil piping. Use argon to purge when required.

Weld Joints: See structural joint design procedure; the use of the open root joint without backing or back gouging to clean metal is not approved.

Electrode Diameter	Amperage Range
.040	15-80
1/16	70-150
3/32	150-250
1/8	250-400

14.11.2 ER3XX
Base Metal A 300 Series Stainless -- see 14.2
Base Metal B 300 Series Stainless

Filler Metal Selection: See the stainless steel electrode selection chart.

Thickness: l/8 to 3/4 inch
Polarity: DCSP
Preheat: 60°F
Interpass: 350°F
Positions: All

Electrode: Use 2% thoriated electrode; AWS EWTh-2(Red). Sharpen the electrode to about a 60 degree included angle; this will be a bevel about as long as two times the diameter.

Gas Cup Size: This depends on the amount of draft, the size of the bevel, and the technique used. Use the largest cup which still allows adequate manipulation and visibility. Minimum cup size is no. 6.

Cleaning: Remove oxide, scale, slag, grease and paint from within 1/4 inch of the expected weld toe. Weld through primer is not permitted. Do not use tempil sticks, grease crayons or marking pens within the cleaned area. Do not allow contact with copper, lead, mercury or other low melting point metals. Do not attempt to weld over previously brazed joints.

Purging: Purging is required whenever welding full penetration joints on stainless steels. Use argon gas for purge.

Weld Joints: See structural joint design procedure; the use of the open root joint without backing or back gouging to clean metal is not approved.

Electrode Diameter	Amperage Range
.040	15-80
1/16	70-150
3/32	150-250
1/8	250-400

14.11.3 ER5356.ER5556

Base Metal A Aluminum, see 14.4

Base Metal B Aluminum

Thickness 1/8 to 3/4 inch

Polarity: AC

Preheat and Interpass: Avoid holding 5000 series aluminum in the range of 150-400°F.

Positions: All

Shielding Gas: Argon

Electrode: Use pure tungsten, EWP (green) or zirconiated tungsten, EWZr(brown). Ball the end by heating electrode, using a current higher than the recommended range.

Electrode Diameter	Amperage Range	
	Pure (green)	Zirconiated (brown)
1/16	50-100	70-150
3/32	100-160	140-235
1/8	150-210	225-325
5/32	200-275	300-400

Cleaning: Clean all oxide, grease and other contaminants from within 1/4 inch of the expected weld toes. Use acid cleaner if X-ray is required.

Weld Joints: See structural weld joint procedure.

14.11.4 CuAL-A2

Base Metal A M.S. HTS HY 80

Base Metal B Aluminum Bronze Door Wedges

Thickness: 1/8 to 3/4 inch

Polarity: DCSP

Preheat: 300°F

Positions: All

Shielding Gas: Argon

Electrode: Use 2% thoriated electrode; AWS EWTh-2 (Red). Sharpen the electrode to about a 60 degree included angle; this will be a bevel about as long as two times the diameter.

Gas Cup Size: This depends on the amount of draft, the size of the bevel, and the technique used. Use the largest cup which still allows adequate manipulation and visibility. Minimum cup size is no. 6.

Cleaning: Remove oxide, scale, slag, grease and paint from within 1/4 inch of the expected weld toe. Weld through primer is not permitted. Do not use tempil sticks, grease crayons or marking pens within the cleaned area. Do not allow contact with lead, mercury, or other low melting point metals. Do not attempt to weld over previously brazed joints.

Weld Joints: See structural joint design procedure; fillet weld joints only.

Welder Qualification: Welders will qualify on a production joint which will pass PT inspection.

Electrode Diameter	Amperage
1/16	70-150
3/32	150-250
1/8	250-400

14.11.5 RN67
Base Metal A CuNi
Base Metal B CuNi
Thickness: 1/8 to 3/4 inch
Polarity: DCSP
Preheat: 60°F
Interpass: 350°F
Positions: All
Shielding Gas: Argon

Electrode: Use 2% thoriated electrode; AWS EWTh-2 (Red). Sharpen the electrode to about a 60 degree included angle; this will be a bevel about as long as two times the diameter.

Gas Cup Size: This depends on the amount of draft, the size of the bevel, and the technique used. Use the largest cup which still allows adequate manipulation and visibility. Minimum cup size is no. 6.

Cleaning: Remove oxide, scale, slag, grease and paint from within 1/4 inch of the expected weld toe. Weld through primer is not permitted. Do not use tempil sticks, grease crayons or marking pens within the cleaned area. Do not allow contact with lead, mercury, or other low melting point metals: Do not attempt to weld over previously brazed joints.

Purging: Purging is required whenever welding full penetration joints on stainless steel. Use argon gas for purge.

Weld Joints: See structural joint design procedure; the use of the open root joint without backing or back gouging to clean metal is not approved.

14.11.6 RN60

Base Metal A	CuNi	MONEL	CuNi	MONEL
Base Metal B	MONEL	MONEL	Steel	Steel

Thickness: 1/8 to 3/4 inch.
Polarity: DCSP
Preheat: 60°F
Interpass: 350°F
Positions: All
Shielding Gas: Argon

Electrode: Use 2% thoriated electrode; AWS EWTh-2 (Red). Sharpen the electrode to about a 60 degree included angle; this will be a bevel about as long as two times the diameter.

Gas Cup Size: This depends on the amount of draft, the size of the bevel, and the technique used. Use the largest cup which still allows adequate manipulation and visibility. Minimum cup size is no. 6.

Cleaning: Remove oxide, scale, slag, grease and paint from within 1/4 inch of the expected weld toe. Weld through primer is not permitted. Do not use tempil sticks, grease crayons or marking pens within the cleaned area. Do not allow contact with lead, mercury, or other low melting point metals. Do not attempt to weld over previously brazed joints.

Purging: Purging is required whenever welding full penetration joints on stainless steels. Use argon gas for purge.

Weld Joints: See structural joint design procedure; the use of the open root joint without backing or back gouging to clean metal is not approved.

14.11.7 RN82
Base Metal A Cu-Ni MONEL
Base Metal B 300 Series stainless - approved for specific applications only; see welding engineers for detail.
Thickness: 1/8 to 3/4 inch.
Polarity: DCSP
Preheat: 60°F
Interpass: 350°F
Positions: All
Shielding Gas: Argon

Techniques: Before fitting the joint, butter the stainless steel with at least one layer of RN 82. The buttering must cover all areas that will be welded to the CuNi or MONEL. If this is not done, the weld will crack all the way down the centerline.
Electrode: Use 2% thoriated electrode; AWS EWTh-2 (Red), Sharpen the electrode to about a 60 degree included angle; this will be a bevel about as long as two times the diameter.

Gas Cup Size: This depends on the amount of draft, the size of the bevel, and the technique used. Use the largest cup which still allows adequate manipulation and visibility. Minimum cup size is no. 6.

Cleaning: Remove oxide, scale, slag, grease and paint from within 1/4 inch of the expected weld toe. Weld through primer is not permitted. Do not use tempil sticks, grease crayons or marking pens within the cleaned area. Do not allow contact with lead, mercury or other low melting point metals. Do not attempt to weld over previously brazed joints.

Purging: Purging is required whenever welding full penetration joints on stainless steels. Use argon gas for purge.

Weld Joints; See structural joint design procedure; the use of the open root joint without backing or back gouging clean metal is not approved.

14.12 WELDING ALUMINUM/STEEL BI-METALLIC TRANSITION JOINT

14.12.1 GENERAL Due to the different coefficients of thermal expansion of steel and aluminum, structures like the "Detacouple" transition joint, which holds aluminum and steel in rigid contact, requires special care in welding.

14.12.2 PURPOSE The purpose of the procedure is to set forth the requirements which apply to welding of "Detacouple" to ensure a quality end result.

14.12.3 APPLICABILITY All trades involved in the installation of Detacouple shall be fully familiar with the requirements of this document prior to beginning any work pertaining to this material.

14.12.4 JOINT PREPARATION

14.12.4.1 Cutting the "Detacouple" -- Detacouples will be cut by using mechanical processes only: Sawing, machining, grinding, burring, etc. Flame cutting, carbon-arc scarfing and plasma cutting are not allowed because the bond zone will be raised to a temperature above 600 Fahrenheit and thus weakened.

14.12.4.2 Fit up -- Must be within the tolerances shown in figures 14.12-1, -2 and -3 to minimize restraint, heat buildup and distortion. Prior to tack welding, all joints must have proper bevels and be cleaned per 14.12.4.3. Tacking will be done in accordance with 14.12.5.

14.12.4.3 Surface Cleaning

* All aluminum surfaces which require welding will be cleaned prior to tack welding. The weld area: Faying surfaces and adjacent surfaces within 1/2" from the expected weld edges will be clean, dry and free of surface matter like paint, oil, grease, etc. Nicks, gouges and sharp irregularities caused by sawing, chipping, plasma burning, etc. , will be ground smooth. Surface oxides in the weld area will be removed with chemical means or by brushing with a powered clean CRES brush.

* All steel surfaces will be free of paint, loose rust, oil, grease, etc. Slag and burrs from burning and sawing, etc., will be removed from the weld area prior to tacking.

14.12.5 Welding Requirements

14.12.5.1 Preheat -- none required

14.12.5.2 Interpass Temperature -- No welding will be done to the bi-metallic strip when the strip is 400 Fahrenheit or hotter. Tempil sticks will be used, reading the temperature at the bond zone on the side of the strip. This is particularly critical in multi-pass welding.

14.12.5.3. Filler Material and Welding Processes

* The aluminum side will be welded with 5356 or 5556 filler of 3/64" or 1/16" diameter using the GMAW process. No GTAW (Heliarc) will be used.

* The steel side will be welded with the SMAW, GMAW, or FCAW Processes, no GTAW (Heliarc). Be sure to note to what material the strip will be joined before selecting a detailed weld procedure.

14.12.5.4 Weld Sizes and Joint Design -- The joint design will be detailed on the applicable drawings and will conform to the requirements of figures 14.12-1, -2 and -3. Sizes of fillets will be detailed on the applicable drawings and will be labeled on the applicable joint prior to welding.

14.12.5.5. Welding Techniques

* All welding will be done with stringer beads with 1/2" maximum distance across the face of weld bead.

* Undercut in excess of 1/64" is unacceptable.

* Weld beads will be smooth and flat with good tie-ins. Rollover and other sharp irregularities in the weld beads will not be allowed.

* Run-on and run-off tabs will be used for aluminum side of butt welds in the "Detacouple". They are recommended for the steel side as well.

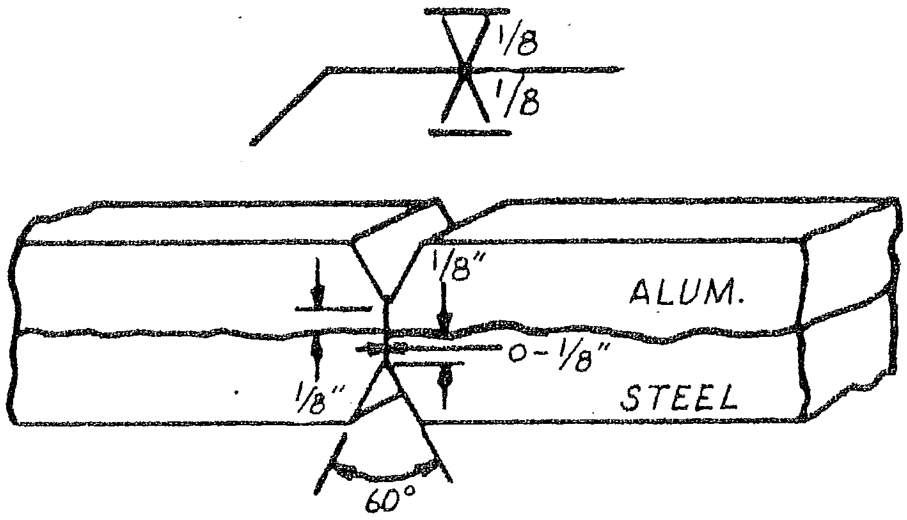
14.12.5.6 Welding Sequence

* Fillet welds will be back stepped in 2' to 3' increments.

* Butt welds between two pieces of "Detacouple" will be welded in the following manner:

(a) Fillet welds which cross butt welds will be left unwelded at least 3" back from the weld edge.
(b) Weld the aluminum side of the "Detacouple" complete.
(c) Weld the steel side of the "Detacouple" joint complete. (No back gouging is allowed in order to keep aluminum from dissolving into the steel or vice-versa.)
(d) Weld temporary snipes and dress with a grinder as necessary.
(e) Complete fillet welds.
(f) Remove aluminum run-on and run-off tabs and dress edge with a grinder.
(g) Peen the sides of the butt to close the unwelded root to seal out moisture. Peening will be done with a power-operated hammer gun and a blunt, slightly rounded peening tool.

Figure 14.12-1



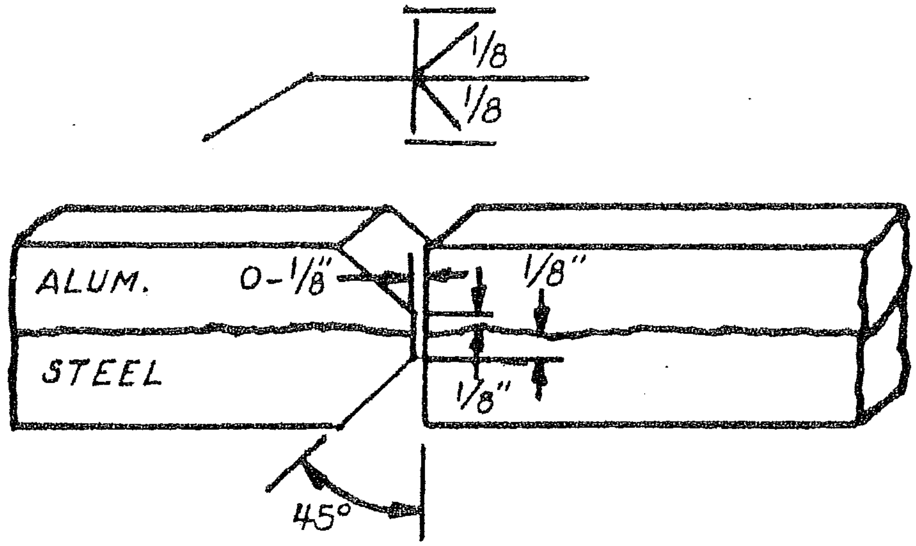


Figure 14.12-2

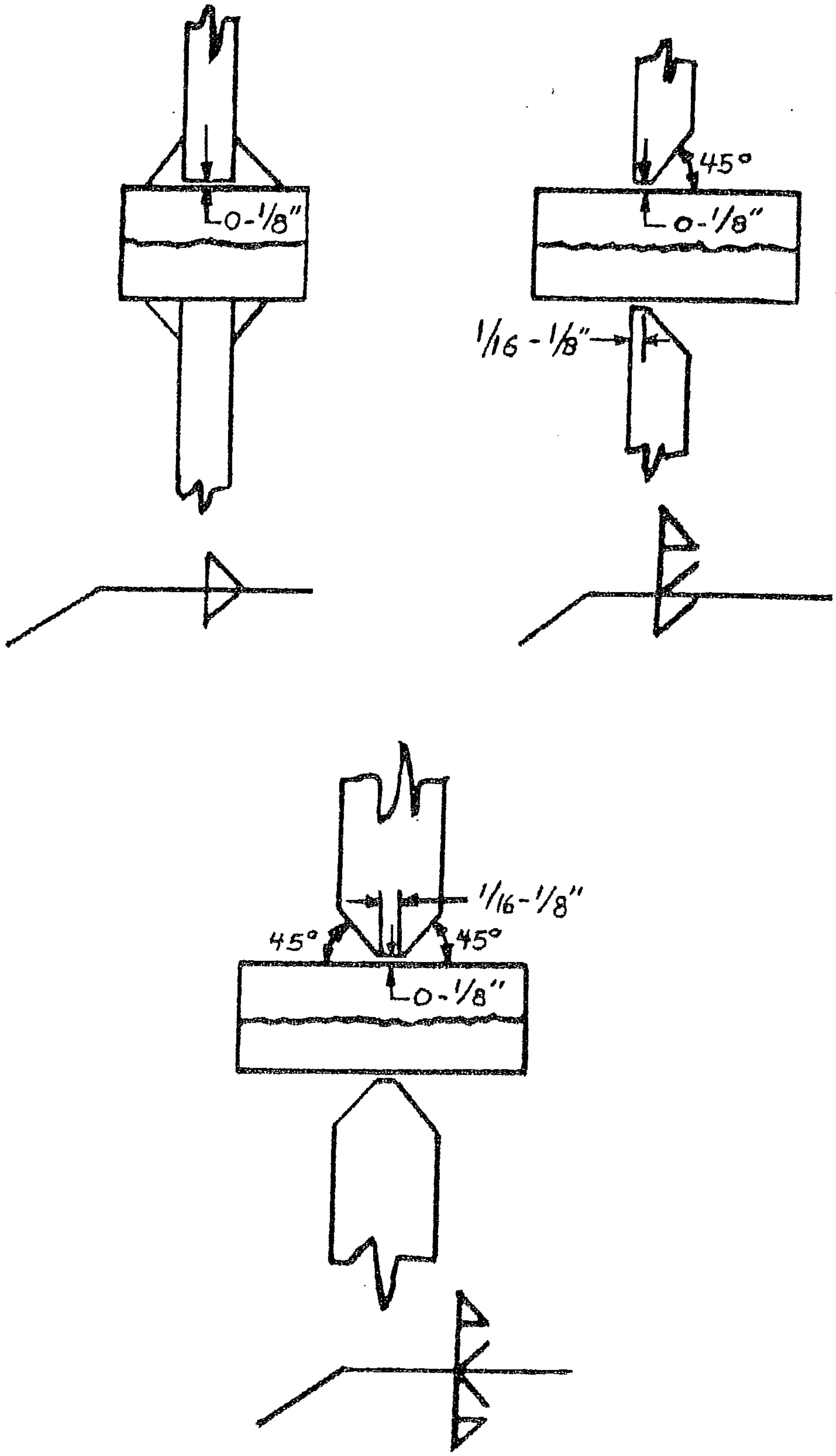
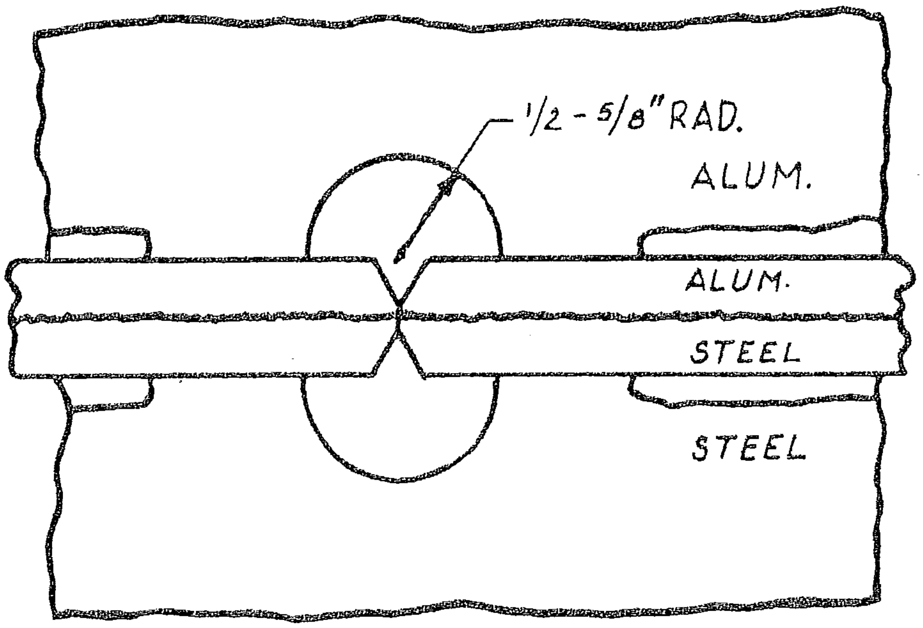


Figure 14.12-3



14.13 WELDING SEQUENCE PLAN

14.13.1 PURPOSE To disseminate standardized techniques to be used to minimize distortion, residual stresses, and cracking when welding assemblies together.

14.13.2 SUMMARY A welding sequence can be the most important program used in the building of ships. From the smallest part to complete sub-assemblies the welding sequence is of the greatest importance. No universal rules exist. However, many general principles have been developed and are incorporated in this instruction.

It should be noted that weld sequencing cannot eliminate shrinkage, so design principles like part symmetry and fitting practices like gap control, egg boxing, presetting and strongbacking may also be required to ensure success in manufacturing.

14.13.3 GENERAL PRINCIPLES Some general principles to be followed are listed below.

14.13.3.1 Fitting of the weld joint shall be complete, including installation of fairing aids and strongbacks, before the start of welding.

14.13.3.2 All butts shall be checked for fairness before welding.

14.13.3.3 Strongbacks should be applied before welding, as follows:

a) On the panel line, strongback free edges of all panels under 3/8 inch thick. (Figure 14.13-7)
b) Strongback or apply fairing aids across weld joints on panels and modules to be welded using ceramic backing. (Figure 14.13-8)
c) Strongback across ends of butt welds on panels where knuckling can cause problems. (Figure 14.13-8)
d) Use strongbacks with saddles to permit movement along seams while welding master butts. (Figure 14.13-9)
e) Use welded strongbacks (without saddles) on thin plate, restrict movement causing "drumheading".
f) Strongback parallel to edges of inserts.

14.13.3.4. In general, the grooved side of single "V" joints or the side having the largest groove on double "V" should be welded first, unless otherwise stated.

14.13.3.5. All longitudinal and transverse attachments of sub-assemblies and assemblies in way of erection joints should be left unwelded for a distance of 12 inches or more on each side of said joint in order for plate to be as unrestricted as possible during welding operation. These may, however, be welded after about 2/3 of the thickness of this joint has been welded.

14.13.3.6. Continuous seam welds shall not be carried beyond an unwelded dead end butt until the latter has been welded (cross tees). Welding shall progress to a point 9" back of an unwelded butt. (Figure 14.13-1 and 14.13-2)

14.13.3.7 Continuous lines of welding using manual or semi-automatic processes should be backstepped, (see Figure 14.13-3) or use controlled wandering sequence (see Figure 14.13-4).

14.13.3.8 Where multi-pass welding is used, passes shall not start and end at the same point. Passes shall be staggered to overlap the preceding pass by about 1 inch.

14.13.3.9 When using automatic welding equipment such as OTC, Bug-O, Subarc, start at alternating ends of stiffeners or butt welds.

14.13.3.10 Do not over-weld. Excessive weld contributes little to weld strength, but it adds a considerable amount of excess shrinkage.

14.13.3.11 All welding shall progress as symmetrically as possible around the structure's theoretical center. Port and starboard welding shall be performed simultaneously where practical.

14.13.3.12 Each layer of weld except the first and last, may be peened if considered necessary to control distortion and minimize residual stresses. Peening shall be done with a round nose smooth-faced tool and a power hammer (not a needle gun) to be certain that no nicks or notches result. Peening, when performed, shall be cleaned and brushed after each pass before another is started.

Care shall be taken so that all visual defects such as slag, porosity, cold laps, or excessive undercutting are removed by grinding prior to peening.

14.13.4 SUB ASSEMBLY FABRICATION

The following are applicable to the sub assembly fabrication stage.

14.13.4.1 Innerbottom and assemblies and turntable, stern gate, etc. Shall be built by "egg box" construction. Sub assemble longitudinal girders with floors in "cross" and "box" sections (see Figure 14.13-12 and 14.13-13). Then fit together on jig and finish the egg box before fitting and welding to shell or tank top. Next, fit egg box to tank top and weld. Las, turn over and weld to shell.

14.13.4.2 Small foundations for machinery or unit assembly should be welded on a positioner. Position all welds flat or slightly downhand. In general, weld the legs of the foundation first, progressing towards the top. Then weld the top perimeter and weld chocks last. (See Figure 14.13-10 and 14.13-11.)

14.13.4.3 Inserts and doors should be block welded. This will prevent distortion caused by non-uniform weld shrinkage and stress (see Figure 14.13-5). It is important on insets to be sure that there is enough bevel on the first side so that at least 1/3 of the joint will still be welded when the second side is back gouged. If this is not done, the weld will crack.

14.13.4.4 Lapped collars should be welded on the side that draws them in tight first, to the through member first (see Figure 14.13-6). Then finish the first side and weld out second side.

14.13.4.5 Insert (flush) collars should be welded to the cut member first, including back gouging and welding. Then weld to through member, both sides.

14.13.4.6 Pin jig assemblies, sequence as follows:

a) Weld shell butts with ceramic tape backing or sub-arc as applicable.

b) Weld stiffeners to shell. Pre-set twist and camber before welding. Weld in alternating directions.

c) Weld web frames to shell, then weld collars to web frames.

d) Block tack third deck and LB 32 to web frames and to each other.

e) Weld third deck and LB 32 to shell. Leave overhead welding on LB 32/WF on third deck/WF until the module is turned over on assembly slabs.

14.13.5. MODULE ASSEMBLE AND ERECTION

The following are applicable to module assembly slabs and shipway erection.

14.13.5.1 All framing and stiffeners should be welded to each other prior to welding to plating.

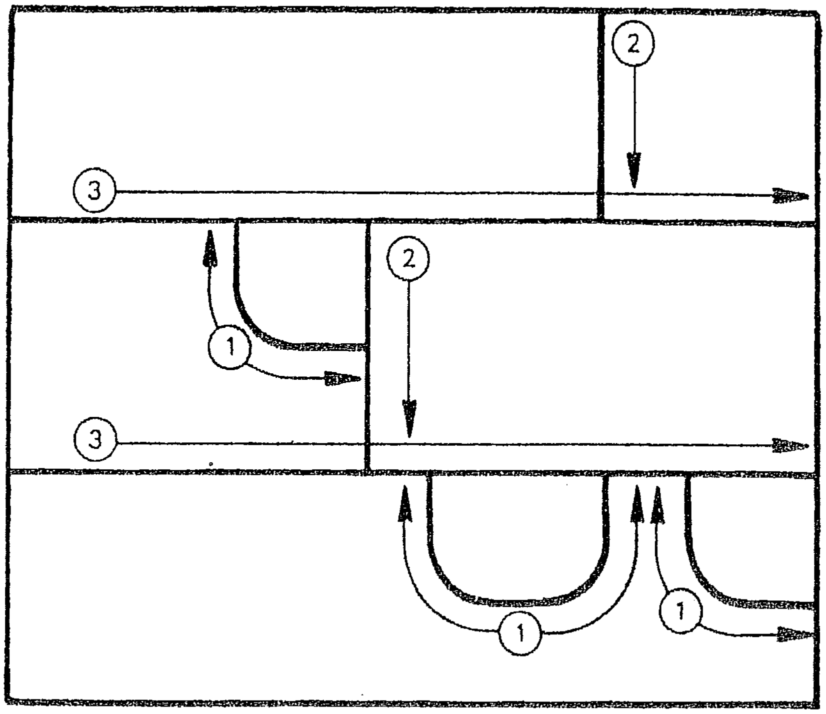
14.13.5.2 Whenever practical, decks and flats shall be welded to the shell only after all structural welding to them has been completed.

14.13.5.3 Generally, all internal structure shall be welded to the shell only after the shell welding has been performed in that given area. Otherwise internal structure will buckle. Leave a gap when fitting shell longitudinals prior to welding shell butts.

14.13.5.4 When longitudinal stiffeners cross shell butts, this sequence should be followed: (1) weld shell butt; (2) weld butt in stiffener; (3) fillet weld stiffener to shell. (Note: The shell butt in thick plate should be welded at least 2/3 of its depth before welding the stiffeners.)

14.13.5.5 Connections through the shell (sea chests, etc.) shall be welded to the shell only after shell welding in that area has been completed.

Figure 14.13-1



When the manufacturing sequence requires that A be done before weld B, weld A must be either left unwelded or cut back as shown until weld B is completed.

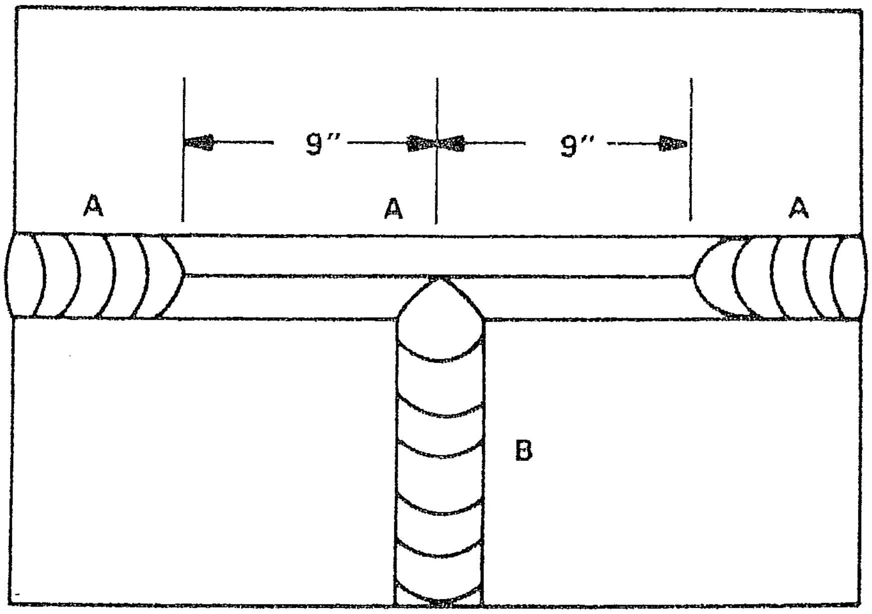


Figure 14.13-2

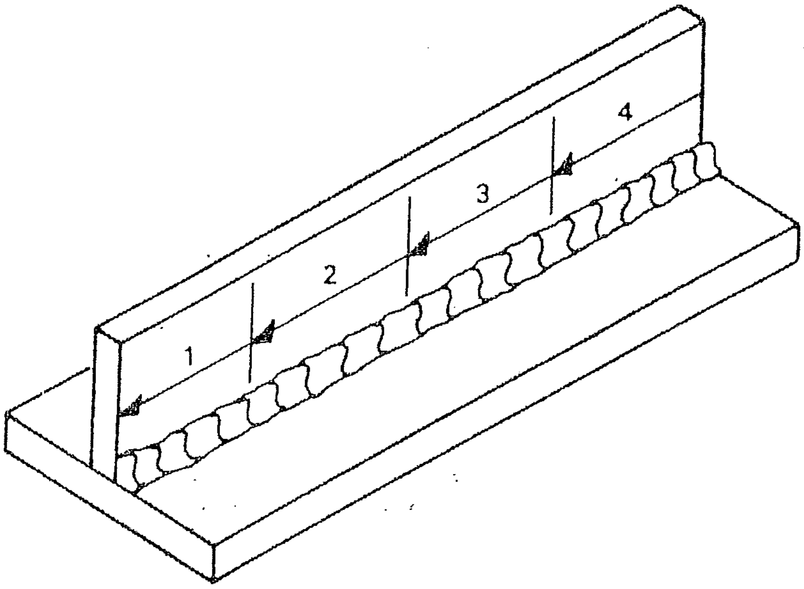


Figure 14.13-3 BACK-STEP

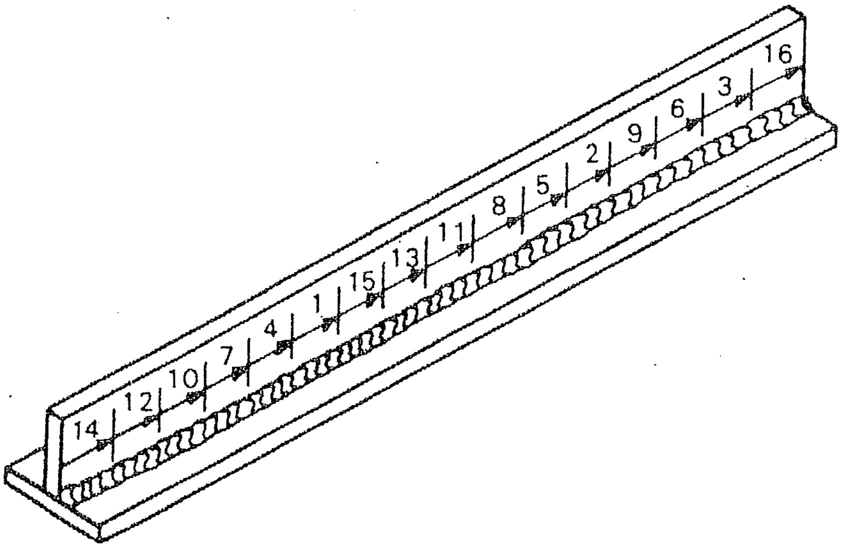
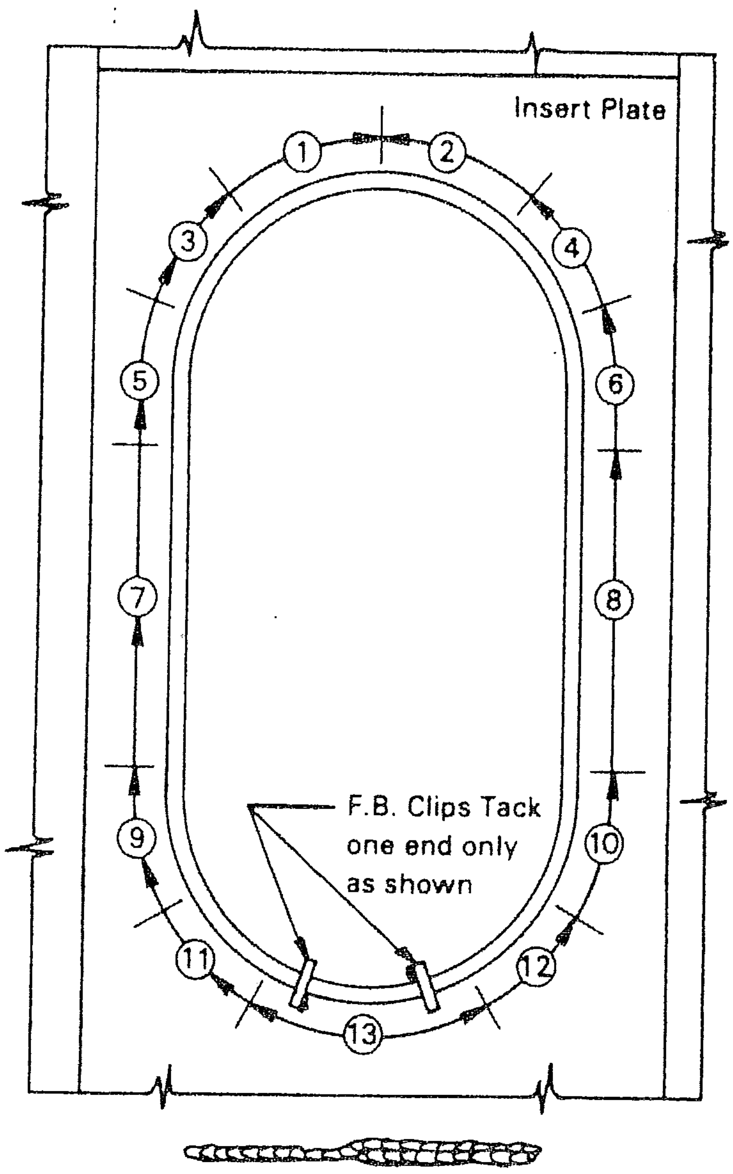


Figure 14.13-4 CONTROLLED WANDERING SEQUENCE

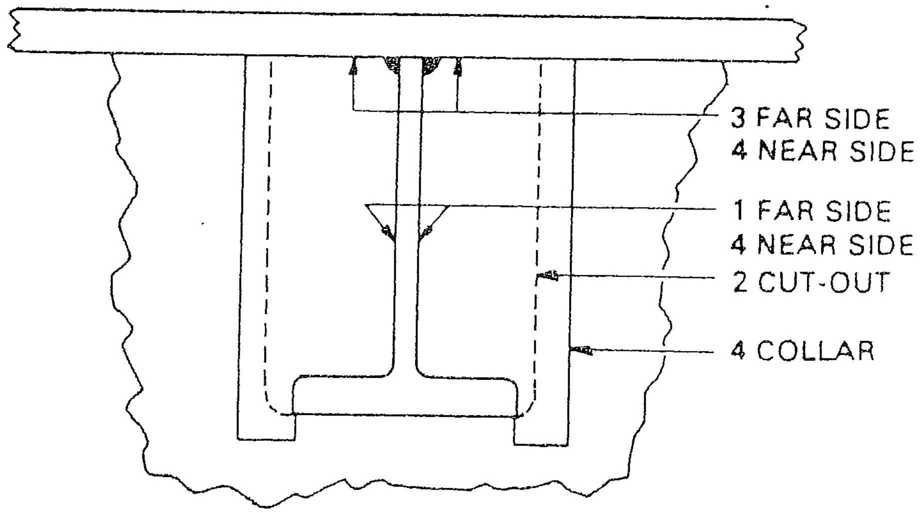


Detail "A"

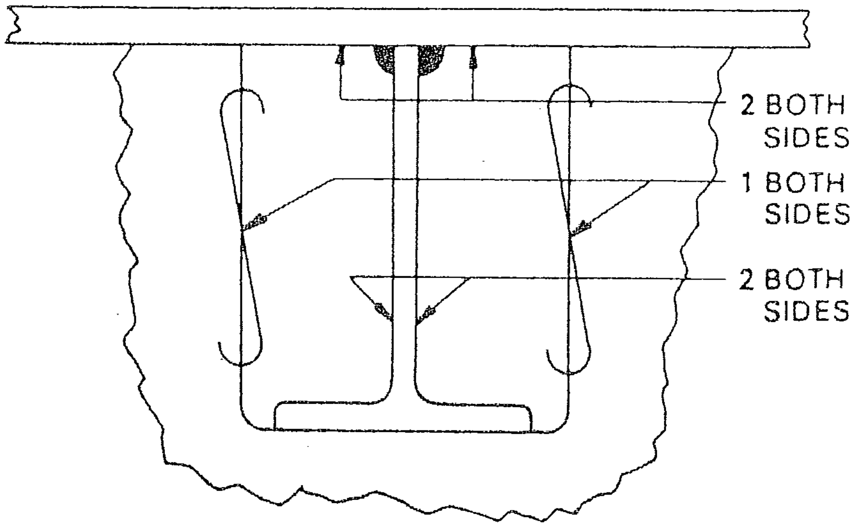
Notes:

1. Weld sequence, as indicated by the encircled numbers using the back-step method.
2. Weld Steps 1-3, leaving Steps 4,5 and 6 unwelded until weld is completed on both sides of plating.
3. Tack other side of plate and remove F.B. clips before welding 4, 5 and 6.
4. Where more than one pass is required, use back-step sequence cascading two passes for first and second pass. (See Detail "A".)

Figure 14.13-5 TYPICAL INSERT SEQUENCE



LAP TYPE COLLAR



INSERT TYPE COLLAR PLATES

Notes:

1. Welds should be made in numerical order as shown in above figures.
2. Lapped collars should be welded to through member before being welded to the cut member.
3. Insert collars shall be welded to cut member before welding to through member.

Figure 14.13-6 TYPICAL COLLAR WELD SEQUENCES

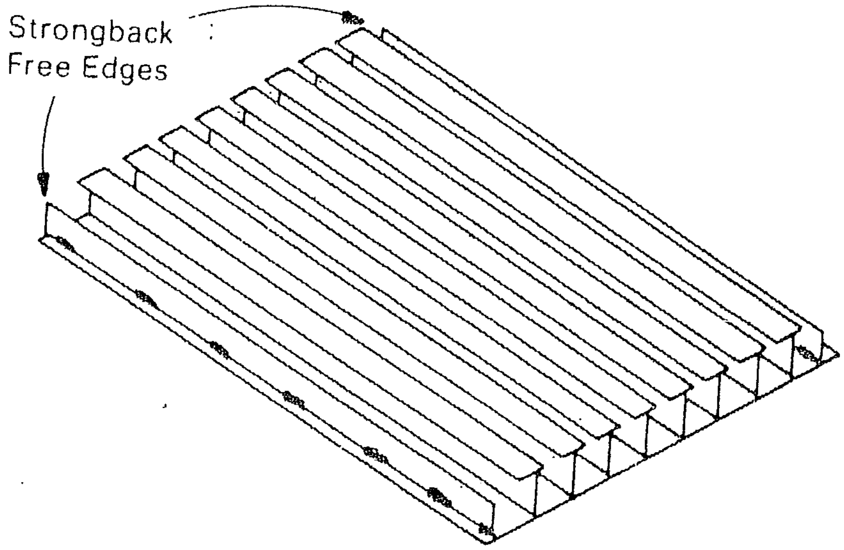


Figure 14.13-7 PANEL LINE SUB ASSEMBLY

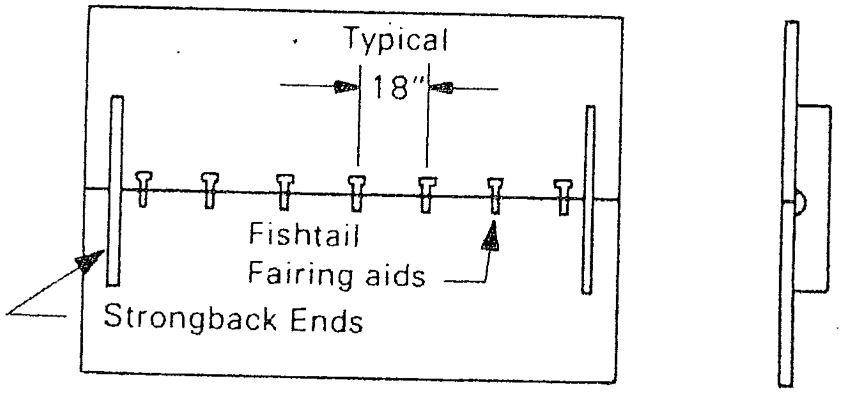


Figure 14.13-8 TYPICAL PANEL

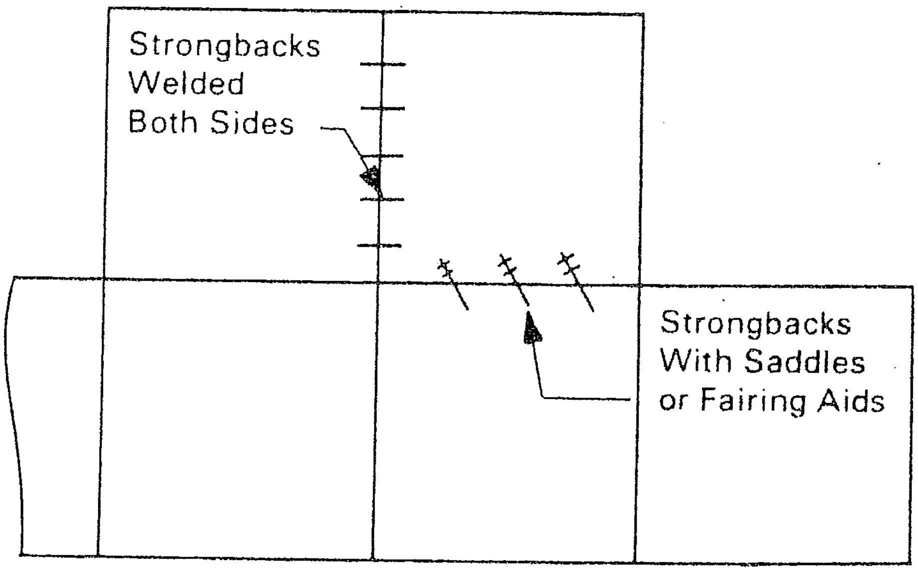
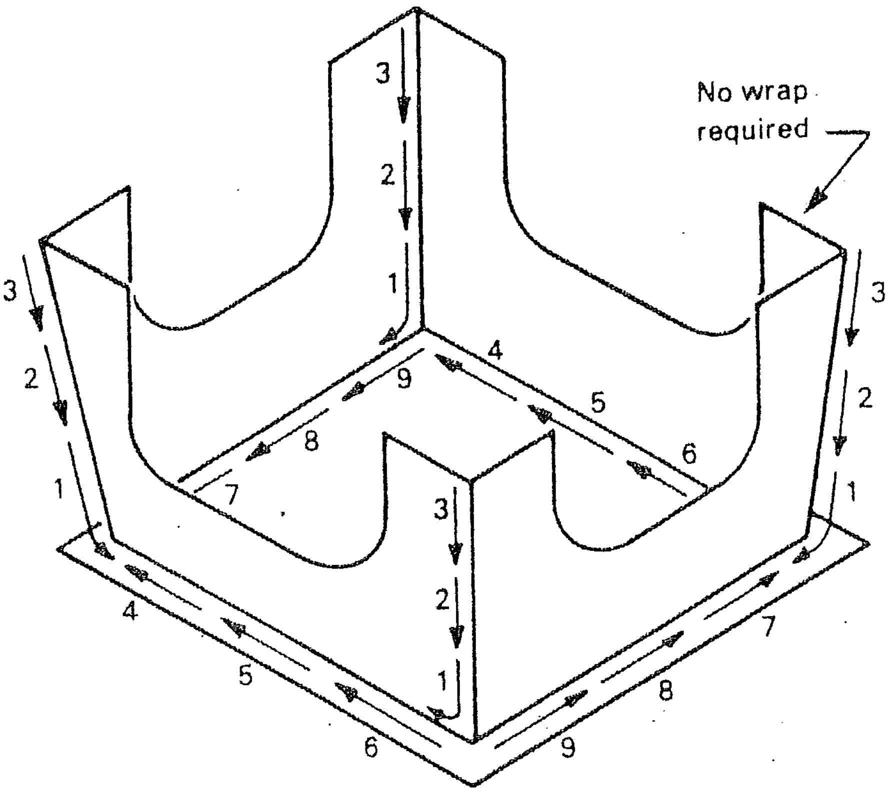


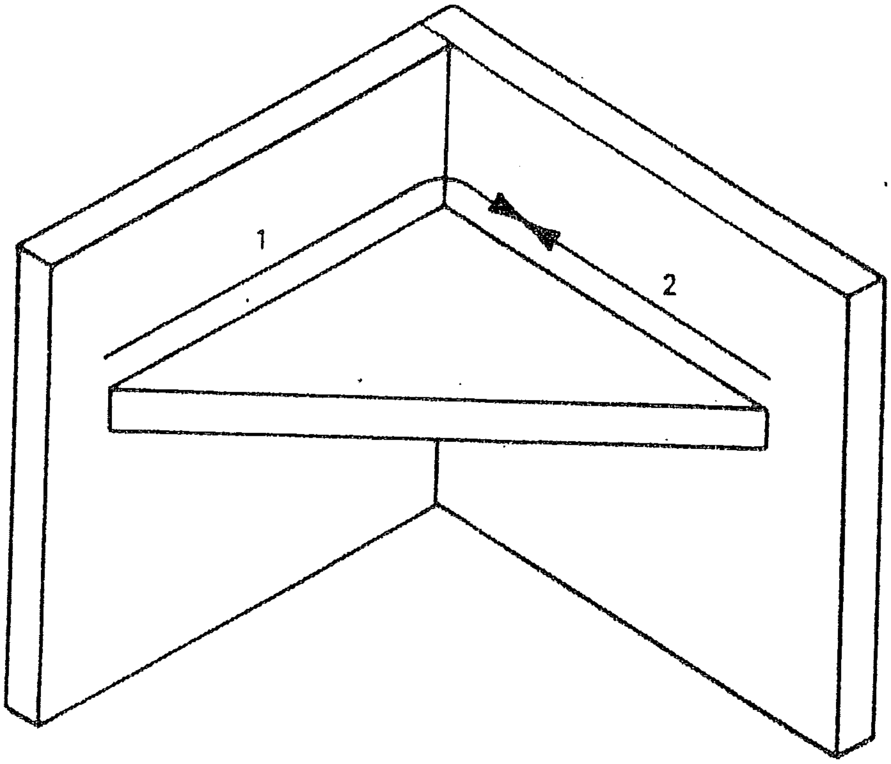
Figure 14.13-9 MODULE ERECTION



Notes:

1. Tack or clamp to positioner.
2. Position all welds flat or horizontal.
3. Weld legs, backstep towards "top" of foundation.
4. Weld flats inside and out, backstep.
5. Avoid stopping in corners, weld around.

Figure 14.13-10 GENERAL SEQUENCE FOR MISC.FOUNDATION



Notes:

1. Position flat, if possible.
2. Weld through corner, do not stop in corner.

Figure 14.13-11 TYPICAL CHOCK ON FOUNDATION

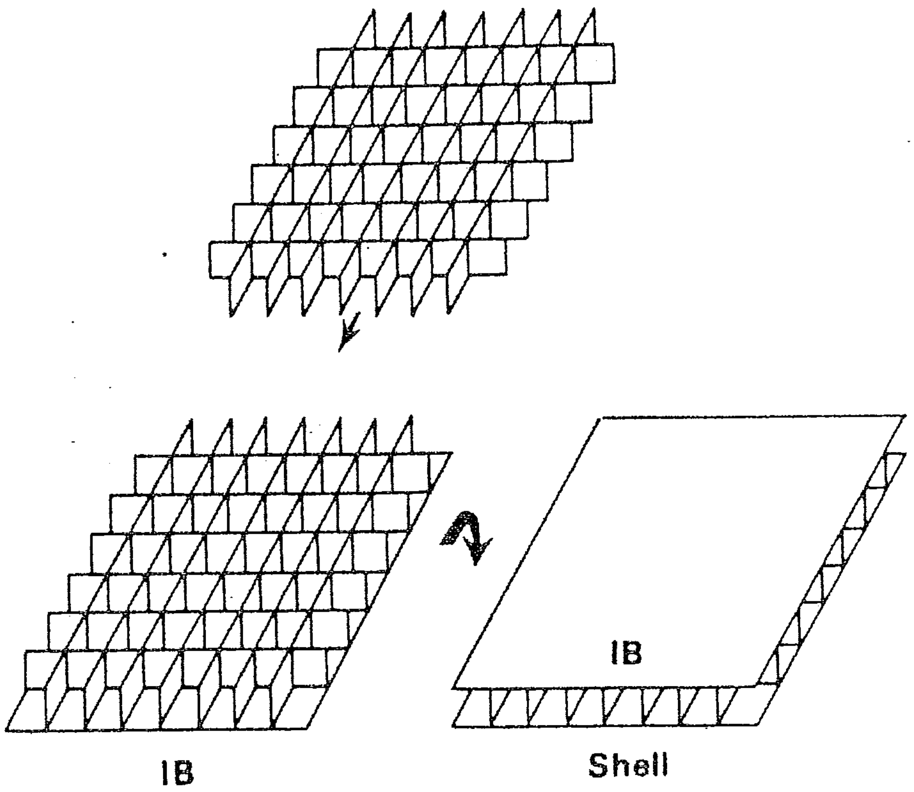
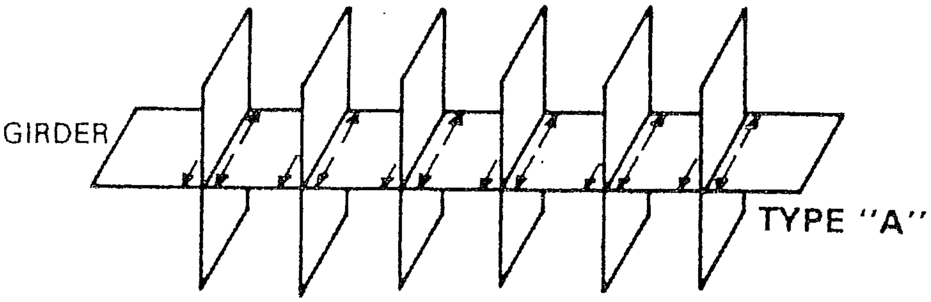
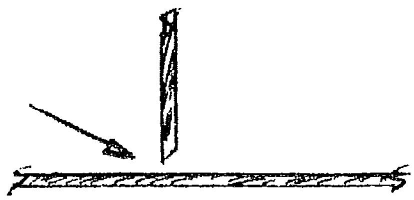


Figure 14.13-12



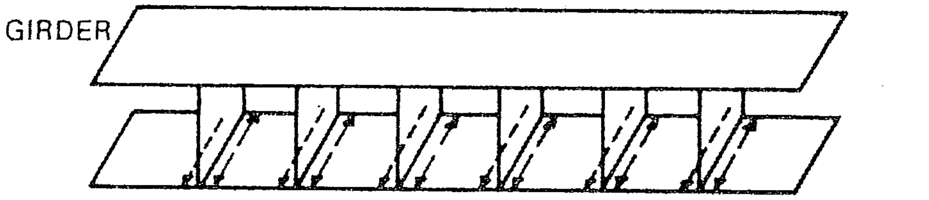
FLOORS (sequence for welding 1/2 of each floor on first side of girder)

For welding floors, weld side opposite kerf first.



TYPE "A" --

1) Weld 1/2 of each floor on first side of girder.
2) Turn over and weld all of each floor on second side.
3) Turn back over and complete welding on first side.



TYPE "B" --

1) Dog girder securely to slab between each floor.
2) Weld 1/2 of first side of each floor.
3) Weld all of second side of each floor.
4) Turn over, dog securely, and repeat steps 2 and 3.

Welding "Egg crates" --

1) Weld all verticals on the high jig, from center out.
2) Weld flats to tank top, from center out.
3) Weld flats to shell, from center out.

Figure 14.13-13 INNERBOTTOM SUB ASSEMBLY

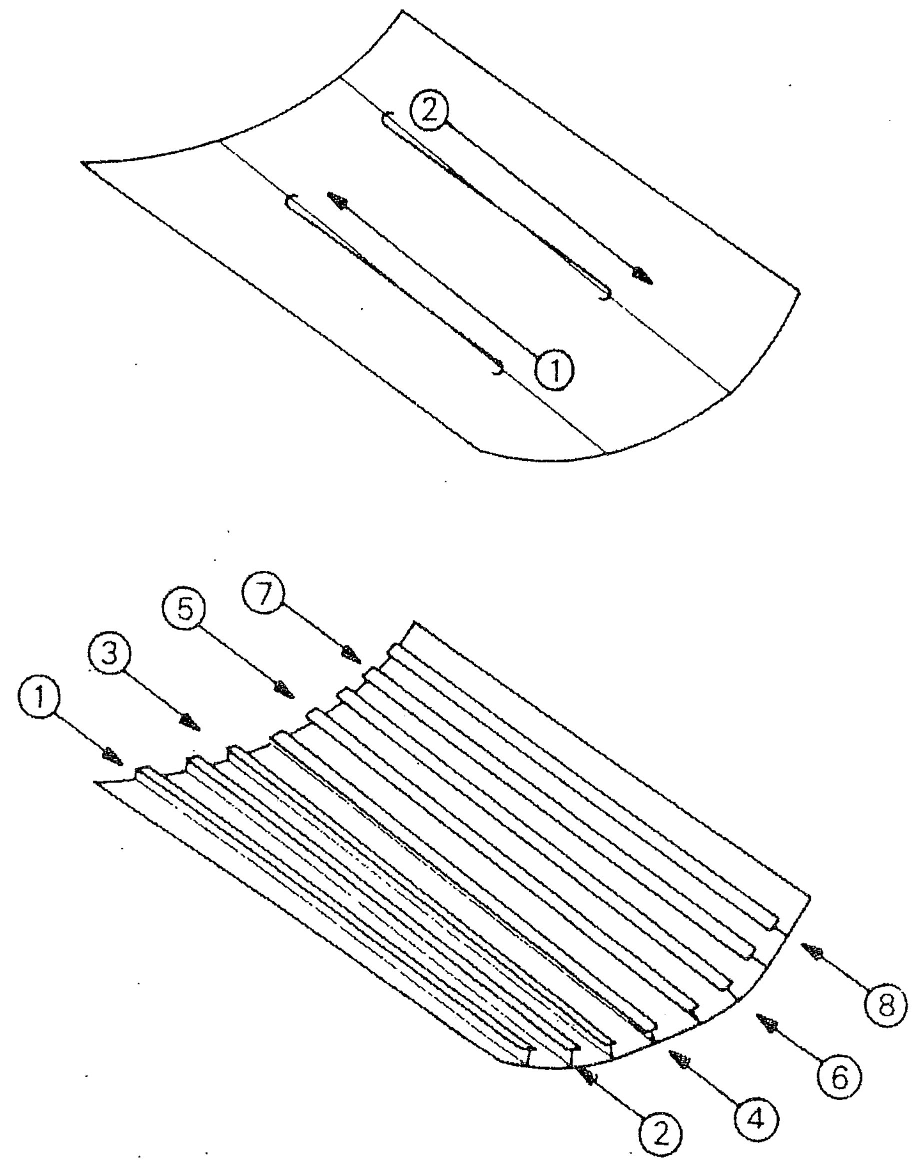


Figure 14.13-14 TYPICAL PIN JIG MODULE SEQUENCE

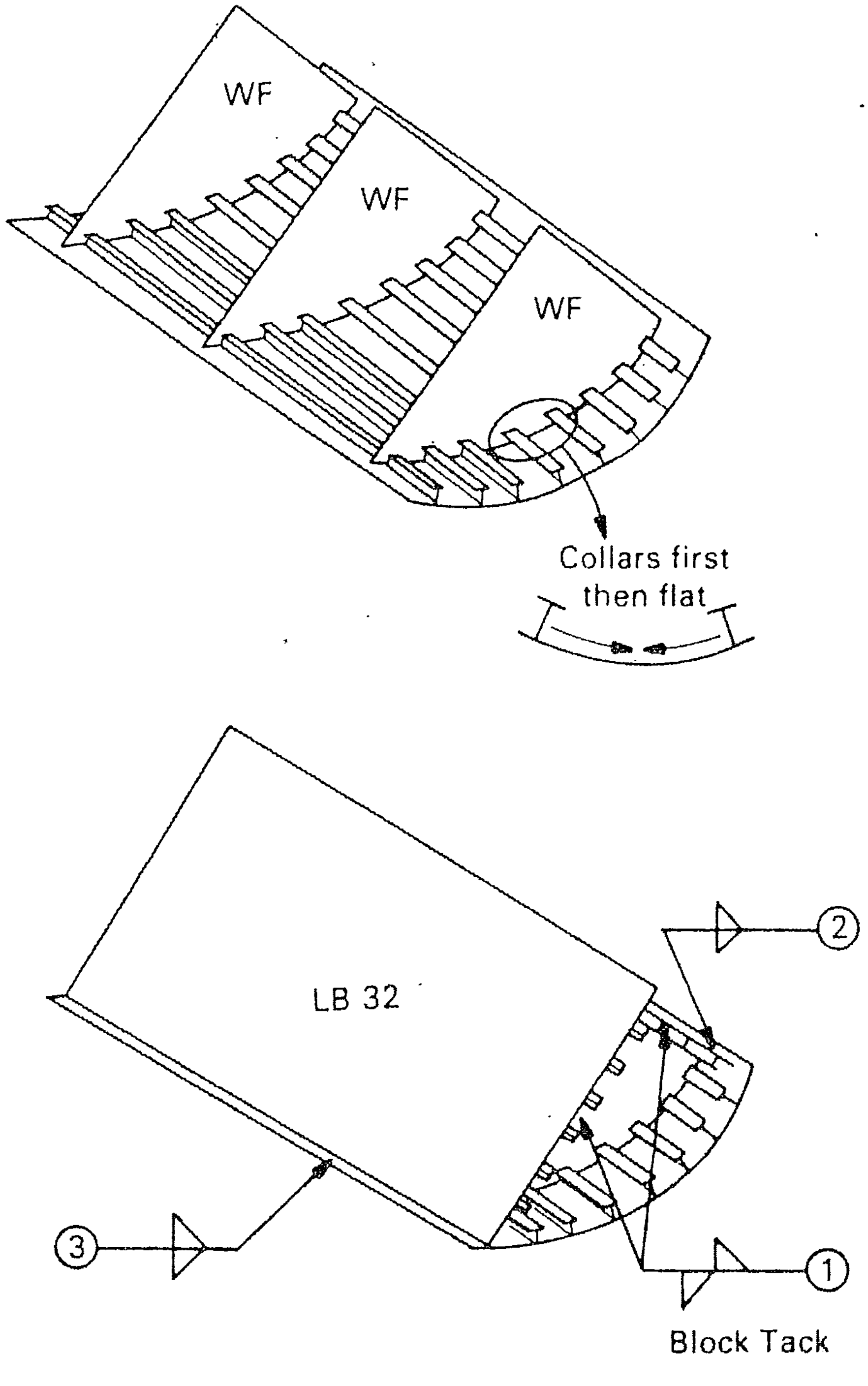


Figure 14.13-14 TYPICAL PIN JIG MODULE SEQUENCE (Cont'd)

14.14 PROCEDURE FOR WELDING HIGH YIELD STEEL INCLUDING FITTING, WELDING AND INSPECTION REQUIREMENTS

14.14.1 PURPOSE This procedure has been developed to control welding of HY steel, assuring weld quality.

14.14.2 SUMMARY HY steel is highly hardenable, low-alloy, quenched and tempered steels. What this means to fabrication is that HY is very likely to crack, or to not maintain toughness in service if fabrication techniques are not controlled.

14.14.3. GENERAL Hydrogen cracking is seen most often as transverse cracks originating in the weld metal or Heat Affected Zone (HAZ) and frequently extending well into the base metal. Three factors are necessary to cause hydrogen cracking: 1) Material; 2) Residual stress; 3) Hydrogen.

14.14.3.1 A susceptible weld of HAZ microstructure -- What this means is a high hardness, with microscopic flaws that are present in all welds. The use of HY steel guarantees high hardness in the HAZ.

14.14.3.2 Residual Stress - As welds cool, shrinkage has to occur. The more restrained the structure is, the higher the residual stress that is locked in. Any amount of welding over what is required for 100% joint efficiency causes unnecessary added shrinkage and increased residual stress. Weld sequencing with backstep or block welding helps to reduce the amount of locked in stress. All welds shrink in at least two directions, causing bi-axial stress. Welds that are made on rings, into corners and crossing "tees" cause shrinkage in three directions -- tri-axial stress. The added direction of stress requires special care in minimizing the other two crack causing factors.

14.14.3.3 Hydrogen -- Hydrogen gas dissolves in hot metal. As the weld cools, less hydrogen can be held in the metal and it must come out. The hydrogen moves into microscopic flaws that have been stretched by high residual stress. The hydrogen tries to form a bubble, and the expansion fractures the weld metal. The crack can then run into the base metal. Sources of hydrogen are: moisture, oil or grease on the plate, moisture in covered electrodes, moisture in shielding gases or absorbed by rust on plate or wire and humidity in the air.

14.14.3.4 Cleaning Prior to Welding -- Flame cut or carbon arc cut surfaces on HY steel shall be lightly ground before welding. All rust, scale, burning slag and paint shall be removed to at least 1/2 inch on each side of the joint. Welding through pre-construction primers is not approved for HY steel.

14.14.3.5 Welder Qualifications -- Welders shall be qualified to weld HY steel using the appropriate process. Welder qualification tests are administered by the weld school and approved by the welding engineer. Additional training of HY crews shall be given by on-the-job welding instructors.

14.14.3.6 High Residual Stress - In the areas of high residual stress, like inserts or reinforcing rings, the highest practical preheat within the bounds of the interpass temperature limits should be used to reduce the tendency toward cracking. Also use a post weld heat soak at the preheat temperature for 8 to 24 hours to allow hydrogen to diffuse out and stresses to stabilize.

14.14.3.7 Uncompleted HY Weld Joints -- If the preheat drops below 115°F, on an uncompleted welded joint in or to HY (or other structural steel requiring preheat over 150°F), the partially completed weld must be M.T. inspected by Q.A. for cracks before the reheating and restarting of the weld.

14.14.4 PREHEAT AND INTERPASS TEMPERATURE CONTROL - The temperature of materials must be controlled to preserve or obtain various properties in the weld and heat affected zones of the base material. Heat will reduce temperature gradients in the structures which will slow the cooling rate of weld and minimize locked up stresses. Heat will also evaporate off condensed moisture and allow hydrogen, which dissolved in the weld during the high temperature phase, to diffuse out of the metal to the atmosphere. The various welding procedures impose temperature controls upon the welding cycle which must be followed to be sure that weldments meet their intended service requirements.

14.14.4.2 Interpass Temperature -- When a welding procedure imposes an interpass temperature, it means that the base material must be allowed to cool down to the specified temperature between passes. When welding small structures, thin plate and especially pipe where the heat has a chance to build up, a pass will have to be interrupted to allow the material to cool to the specified interpass temperature before continuing the weld pass to complete the joint.

14.14.4.3 Post-weld Heat Treatment -- The preheating temperature may be maintained after welding to allow hydrogen to diffuse out of the weld metal. When used for this purpose, preheat temperature should be held for 12 hours or more. Stress relieving, normalizing, or annealing of HY steel shall not be permitted.

14.14.4.4 Temperature Measurement -- Preheat and interpass temperature may be measured with temperature indicating crayons, surface thermometers/pyrometers or infrared indicators. The temperature must be measured within 1-3 inches of the expected weld toe immediately prior to welding. When using temperature indicating crayons, be careful to prevent the residue from contaminating the weld as it is a hydrogen containing substance. When using infrared temperature indicating equipment, the operator must be fully aware of what temperature and over what regions the temperature is indicating. Some machines average the temperature over a wide region, some indicate the highest temperature in a region and some have wider regions than others. Preheat below 115°F, will be considered the same as the surrounding air temperature.

14.14.4.5 Heating Techniques -- The material being heated does not know how it is heated, but various techniques offer definite advantages and disadvantages which must be recognized. The disadvantages and advantages of these processes are as follows:

14.14.4.6 Torch Heating

A) Disadvantages

-- Local heating increases residual stresses
-- Quick heating interval may not allow heat to "soak-in"
-- Moisture caused by combustion in a flame will condense on cold material and contaminate a weld.

-- Hot spots caused by holding a torch in one place too long will distort, weaken or crack materials.
-- Human nature tends to rebel against constantly re-igniting a torch to maintain large expanses at the proper temperature over extended periods where the heat dissipates.

B) Advantages
-- Torch heating is portable and easy to set up.

14.14.4.7 Resistance (Electric) Heaters

A) Disadvantages
-- Heating elements take time to install and can be a safety hazard if not properly used.
-- It takes a while to bring a structure "up to heat' before welding can begin.

B) Advantages
-- Heating elements can be placed to provide uniform heat to minimize distortion.
-- Heating elements can be easily adjusted to maintain control for long periods.
-- Some heating elements can be selected to accommodate both preheat and post heat requirements.

14.14.4.8 Furnace Heating

A) Disadvantages
-- Assemblies must be wrapped in an insulating material to keep them hot for transporting to and from welding

B) Advantages
-- Furnace heating will uniformly heat small assemblies.

14.14.4.9 Preheat and Interpass Temperatures -- Preheat temperature is determined by the thicker member. Use the higher preheat and lower interpass when welding dissimilar materials. Preheat and interpass temperatures are shown in Table 14.14-1.

TABLE 14.14-1
PREHEAT AND INTERPASS TEMPERATURES

MATERIAL	THICKNESS	Preheat & Interpass °F WELDING MIN	WELDING MAX	AIR ARC CUTTING MIN	AIR ARC CUTTING MAX
M.S. & HTS	Below 1"	32	600	N/A	
.3% C MAX	1" to 2"	60	450	N/A	
	Over 2"	25	450	N/A	
HY Steel	1/2" or less	125	300	60	300
	Over l/2"	(With Strip Heaters)			
	to 1-1/8"	125	300	60	300
	Over 1/2"	(With Torch)			
	To 1-1/8"	150	300	60	300
	Over 1-1/8"	(With Strip Heaters)			
		200	300	125	300
	Over 1-1/8"	(With Torch)			
		250	300	12	300

14.14.5 PROCESS SELECTION The appropriate welding process must be selected in order to maximize productivity while maintaining quality. Automatic and semi-automatic welding are selected wherever practicable.

14.14.5.1 Submerged Arc Welding (SAW) may be used on plate thickness of 1/4 inch and up in the flat position for butt welds.

14.14.6 ELECTRODE SELECTION

TABLE 14.14-2
HY STEEL WELDING ELECTRODE AND PROCESS SELECTION

	(BASE METAL 2)	MS or HTS HY	HY80 HY80	HY 100 HY 100
PROCESS	ELECTRODE FLUX			
SMAW	9018	X	X	
SMAW	11018	X	X	X
SMAW	12018			X

spool of bare wire shall carry an identification label. Each container of submerged arc flux shall be labeled by type.

14.14.7 HEAT INPUT CONTROL HY steel is used for the added strength over mild steel. Some portion of that strength and the toughness, or resistance to brittle fracture, is lost in the HAZ. The size of the HAZ must be minimized by keeping heat input low to prevent the loss of these properties. Heat input is increased as volts or amps are increased and as travel speed is decreased.

Most welding processes control amps to control penetration, and volts to control puddle fluidity and weld width. The main variable for controlling heat input is travel speed. If the weld is made slower, weaving or filling, more heat goes into heating base metal, creating a large HAZ. To control this we limit weave width, weld bead width and specify volts/amps/travel speed to keep heat input below allowable maximum. The size of the HAZ is also dependent on the material thickness - thicker plate chills the weld faster. Therefore heat input allowable is higher on plate 1/2 inch thick and greater than on plate under 1/2 inch thick.

14.14.7.1 Control of Heat Input -- Heat input of welding on HY steel shall be controlled in accordance with MIL STD 1689. All automatic and semi-automatic processes shall have heat input controlled by limiting joules per inch. Heat input shall be limited to the values in Table 14.14-3, determined for the thinner member if welding dissimilar thicknesses.

TABLE 14.14-3

PLATE THICKNESS	HEAT INPUT (JOULES/INCH)
Less than 1/2	45,000
1/2 and greater	55,000

Heat input shall be calculated by:

$$\text{Heat input (joules/inch)} = \frac{\text{Volts} \times \text{Amps} \times 60}{\text{Travel Speed (IPM)}}$$

Travel speed for automatic and semi-automatic processes may be determined by measuring length of weld made in 15 seconds and multiplying by 4. Heat input control of SMAW welding shall be determined by measuring bead length from a 14 inch electrode, burning 12 inches. Minimum allowable bead length shall be as shown in Table 14.14-4.

TABLE 14.14-4

PLATE THICKNESS	ELECTRODE SIZE	BEAD LENGTH
Less than 1/2	1/8	4
Less than 1/2	5/32	5-3/8
Less than 1/2	3/16	8
1/2 or greater	1/8	3-3/8
1/2 or greater	5/32	4-3/8
1/2 or greater	3/16	6-1/4
1/2 or greater	7/32	11-3/8

Heat input control shall also be by fillet weld size and weld bead width. Single pass fillet welds shall not exceed the size shown below:

PLATE THICKNESS	FILLET WELD SIZE
Less than 1/2	3/16
1/2 and greater	7/32

Weld bead widths shall not exceed those shown below. Exception to this is permitted if heat input is calculated by joule count.

PLATE THICKNESS	FILLET WELD SIZE
Less than 1/2	3/8
1/2 and greater	1/2

14.14.8 SPECIAL TECHNIQUES Tack Welding -- HY steel shall be preheated prior to tack welding, at the same temperature required for butt welding. Tack welds shall be made by SMAW using the filler metal shown in Table 14.14-2. Tack welds shall be made by qualified welders or fitters, and shall be inspected by the welder or lead man for cracks. Cracked tack welds shall be removed by grinding. Tacks not removed prior to final welding shall be faired in by grinding.

14.14.8.1 Temporary Attachments -- Temporary attachments shall not be removed by knocking off. Attachments may be flame cut or arc gouged to 1/16 inch from the surface of the HY steel. The final 1/16 inch shall be removed by grinding. After grinding, the area shall be inspected by MT.

14.14.8.2 Arc Strikes -- Accidental arc strikes outside of the weld joint, including arc strikes caused by poor ground connections, shall be removed by grinding into the plate about 1/32 inch. The grinding shall be faired into the plate so there is no apparent gouge visually or by NDT.

14.14.8.3 Flame Gouging and Flushing -- When flame gouging or flushing is required, an area 3 inches wide surrounding the area to be gouged shall be preheated to 150°-200°F to prevent condensation while burning. The gouging shall leave 1/16 inch to be ground flush to the surface.

14.14.8.4 Carbon Arc Gouging -- When carbon arc gouging, preheat as shown in Table 14.14-1. Arc gouging of welds or weld joints shall be cleaned up by light grinding prior to final welding.

14.14.8.5. Stud Welding -- Stud welding by capacitive discharge stud machines for temporary attachments such as strip heaters, etc., is permitted. Preheat shall be 60°F for capacitive discharge studs, except that temporary capacitive discharge studs may be welded with no preheat.

14.14.9 VISUAL INSPECTION Inspection of HY Steel Welding -- Structural welding inspection acceptance MIL STD 2035, class 2 for visual examination and magnetic particle testing and MIL STD 2035, class 3 for radiographic examination.

14.14.9.1 Visual Inspection -- Visual inspection of fit-up shall be performed by the welder prior to tack welding and prior to final welding. Welders shall inspect tack welds which are not removed prior to final welding. Lead person or Quality Control shall inspect final welds.

14.14.9.2 Magnetic Particle Testing -- Magnetic particle testing (MT) of HY steel welds shall be performed not less than 8 hours after the weldment has cooled to ambient temperature. Sixteen hours shall be allowed for cooling to ambient temperature. Back gouged areas to be welded shall be MT inspected prior to welding. Areas where temporary attachments have been removed shall be MT inspected after grinding.

14.14.9.3 Radiography -- Radiography shall be performed where required by MIL STD 1689.

14.14.9.4 Ultrasonic Inspection -- Ultrasonic inspection shall be performed where required by MIL STD 1689. Acceptance criteria shall be MIL STD 2035, class 3.

15.0 WORKMANSHIP -- HULL

15.1 APPLICABILITY

This is intended to be a minimum standard of acceptability for production workmanship and a tool to define rework items so that hot work can be completed at the earliest possible stage of construction. It is not intended that this standard be used to re-inspect work which has been found acceptable at an earlier date. Inspection performed at a later stage of construction should be accomplished with regard to design criteria and costs of related rework, not just workmanship.

15.1.1 Structural items are defined to be those assemblies which support, reinforce or otherwise carry loads which upon failure could be injurious to personnel or the structural integrity of the ship or its systems. Excluded in this definition are piping, rotating machinery, and non-critical structures such as furniture and galley equipment. Included are machinery foundations, pipe hangers and supports for all types of equipment.

15.1.2 Inspection of welds will be performed in the "as-welded" condition with all slag removed, without magnification, except for corrective eye glasses as necessary and otherwise as noted herein. Standard tools such as ruler, fillet leg gauge, throat gauge, undercut gauge, etc., will be used. Inspections will be performed in well lighted areas or with a good flashlight. Debris will be removed from the area of interest during the inspection as necessary with a whisk broom or other suitable tool.

Definitions of terms used herein conform to the definitions used by the American Welding Society.

The following sub-paragraphs outline the acceptance criteria for various weld-related defects. Welds not meeting these minimum requirements will be reworked according to established procedures.

15.1.3. WELD JOINT SURFACE PREPARATION All weld joint surfaces shall be cleaned and visually inspected. Surfaces to be welded upon and adjacent surfaces for a distance of approximately 1/4 inch from the expected weld area shall be clean, dry, and reasonably free of surface matter, defects or rust, and objectionable nicks, gouges and irregularities. Welding through primer is permitted by using applicable approved Welding Procedure.

15.1.4 ZINC COATINGS In the following cases, metallic zinc shall be removed from all joint surfaces on which welds are to be deposited and for a distance which will be at least 1/2 inch from the edges of the finished welds:

(a) Connections of main transverse water tight bulkheads to shell
(b) Main cooling intake and discharge sea chests and their connections to the shell or innerbottom plating.
(c) All deck seamanship installations and fittings.
(d) Weight-handling equipment
(e) All connections of main propulsion machinery foundations to shell or innerbottom plating.
(f) All attachments to the following materials: Stainless steel, HY steel or nonferrous metals except copper-zinc alloys.
(g) All other connections to be welded with electrodes other than those of the types MIL-G-6010 or 6011 or QQ-E-450, or other electrodes qualified by procedure.

15.1.5 Removal of metallic zinc may be accomplished by any of the following means: blasting, grinding, chemicals or localized heating and subsequent removal of molten zinc by wire brushing. Where localized heating is employed, a slightly oxidizing flame (oxyfuel gas) shall be used; base material temperatures shall not exceed 950°F. Temperature - indicating crayons or other temperature-measuring equipment shall be used.

15.1.6 WELD ROOT CLEANING Unless otherwise permitted by welding procedure approval, the root of a joint to be welded from both sides and which requires complete penetration shall be chipped, ground, or gouged after sufficient welding has been done on one side. Before any welding is started on the opposite side in way of the weld deposited on the first side, the weld root area shall be cleaned to sound metal and contoured so as to allow sound deposition of the root pass from the second side.

15.1.7 CRACKS Welds will be free of cracks. Where cracks are suspected, magnification (3x or 5x), PT or MT should be used to verify acceptability.

15.1.8 LACK OF FUSION Welds will be free of incomplete fusion. Where incomplete fusion is suspected, magnification (3x or 5x), PT or MT should be used to verify acceptability.

15.1.9 CRATERS Craters at the ends of welds will be filled to the full cross-section of the weld. Crater associated defects are subject to the requirements specified within this standard.

15.1.10 ARC STRIKES All visible evidence of arc strikes on high hardenable materials such as HY steel, STS, AISI 1040, 4130, etc., shall be removed. Arc strikes with objectionable appearance on low carbon steels and other non-hardenable materials will be removed.

15.1.11 SPATTER Tightly adhering weld spatter with a flat or slightly rounded contour is acceptable. Loose or partially bonded spatter will be removed and areas where the appearance of spatter is objectionable will be ground smooth.

15.1.12 GOUGE MARKS Surface gouge marks caused by carbon-arc scarfing or oxy-fuel burning or flushing which are rounded and smooth and are not deeper than 1/16" are acceptable. Sharp defects and those deeper than 1/16" will be repaired.

15.1.13 FILLET WELD SIZE

(a) The size of fillet welds as specified on drawings or other documents is considered to be the length of the legs of convex fillets. Concave fillet welds are acceptable if the throat size is not less than 0.7 times the specified leg size.

(b) Fillet welds up to and including 3/8" size shall not vary below the specified size by more than 1/16" for a total distance greater than one-fourth of the entire joint length nor more than 6" at any one location.

(c) Fillet welds 7/16" and larger shall not be smaller than the specified size.

(d) Fillet welds in excess of those required by plan are acceptable.

15.1.14 BUTT WELD REINFORCEMENT The surface of butt and seam welds shall be flush with or higher than the adjacent base metal surface not to exceed the following:

(a) For base metal thickness to and including 1/2" reinforcement will not exceed 3/32".

(b) For base metal exceeding 1/2" reinforcement will not exceed 5/32". The thicker plate determines the criteria for transition joints.

15.1.15 POROSITY AND WORMHOLES Porosity and wormholes in single pass fillet welds are acceptable as long as:

(a) There is not more than one 1/16" indication in any 6" of weld.

(b) The indications are not found to be located in an oiltight, water tight or air tight boundary prior to pressure or hydro test.

Porosity and wormholes in multipass fillet, butt and seam welds shall be repaired.

15.1.16 WORM TRACKS Worm tracks which are characteristic of the FCAW (dual shield) process are acceptable as long as the porosity and weld throat size requirements are met.

15.1.17 SLAG Slag will be removed from all welds.

15.1.18 UNDERCUT Undercut at the edge of a weld is allowed as long as it does not exceed 1/32" or 10% of the base metal thickness, whichever is less.

	BASE METAL THICKNESS	MAXIMUM ALLOWABLE U.C.
	1/8"	.013"
1/32" = .031"	3/16"	.019"
1/64" = .016"	1/4"	.025"
	5/16"	.031"
	3/8"	.031"

15.1.19 WELD CONTOUR The surface of welds shall be free of sharp irregularities and discontinuities which form vertex or apex angles of less than 90°F.

15.1.20 ROLLOVER The weld shall not form a re-entrant angle with the base plate due to excessive rollover.

15.1.21 STOPS AND STARTS The beginning and ends of weld beads shall blend together so as to meet the requirements of this standard for rollover, undercut, craters, reinforcement, weld size, etc.

15.1.22 WRAP AROUNDS Fillet welds shall extend around exposed ends of members, and through snipes, ratholes, oil stops, etc., to form continuous closed loops. Single pass welds must form a complete seal, however, weld size through the wrap is not critical. Wraps for multipass welds must be full sized.

15.1.23 TEMPORARY SNIPES Where continuous full penetration welds in systems on intersecting structure are required, temporary snipes shall be provided to assure the deposition of sound metal at such intersections. Temporary snipe locations shall be governed by the details of the welding sequence. Snipe dimensions shall be of adequate size to allow satisfactory completion of welding in the through joint and shall be kept as small as possible to facilitate re-welding.

15.1.24 INTERMITTENT WELDS The length of intermittent welds shall be at least that specified by the drawing and the interval between weld centers will be at most that specified by the drawing.

The ends of members welded intermittently will be welded continuously for three times the length required for each weld by the drawing.

An intermittently welded member will be welded continuously on both sides for two times the length required for each weld by the drawing in way of an intersecting member.

15.1.25 SURFACE REPAIRS Where repairs have been made to surfaces due to gouge marks or temporary attachments, etc., the complete surface will be ground to a depth between flush to 1/16" below the base metal surface on exterior hull surfaces and on uninsulated interior living spaces. Other areas will be "as welded" as long as the welds conform to the requirements of this standard, or they may be faired smoothly into the base metal by grinding, but need not be flush.

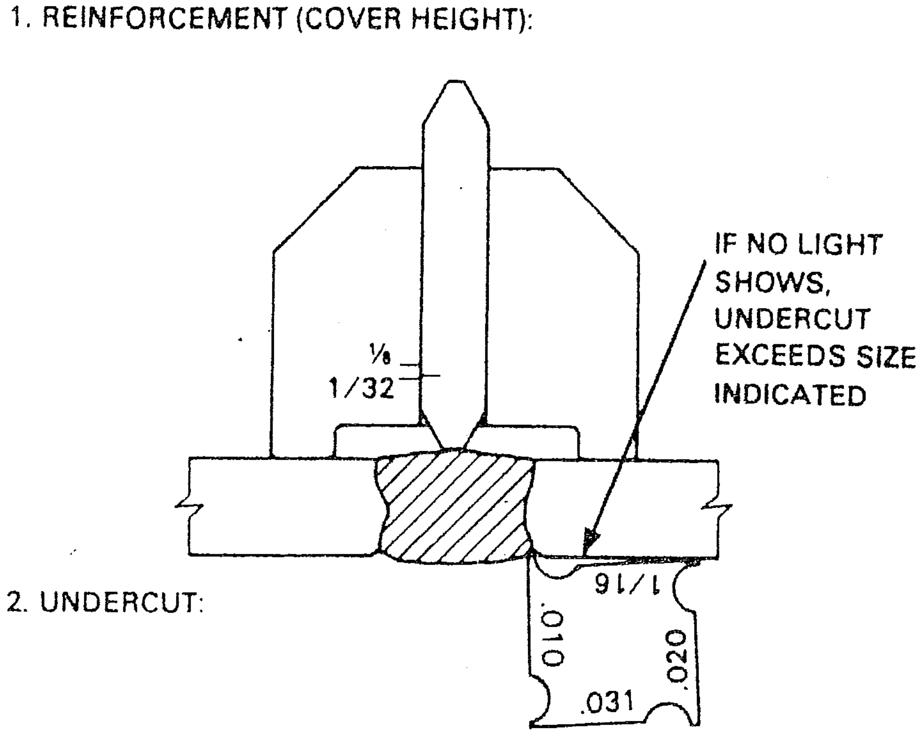
15.1.26 PEENING Peening may be used to correct distortion or to minimize residual stress. Peening shall not be used on first and last layers deposited. Peening shall be accomplished with a round or blunt-nosed tool of circular or oblong cross-section. Light grinding shall be employed to remove visual indications of flaking or laps. Surface slag, slag inclusions, cracks and gas holes shall be removed before peening to prevent entrapment of foreign materials or unfused areas in the weld. Peening shall be done with power-driven equipment only.

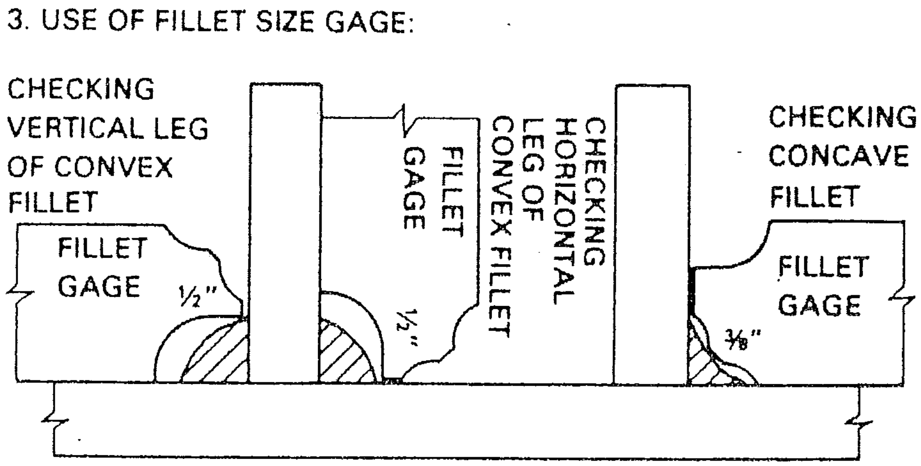
1. REINFORCEMENT (COVER HEIGHT):

2. UNDERCUT:

3. USE OF FILLET SIZE GAGE:

Figure 15.1-1 Weld size inspection use of reinforcement undercut and filler gages.





15.1.27 PLATE EDGE LAMINATIONS--GENERAL
Only those laminations need be removed and repaired to render the plate edge acceptable to the following requirements. Laminations visually disclosed on exposed plate edges which will not be covered by weld metal shall be repaired by welding as specified below.

A) Shell plate laminations disclosed in weld-edge preparation during fabrication or weld repair shall be visually inspected to the acceptable standards of 5.1.27(b). Laminations which are acceptable for repair in 5.1.27(b) shall be closed by excavating to a depth of approximately 3/8 inch, or one-half the material thickness, whichever is less, and the excavation filled with weld metal.

(B) Continuous laminations 8 inches or less in any 24 inch length, or discontinuous laminations whose total length if 12 inches or less in 24 inch length and with no single continuous laminations greater than 6 inches, are acceptable. Edge laminations which exceed these limitations shall be repaired or the affected plate area shall be replaced. Any lamination disclosed on exposed plate edges which will not be covered by welding shall be repaired by welding.

15.2 PREHEAT AND INTERPASS TEMPERATURES AND POST HEAT

15.2.0 GENERAL The temperature of materials must be controlled to preserve or obtain various properties in the weld and heat affected zones of the base material. Heat will reduce temperature gradients in structures which will in effect slow the cooling rate of a weld and/or minimize locked-up stresses. Heat will also evaporate off condensed moisture and allow hydrogen, which dissolved in the weld during the high temperature phase, to diffuse out of the metal to the atmosphere. The various welding procedures impose temperature controls on the welding cycle which must be followed to be sure that the resulting weldments meet their intended service requirements.

15.2.1 PREHEAT When a welding procedure imposes a preheat requirements, it means that the base material must be heated to and maintained at or above the specified temperature before and while welding is going on. It must be applied in a way that the heat "soaks-in" so that the material is heated through (not just surface heated). Structure may be heated to a temperature of 200°F, above the interpass temperature and allowed to cool to proper temperature range to accomplish this.

15.2.2 INTERPASS TEMPERATURE When a welding procedure imposes an interpass temperature, it means that the base material must be allowed to cool down to the specified temperature between passes. When welding small structures, thin plate and especially pipe where the heat has a chance to build up, a pass will have to be interrupted to allow the material to cool to the specified interpass temperature before continuing the weld pass to complete the joint.

15.2.3 POST HEAT When a welding procedure imposes a post heat requirement, it may mean one of a number of things; stress relief, tempering, or normalizing heat treatments, post weld heat soak at the preheat temperature for stress relaxation or hydrogen diffusion, or slow cool down to minimize thermally imposed stresses. Each post heat will have with it an associated interval of time which is as critical as temperature.

15.2.4 TEMPERATURE MEASUREMENT Preheat and interpass temperature may be measured with temperature-indicating crayons, surface thermometers/pyrometers or infrared indicators. The temperature must be measured within 1-3 inches of the expected weld toe immediately prior to welding. When using temperature-indicating crayons, be careful to prevent the residue from contaminating the weld as it is a hydrogen containing substance. When using infrared temperature indicating equipment, the operator must be fully aware of how and what temperatures and over what regions the temperature is indicated because some machines average the temperature over a wide region, some indicate the highest temperature in a region and some have wider regions than others. Preheat below 115°F will be considered the same as the surrounding air temperature.

15.2.5 HIGH RESIDUAL STRESS In areas of high residual stress like inserts or reinforcing rings, the highest practical preheat within the bounds of the interpass temperature limits should be used to reduce the tendency toward cracking. Also use a post weld heat soak at the preheat temperature for 8 to 24 hours to allow hydrogen to diffuse out and stresses to stabilize.

15.2.6 UNCOMPLETED HY STEEL WELD JOINTS If the preheat drops below 115°F on an uncompleted welded joint in or to HY steel (or other structural steel requiring preheat over 150°F, the partially completed weld must be M.T. inspected by Quality Assurance for cracks before the reheating and restarting of the weld.

15.2.7 BELOW 60°F AND/OR MOISTURE PRESENT Where the preheat requirement is for 60°F minimum and the air temperature is below 60°F, and/or there is moisture present on the material surface, preheat shall be applied until the area is warm to the touch and dry. Where the preheat requirement is for 32°F, minimum, the material will be dry within 1-3 inches of the weld toes (preheat may be used for this) and there will be no ice or snow within 18 inches of the weld joint.

15.2.8 5XXX ALUMINUM Avoid holding 5XXX aluminum between 150°F and 450°F as far as practical.

15.2.9 DISSIMILAR THICKNESS Preheat requirements are determined by the thicker member.

15.2.10 DISSIMILAR MATERIALS Use the higher preheat and lower interpass requirement while joining dissimilar materials.

15.2.11 HEATING TECHNIQUES The material being heated does not know how it is heated but various techniques offer definite advantages and disadvantages.

15.2.12 TORCH HEATING Use for tack welding and small or localized welds. Be sure to allow the heat to "soak-in" so that more than just the surface is heated. Also, moisture will collect on cold plate where the gasses generated in the flame condense when they hit the cold surface.

15.2.13 STRIP HEATERS Although strip heaters take awhile to set up and get the steel up to temperature, they should be used whenever long welds or wide expanses must be worked to provide and maintain uniform heat. Strip heaters must be used for a post weld heat soak.

15.2.14 FURNACE HEATING Use a furnace to heat a large number of small parts or where convenient for special applications.

		PREHEAT AND INTERPASS TEMPERATURE			
MATERIAL	THICKNESS	WELDING°F		AIR ARC GOUGING°F	
		MIN	MAX	MIN	MAX
MS & HTS	Below 1"	32°	600°	N/A	
.3% C MAX	1" TO 2"	60°	450°	N/A	
	Over 2"	125°	450°	N/A	
HY 80	1/2" or less	125°	300°	60°	300°
& HY 100	Over 1/2" 1-1/8"	W/HEATERS			
		125°	300°	60°	300°
		W/TORCH			
		150°	300°	60°	300°
	Over 1-1/8" W/HEATERS				
		200°	300°	125°	300°
		W/TORCH			
		250°	300°	125°	300°
MED & HIGH C STEEL (1055,ETC.)	ALL	CHECK WITH THE DETAILED WELDING PROCEDURE			
3XX CRES	ALL	32°	350°	N/A	
MONEL	ALL	32°	350°	N/A	
CUNI	ALL	32°	150°	N/A	
ALUMINUM (5XXX)	ALL	SEE ALUMINUM (5XXX)) REQUIREMENTS			

Figure 15.2-1 PREHEAT REQUIREMENTS -- STRUCTURAL

15.3 REPAIRS

15.3.1 SCARS AND FABRICATION DAMAGE Repair welding for scars and other fabrication damage shall be limited to those locations which cannot be repaired by grinding as detailed in this section.

15.3.2 GRINDING Grinding may be used for repair defects including undercut, scars, scrapes, arc strikes, etc., as long as the grinding is well faired and does not reduce the plate thickness more than 1/16" below design thickness except:

1. To a depth not to exceed 3/32" for a length of 12" in any 36" length of weld.
2. To a depth of 1/16" below the level of the ungrounded surface adjacent to the ground area.

15.3.3 WELDING Welding may be used to repair defects where grinding is not applicable. Essential elements including electrode, preheat, etc., will be determined by the requirements for welding the applicable base material and special requirements of this section.

15.3.4 WELD ROOT AND REPAIR EXCAVATION CONTOUR Gouged roots and weld repair areas should be contoured by carbon arc-air and/or grinding to product 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 sidewalls sloping without sharp breaks or "keyholing" from the surface to the bottom, with a bottom radius of approximately 1/8 inch minimum and widths sufficient to allow proper electrode accessibility and manipulation.

15.3.5 REMOVAL OF TEMPORARY ATTACHMENTS All welds used for temporary attachments on or to HY steel and other high hardenable materials shall be removed by grinding.

(a) Temporary attachments in way of insulation must be removed to within 1/4" of the base metal provided the protrusions are seal welded with no sharp edges and slag or burrs have been removed.

(b) Temporary attachments inside tanks must be removed to within 1/4" of the base metal. The protrusions must be seal welded and rounded with no slag or burrs, in order to accept paint. If the base metal is gouged, the gouge must be welded. Pickup welds, if smooth with no sharp edges, need not be ground.

(c) Temporary attachments in way of vermiculite must be removed to within 1/8" of the base metal. The protrusion must be seal welded with no slag or burrs remaining.

(d) Temporary attachments in open painted areas, such as habitability and engineering spaces, must be removed to the base metal. Any gouges in the base metal, resulting from removal of temporary attachments, must be welded and then ground smooth to the base metal.

(e) Temporary attachments on decks that are covered with terrazzo or underlay need not have attachments removed to base metal. 1/8" protrusions are acceptable provided the protrusions are seal welded with all slag and burrs removed.

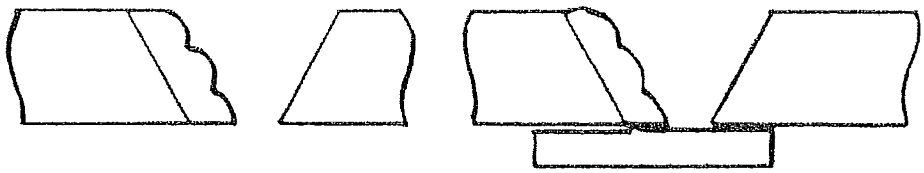
15.3.6 ARC STRIKES All visible evidence of arc strikes (and arc marks under ground connections) shall be removed by grinding. This is required for all HY steel and other high carbon or low alloy steels. All other materials require that arc strikes be ground flush.

15.3.7 UNDERCUT Weld undercut or other undercuts of the base material should be repaired by grinding when possible or by welding, depositing a weld bead in the undercut area which will blend smoothly into the adjacent weld or plate.

15.3.8 POROSITY Where surface porosity is found to be unacceptable, the reason for its unacceptability should be understood before repairing it. Where it exceeds limits for structural integrity it must be gouged out and re-welded to product a sound weld. Where it is within acceptable structural limits, but it violates the integrity of a tank boundary, it may be seal welded, peened shut, or removed and re-welded as necessary. If it violates an integrity of a coating system, as in tanks or areas exposed to the weather, it may be repaired by any of the above methods or by using a suitable non-metallic filler material.

15.3.9 INTERNAL DEFECTS DETECTED BY X-RAY OR U.T. Where a weld has been found unacceptable by N.D.T. examination due to internal defects, first obtain a suitable description and location of the defect from N.D.T. and layout the repair area accordingly. Also, be sure to find out how thick the material is in the area of the defect, then begin to evacuate carefully with light cuts with a carbon arc or a grinder until the defects are found. **Do not** excavate deeper than 3/4 of the thickness of the plate even if the defect has not been located. Be sure to taper the ends of the excavation up to the surface of the weld or base material to allow a good weld tie-in with staggered stops and starts. When excavation is complete, Quality Assurance may want to inspect it before re-welding. After that, re-weld using an appropriate welding procedure for the materials involved. If the second side requires excavation also, weld the first side only part way out in heavy plate before excavating the second side, then weld out using a balanced weld sequence. Note: If the defect continues beyond the inspected area, it still must be repaired in its entirety.

15.3.10 BUTTERING AND BUILDUP Buttering or buildup by welding on joint surfaces to correct oversize root openings, errors in joint preparation, or for fairing, should be done prior to fit up. The amount of weld metal added to any surface shall not exceed 3/8" unless specifically allowed. The buildup may be accomplished by either welding on the edge directly or by welding against a temporary backing strip or similar material which will be removed and ground smooth.



If the joint has been made up before the buttering is accomplished, either of the above methods may be used as long as the 3/8" maximum buildup on one side is observed and the joint is built up to a root gap of 3/16" maximum before the joint is bridged with weld. For butts and full penetration "tee" welds the angle of the bevel after buttering must be at least 45°. Inspection of buttering and buildup is the same as for the final weld.

15.3.11 PLATE EDGE LAMINATIONS Shell plate edge laminations which are found to be acceptable by Quality Assurance, will be closed by excavating w/carbon arc or grinding to a depth of 3/8" or 1/2" of the material thickness, whichever is less, then filling the excavation with weld. Laminations in structures other than shell plate which Quality Assurance finds acceptable need not be closed unless specifically directed to do so.

15.3.12 HOLES -- 2 INCHES OR LESS Holes cut into or through plating may be welded closed without an insert provided the original hole diameter does not exceed 2". Holes less than 1/2" in diameter will be opened up to at least 1/2" in diameter, then a temporary backing plate will be installed. Welding will be done against the backing plate for 1/2" to 5/8" or flush, whichever comes first. Then remove the backing plate and back scarf 3/8" or 1/3 of the thickness whichever is less and weld the second side. Complete the repair and grind smooth as necessary. Inspect as required by Quality Assurance. Note: Where the hole does not exceed 3/4 of the plate thickness, the second side need not be worked.

15.13.13 HOLES -- OVER 2" Holes greater than 2" in diameter will be prepared for an insert as required by Quality Assurance.

15.13.14 HOLES -- LINEAR (e.g., MISPLACED BURNING KERF) Linear holes in plate which are caused by improper cutting, cut backs at butt intersections, or splitting for distortion correction, etc., will be repaired like a butt. Scarf a groove (approximately 60° included angle) on the first side 1/2 to 2/3 of the plate thickness, then weld it using an appropriate weld procedure and sequence for the material type, thickness, and length of repair. Back scarf the second side to clean metal. Inspect as required by Quality Assurance, then weld out the second side. Inspect the final weld as required and grind smooth if required.

15.13.15 CRACKS -- TRANSVERSE Cracks which occur transverse to the weld can be contained entirely in the weld, but most often they start in the heat affected zone beside the weld or at a visible irregularity in the weld. They then generally run all the way across the weld and into the base metal or turn and run along the heat affected zone. They often occur in groups parallel to one another and rarely appear immediately, normally taking 4 to 48 hours to appear, hence they are often called "delayed cracks". Generally high strength low alloy steels like "T-1 or HY 80" and high carbon or thick plate exhibit this type of crack. They occur where a hardened microstructure is created by the heat of welding coupled with hydrogen contamination which has only to exceed a few parts per million. The increased localized stress which builds up around a surface irregularity like a poor tie-in or a short length of undercut will set off the crack.

Repair to a crack should start with a good soaking preheat as high as the interpass limit of the applicable weld procedure. The cracks rarely extend all the way through the plate although they can be deep so a normal "crack stopper" should not be used. Instead, begin the excavation at or ahead of each end of the crack and work toward the middle. Go deep enough to find clean metal, and taper the ends of the excavation to allow a smooth tie-in. M.T. inspect the excavation when complete. Re-weld using new, clean, dry and hot electrodes of the XX18 or XX16 type. Also, use a tempering technique to help amend the heat affected zone. Once the weld is complete, it will look poor as it will lie across the original weld so grind it fair with the base material and original weld, and keep it hot allowing a very slow cool down (wrap or cover it if drafts or rain, etc., are present). Re M.T. inspect for reoccurring cracks at least 48 hours after the weld has cooled to ambient temperatures. If the cracking is extensive or persistent, call Welding Engineering (Extension 432).

15.13.16 CRACKS -- LONGITUDINAL Longitudinal cracks can occur either along the centerline of a weld or at either edge of the weld and are normally caused by stresses across the weld due to the shrinkage of weld metal. (The weld cools and shrinks, and if the weakest part of the weld is not strong enough to hold these stresses, it will crack.) The cracks can also be surface cracks or through-thickness cracks.

15.13.17 SURFACE CRACKS Surface cracks can usually be ground out easily then re-welded (this applies to crater cracks at the end of a weld bead).

15.13.18 THROUGH-THICKNESS CRACKS Indicate that there is a lot of stress tied up which could help the crack continue to run so a "crack-stopper" at each end of the crack should be used to "blunt" the crack tip. Drill, grind or carbon arc a small hole just ahead (1/8" approximately) of the crack. (Peening the metal just ahead of the crack may help, excavate part way into the crack along its length and re-weld to "seal up" the crack. (Peening the weld metal before it falls below 500° will help to keep the crack from tearing out of the new weld.) Excavate the second side to clean metal leaving enough solid metal to hold the stress, inspect and re-weld using the proper weld procedure and a balanced weld sequence. (Preheat within the limit of the interpass temperature requirements and peening will help eliminate the tendency for re-cracking.)

Be sure that the weld blends smoothly with the base metal and that the beads are as smooth as possible. Do not peen the last layer of weld.

If the cracking is extensive or persistent, call Welding Engineering (Extension 432).

16.0
STRUCTURAL REQUIREMENTS

16.1 JOINT NUMBERING SEQUENCE The structural, machinery and pressure vessel joint numbering system is composed of four character groups. By means of the four groups, a unique identification is assigned to each joint design. As an example:

Group 1
First character(s) letter(s) designates type of joint:

B = Butt joint
C = Corner joint
E = Edge joint
L = Lap joint
T = Tee joint
P = Partial penetration

Group 2
Second character (number) designates number of sides welded:

1 = Welded one side
2 = Welded both sides

Group 3
Third character (letter) designates configuration joint:
S = Square groove
V = Bevel or V groove
U = U groove
J = J groove
Period used for separation.

Group 4
Fourth character (number) is assigned in sequence, 1,2,3, etc., to cover distinctive joint differences such as bevel angle, root opening, with backing, without backing, etc.

16.2 STRUCTURAL WELDED JOINT DESIGN AND APPLICATION INSTRUCTION

16.2.1 PURPOSE The purpose of this procedures is to provide all pertinent information necessary to design, prepare and weld joints in structural weldments to be fabricated.

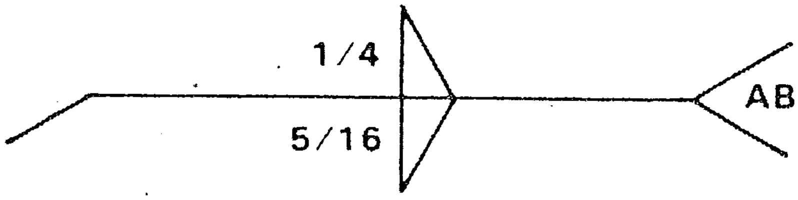
16.2.2 SUMMARY The procedure lists all joints applicable to structural welding, using MIL-STD-22 as a guide. For each joint there is a sketch showing all dimensions, a discussion detailing where the joint is to be used, and notes and suggestions regarding welding, fitting, back gouging, etc. There is also a general notes section which provides information associated with welded joint design and application.

16.2.3 GENERAL This procedure takes the basic requirements of MIL-STD-1689 and MIL-STD-22 and adds to these requirements information derived from weld process application and Todd fabrication practice to provide engineers, loftsmen, planners, shipfitters and welders the ability to utilize the most efficient weld joint for any particular application.

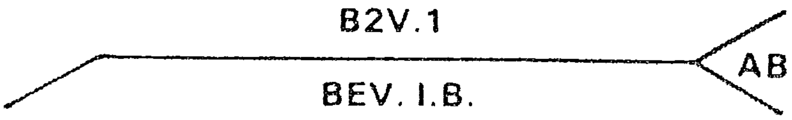
16.2.4 GENERAL NOTES:

1. Application of weld joint details to detailed drawings for Plate Shop and Panel Line, and isometric sketches to Construction Slab and Ways, O.P. Sheets shall be done in the following way:

a. Weld symbols for standard double fillet welds will be standard AWS symbols depicting the proper weld size and, the base metals to be welded.



b. Weld symbols for Butts, Corners, Beveled Tees, etc. Will use modified symbols detailing the actual joint number, the orientation of the bevel and the base metals to be welded. It may also depict the proper AWS symbol.



c. The joint number will be applied to specific applications described herein. It will appear above the line of the weld symbol.

d. Bevels will be applied as specified herein. The nomenclature to be used to describe these requirements will appear below the line of the weld symbol and will be designated as follows:

BEV O.B. Bevel or major bevel will open towards the OUTBOARD.
BEV I.B. Bevel or major bevel will open towards the INBOARD.
BEV O.V. Bevel or major bevel will open towards the TOP side of the plate as it is seen in the specific work area.
BEV U.N. Bevel or major bevel will open towards the UNDER side of the plate as it is seen in the specific work area.
BEV NEAR Bevel or major bevel will open towards the NEAR side or LAYOUT side.

BEV FAR Bevel or major bevel will open towards the FAR side or the side opposite the LAYOUT side.

2. a. Where intermittent fillet welds are shown on drawings, the incremental length and distance between centers of increments will be clearly specified; i.e., (3" - 10") means 3" long welds with 10" between the center of each weld. Where these dimensions are not clearly detailed, continuous welds will be used. Where intermittent welds are allowed, some portions of the numbers require continuous welding as detailed in the workmanship requirements section of the Structural Welding Procedure.

b. The ends of members welded intermittently will be welded continuously for two times the length required for each weld by the drawing for a distance equal to the depth of the member, whichever is greater, except that for members on shell or main transverse bulkheads or bulkheads which form tank boundaries, the ends of the members will be welded continuously for one tenth the length of the member.

c. An intermittently welded member will be welded continuously on both sides for two times the length required for each weld by the drawing in way of an intersecting member.

d. Where intermittent fillet welds are specified by drawings, continuous fillet welds sized as required below may be substituted except where specifically restricted.

Intermittent Weld Size Requirement	Equivalent Continuous Weld
3/16"	1/8"
1/4"	3/16"
5/16"	1/4"

3. Fillet weld sizes will be determined based on welds of the following strength categories:

Base Metal Combination	Minimum Filler Metal Strength
None specified	70 KSI (1)
AB	70 KSI
BB	70 KSI
AC	100 KSI
BC	100 KSI
CC	100 KSI

(1) AA may use 60 xx electrodes for butts and fillets except that the fillet size will have to be increased over the requirements of the applicable drawing

4. **Fillet Weld Size**.
   Fillet weld size requirements as detailed on the drawings will be written beside the joint by the shipfitter who fits the joint before the joint is welded.

5. Joints shall be so located, to the maximum extent possible that the entire weld groove is visible to the welder.

6. **Back Gouging**
   Unless specifically stated on the applicable drawing, all beveled joints are to be considered as full penetration requiring back gouging, chipping, or grinding to clean metal prior to welding the second side. All double sided butt welds will be back gouged, unless specifically approved.

7. **Cut Bevel Before Fit Up**
   Bevels on single bevel joints will be cut prior to fit up. The second side bevel on double beveled joints may be applied by carbon arc scarfing except as specified herein.

8. **Depth of Bevel**
   Where depths of bevels are labeled as t/4, t/3, etc., the bevel shall extend to a depth which is 1/4, 1/3, etc., of the thickness of the plate.

9. In strength members, butt welding of members of unequal thickness, including inserts, shall require chamfering the thicker member with a 4:1 taper down to the thickness of the thinner member in the following locations when the difference in member thickness exceeds the range listed below:
   a. Transverse and vertical butt welded joints in longitudinal strength structure.
   b. All butt welded joints in Ballistic Plating.
   c. Butt welded joints in foundations designed for shock.
   d. Highly stressed transverse structure.

Thin Plate Thickness	Thickness Difference
Up to 1/2"	1/8"
Over 1/2" to 1"	3/16"
Over 1"	1/4"

10. Joint designs for heavy material in excess of 2-1/2" will be handled on a case basis by the Welding Engineer.

11. Butt welds in structural members below 1/8" thickness require special instructions from the Welding Engineer.

12. Joints specified herein conform to the requirements of MIL-STD-22B and include approved joints at MIL-STD-22D.

13. The application of joints as specified herein conform to the requirements of NavShips 0900-LP-000-1000.

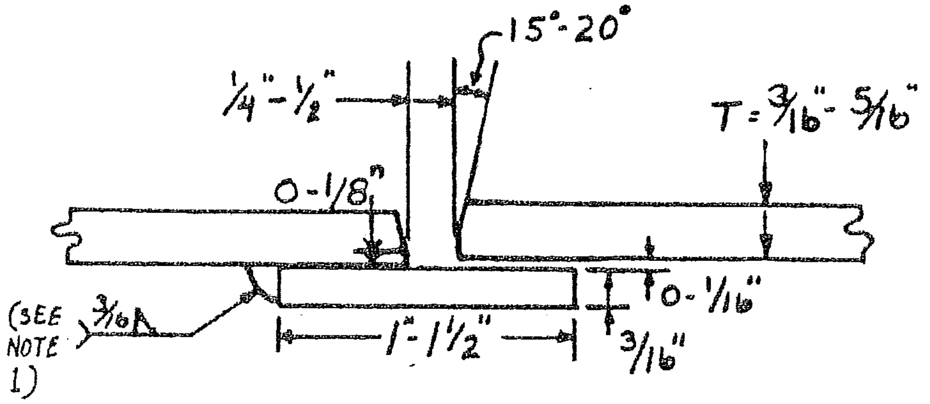
14.A. When drawings call out B2V.1 and B2V.3, Production may use any of the variations to that joint that are listed herein.
Ex. -- drawing calls for B2V.1, Production may use B2V.1-03.
B. When drawings call out B2V.1, Production may use B1V.8 as specified herein.
C. When drawings call out T2V.1, Production may use T1V.8.
D. When drawings call out T1(S)V.3, Production may use T1(S)V.8

16.2.5 JOINT INDEX

JOINT NO.	DESCRIPTION AND APPLICATION
B1V.2	Butt w/backing bar 3/16" - 5/16"
B1V.3	Butt w/backing bar 3/8" and above
B1V.5	Butt w/backing bar 3/16" - 5/16" (horizontal weld inserts)
B1V.7	Butt w/backing bar 3/8" and above (horizontal welds)
B1V.8	Butt w/ceramic tape 3/16" - 1" (flat, one-sided welding)
B2S.1	SQ Butt 1/8" - 1/4"
B2S.1-01	SQ Butt 1/8" - 5/8" (sub-arc)
B2V.1-03	Single bevel butt 5/16" - 3/4"
B2(S)V.2	Single bevel butt 1/4" - 3/4" (horizontal welds, inserts)
B2V.3	Double bevel butt over 3/4"
B2V.3-01	Double bevel butt over 7/8" (sub-arc)
B2(S)V.4-01	Double bevel butt over 3/4" (horizontal welds)
C1V.2 & C1V.4	Corner joint less than 100% efficient--3/4" & under
C1V.5	Corner joint 3/16" - 3/4" closure plates
C2S.1	Corner joint 1/4" maximum
C2V.4	Corner joint 5/16" - 3/4" closure plates
C2V.5	Corner joint flush casting to thick plate
C2V.6	Corner joint over 3/4"
L1S.1	Slot weld
L1V.1	Plug weld
PT2S.1	Double fillet welds 5/8" and below
PT2S.1-01	Double fillet welds members canted 26°-45°
PT2V.1	Partial penetration "T" for equivalent fillet size above 5/8"
T1V1	Full penetration "T" closure plates
T1(S)V.3	Full penetration "T" members canted 45°-75°
T1(S)V.8	"T" connection canted with ceramic tape
T1V.3	"T" connection less than 100% effici3ent
T1V.8	Full penetration "T" with ceramic tape
T2V.1	Full penetration "T" 3/16" - 3/4"
T2V.2	Full penetration "T" over 3/4"

B1 V.2

T = 3/16 - 5/16
F, V, O.H.
Closure Plates

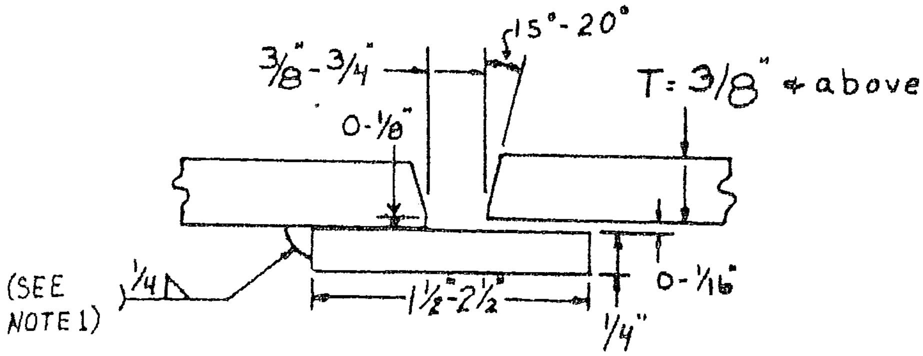


Application
This joint will be used with manual and semi-automatic welding processes for flat, vertical and overhead joints in closure plates. It may also be used for corrective action when plates are cut short as long as the backing strip is removed within 3/5 the midship length.

Note:
1) Unless otherwise specified, the fillet weld may be intermittent (2-1/2"-10").

B1 V.3

T = 3/8" and above
F, V, O.H.
Closure Plates

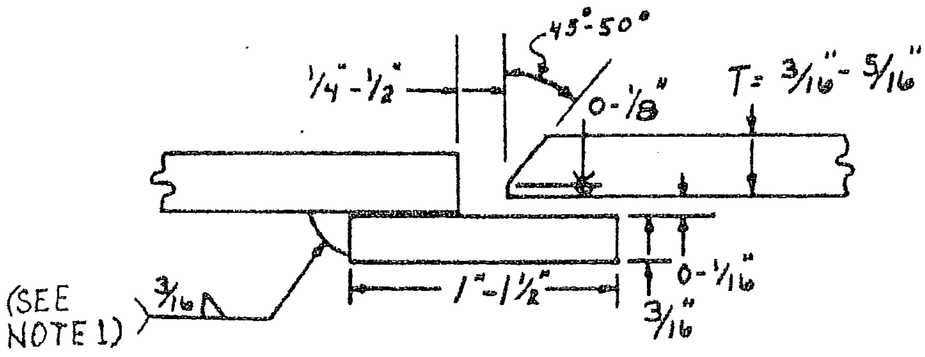


Application:
This joint will be used with manual and semi-automatic welding processes for flat, vertical and overhead joints in closure plates. It may also be used for corrective action when plates are cut short as long as the backing strip is removed within 3/5 the midship length.

Note:
1) Unless otherwise specified, the fillet weld may be intermittent (2-1.2" - 10").

B1 V.5

T = 3/16"-5/16"
Horizontal
Closure Plates
Inserts

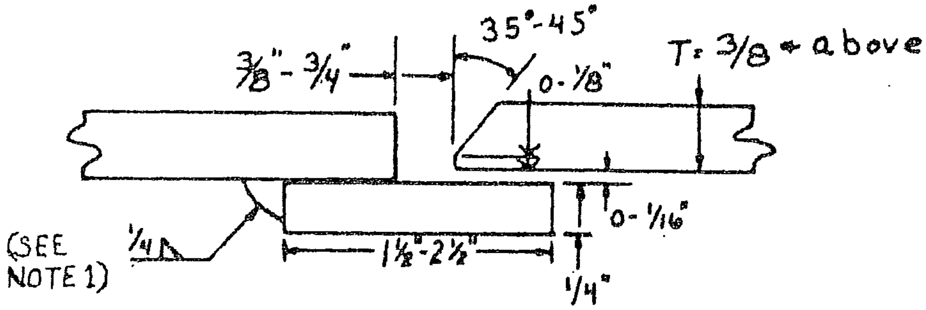


Application::
This joint will be used with manual and semi-automatic welding processes in closure plates where the axis of the weld is within 15° of horizontal and the surfaces of the plate lie within 15° of vertical. It should also be used for inserts in all positions. The bevel will be on the insert leaving the structure square, or it may be used for corrective action when plates are cut short as long as the backing strip is removed within 3/5 the midship length.

Note:
1) Unless otherwise specified, the fillet weld may be placed on either plate and may be intermittent (2-1/1" - 10").

B1 V.7

T = 3/8" and above
Horizontal
Closure Plates
Inserts

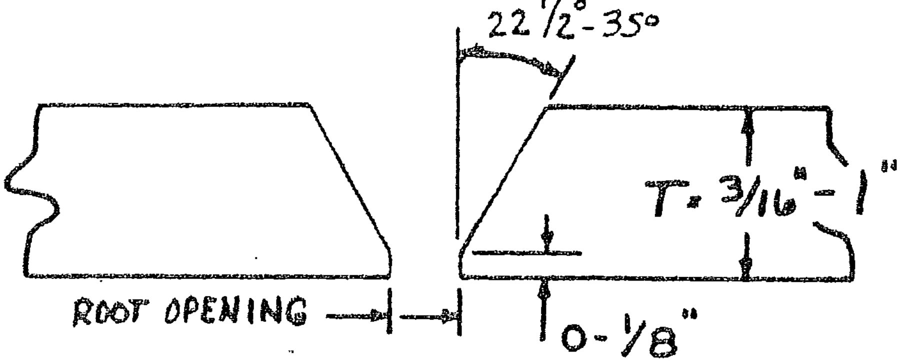


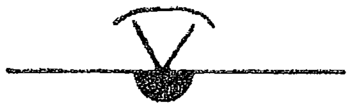
Application:
This joint will be used with manual and semi-automatic welding processes in closure plates where the axis of the weld is within 15° of horizontal and the surfaces of the plate lie within 15° of vertical bevel the top edge. It should also be used for inserts in all positions. The bevel will be on the insert leaving the structure square, or it may be used for corrective action when plates are cut short as long as the backing strip is removed within 3/5 the midship length.

Note:
1) Unless otherwise specified, the fillet weld may be placed on either plate and may be intermittent (2-1/2" - 10").

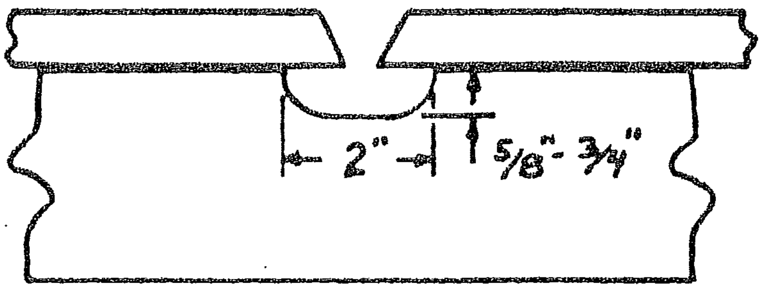
B1 V.8

T = 3/16" - 1"
Carbon Steel
Flat
One Side
w/ Cer Tape





Application:
Use this joint for one sided welding with gas shielded fluxcore where the weld is positioned within 15° of flat (e.g., bottom shell, deck butt and seams, stiffener butts). Strong backs, stiffeners, and other interruptions which will cause stops and starts should be located on the underside and the rat holes must be designed to accommodate the ceramic tape and its adhesive.

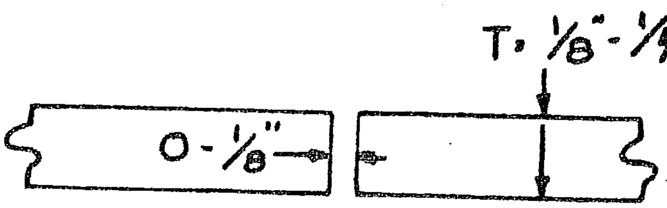


Note:
1) No back gouging is required, however, 100% of each root pass will be M.T. or 5x visually inspected prior to completing the weld.

	Root Opening:	
Weld Position:	Tolerance	Optimum
Flat	3/16	3/16
Vertical	3/16	1/8
Horizontal	1/8	1/8

B2 S.1

T = 1/8"-1/4"



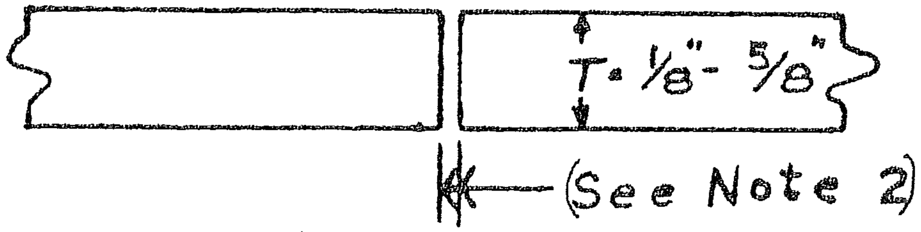
Application:
This joint will be used for all manual and semi-automatic welding processes in all locations and all positions where plates form an angle not less than 120° (see Note 2).

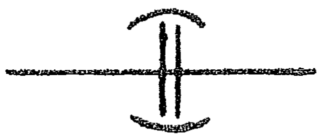
Recommendation:
Fit up to 1/16" wire or sheet metal spacers.

Note:
1) Back gouging is required.
2) Where an angle is formed by two plates being joined, the natural bevel angle formed by square cut plate is acceptable.

B2 S.1-01

T = 1/8"-5/8"
Carbon Steel
Sub-arc
Flat





T = 1/8 - 3/8
HY 80, HY 100
SUB-ARC
FLAT

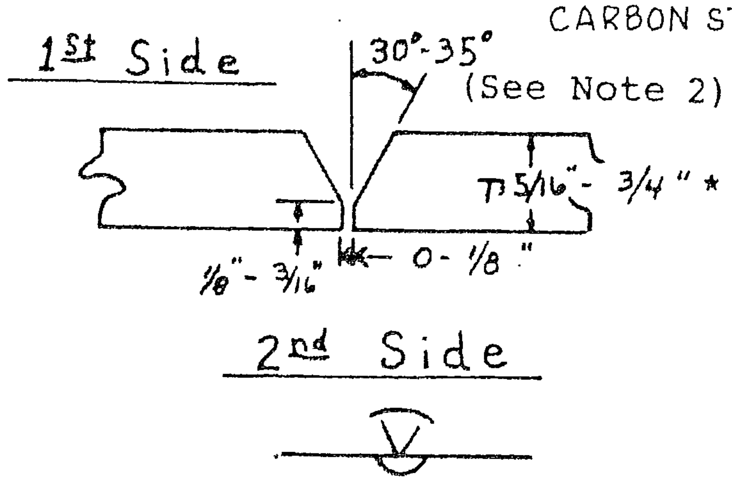
Application:
This joint should be applied to plain carbon steel plates where butts are at least 6' long and will be welded flat and turned over; using automatic submerged arc on both sides. (Panel line, plate shop, slab areas.)

Note:
1) Back gouging is not required.
2) The maximum allowable root gap shall be as follows:

Plate Thickness	Gap
1/8" - 1/4"	0-1/32"
5/16" - 7/16"	0-3/64"
1/2" - 5/8"	0-1/16"

B2 V.1-03

T = 5/16- 3/4"
CARBON STEEL



T = 7/16 - 1 1/8
HY 80 - HY 100
SUB - ARC
LNDG 1/4 FOR T OVER 1/2
LNDG 3/8 FOR T OVER 3/4

Application:

Use this joint for all manual and semi-automatic welding processes for all materials in all locations; and where automatic submerged arc welding is used for second side only in carbon steel; for automatic submerged arc welding on HY 80; and where a knuckle is formed at the joint forming an angle not less than 120° (see Note2). Bevels shall open towards the inside of tanks or small compartments so back gouging can be done in open air. Where accessibility is equal, bevel shall open on stiffener side (or web side of structural shape butts) with back gouging on the smooth side. For decks and flats (not bottom shell) bevel should open towards the underside with gouging done flat except where there are access problems. Bottom shell will bevel towards inside with gouging done outside and overhead.

Recommendation:

Fit up with 1/8" wire or sheet metal spacers for thicknesses 1/2" to 1", except when used for sub-arc welding in HY 80.

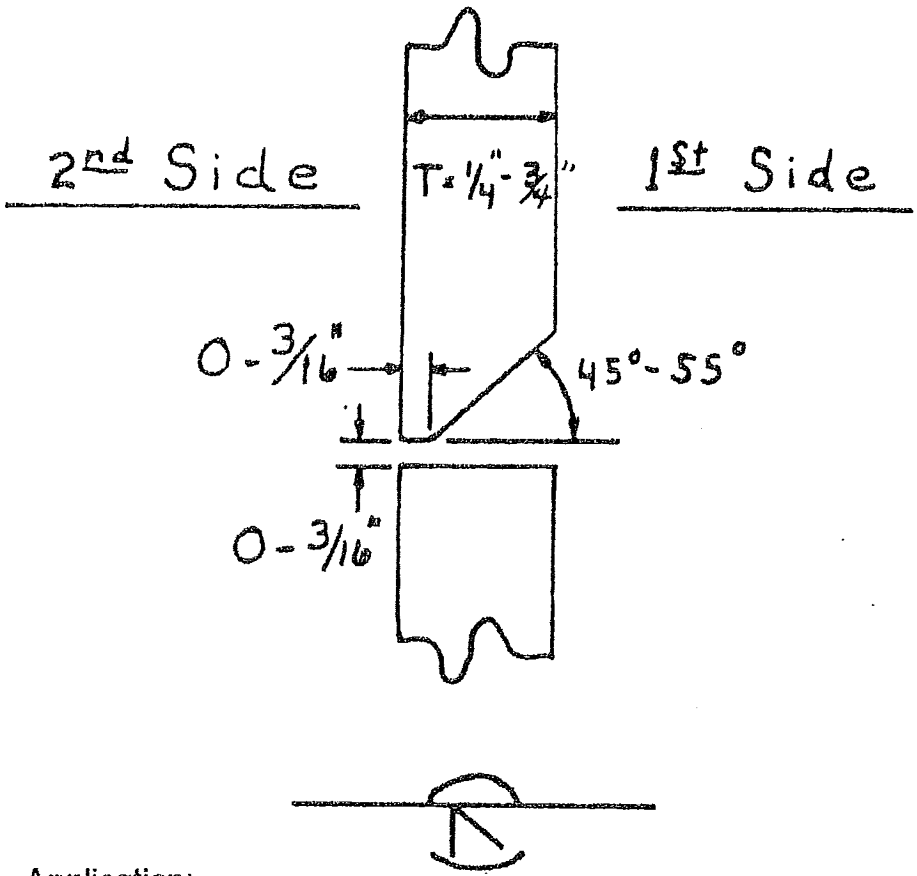
Note:

1) Back gouging is not required for carbon steel if automatic submerged arc welding is done on the second side.

2) Where there is an angle formed by the plates being joined, the natural angle plus the prepared bevel must combine to equal 60° minimum.

B2 (S) V.2

T = 1/4" - 3/4"
Horizontal



Application:
Use this joint for all manual and semi-automatic welding processes for welds where the axis of the weld is within 15° of horizontal and the surfaces of the plate lie within 15° of vertical (e.g., shell erection seams, horizontal bulkhead butts).

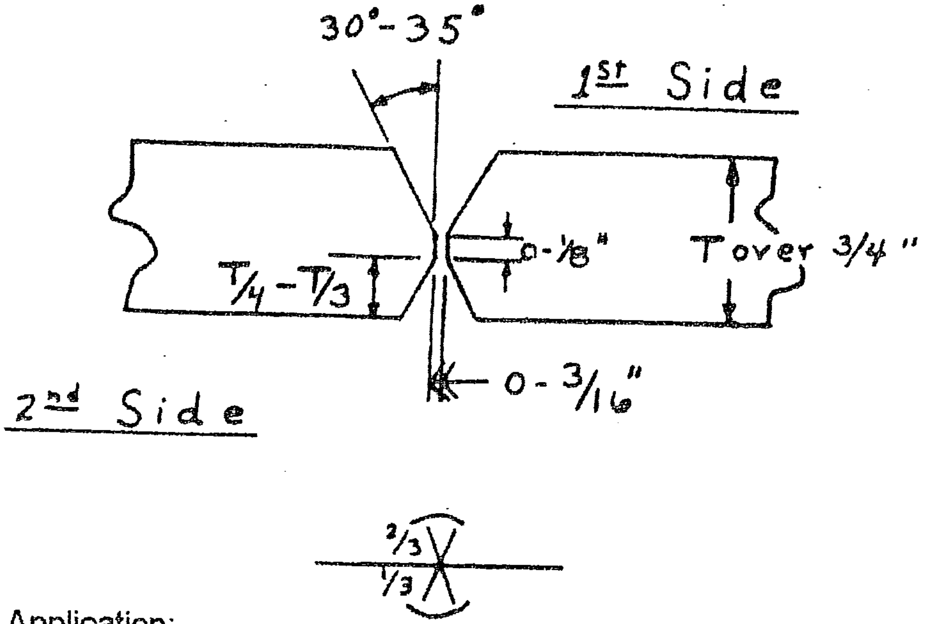
The bevel shall open towards the inside of tanks or small compartments so that back gouging can be done in open air. Where accessibility is equal, the bevel shall open on the stiffener side (or web side of structural shape butts). The 45° beveled edge will be set above the almost square edge. It should also be used for inserts in all positions. Bevel the insert leaving the structure square.

Recommendation:

Fit up with 1/8" wire or sheet metal spacers for thicknesses 1/2" - 1".

B2 V.3

T = over **3/4"**



Application:
Use this joint for all manual and semi-automatic welding processes in all locations and where automatic submerged arc welding is used for second side only.

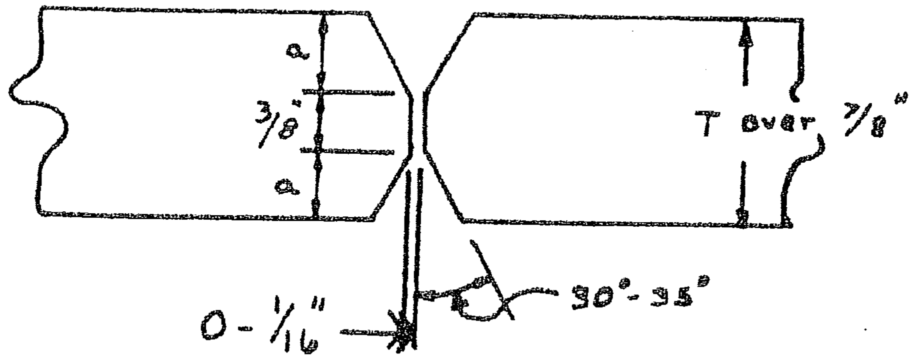
The major bevel shall open towards the inside of tanks or small compartments so that back gouging can be done in open air. Where accessibility is equal, the major bevel shall open on the stiffener side (or web side of structural shape butts). For decks and flats (not bottom shell) the major bevel should open towards the underside with back gouging done flat except where there are access problems. Bottom shell will have the major bevel towards inside with gouging done outside and overhead.

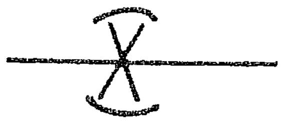
Recommendation:
Fit up with 1/8" wire or sheet metal spacers.

Note:
1) Back gouging is not required if automatic submerged arc welding is done on the second side.

B2 V.3-01

Carbon Steel
Sub-arc
T = over 7/8"
Flat





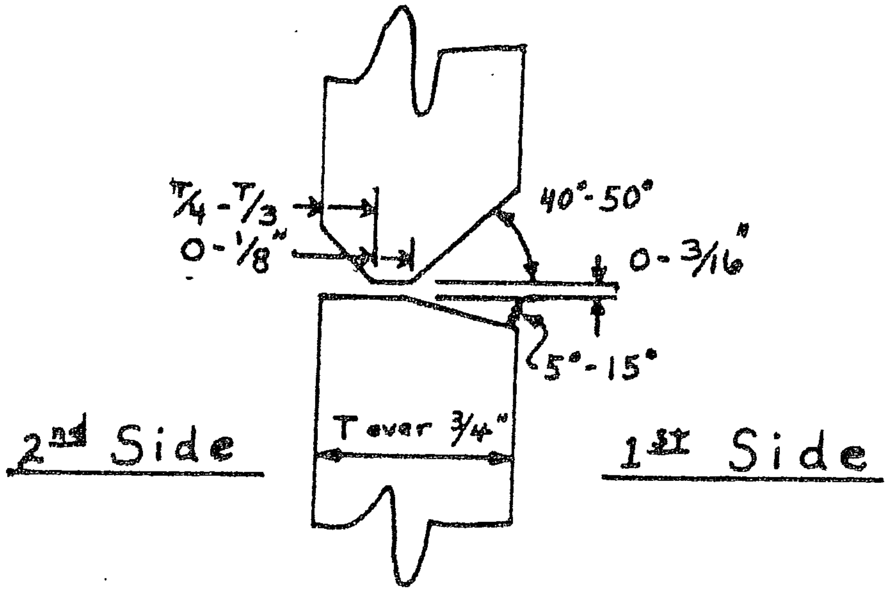
HY 80 & HY 100
SUB-ARC
T OVER 1 1/8 TO 1 1/2
LNDG = 1/4

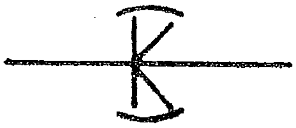
Application:
This joint should be applied to plates where butts are at least 6' (3' in Plate Shop) and will be welded flat and turned over, using automatic submerged arc (panel line, Plate Shop, slab areas).

Note:
1) Back gouging is not required.

B2 (S) V.4-01

T = over 3/4"
Horizontal





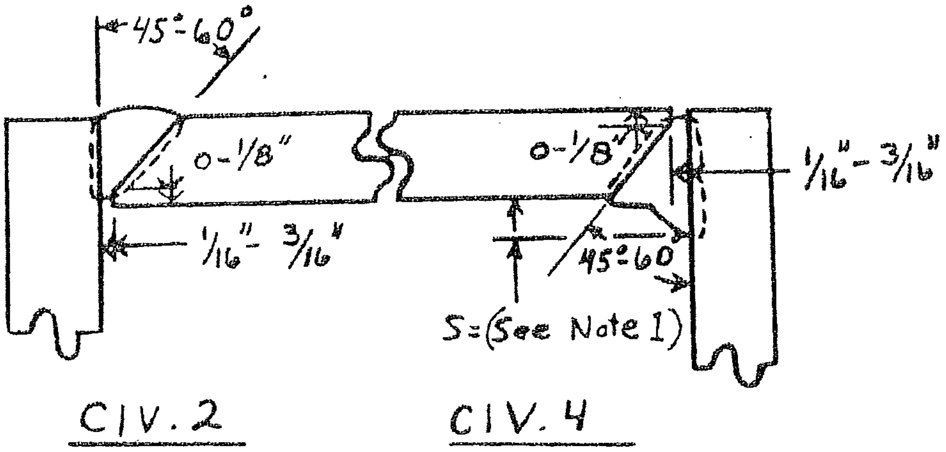
Application:
Use this joint for all manual and semi-automatic welding processes for welds where the axis of the weld is within 15° of horizontal and the surfaces of the plate lie within 15° of vertical (e.g., shell erection seams, horizontal bulkhead butts).

The major bevel shall open towards the inside of tanks or small compartments so that back gouging can be done in open air. Where accessibility is equal, the major bevel should open on the stiffener side (or web side of structural shape butts. The 45° beveled edge will be set above the almost square edge.

Recommendations:
Fit up with 1/8" wire or sheet metal spacers.

C1V.2
C1V.4

NON-CRITICAL
NOT 100% EFFICIENT



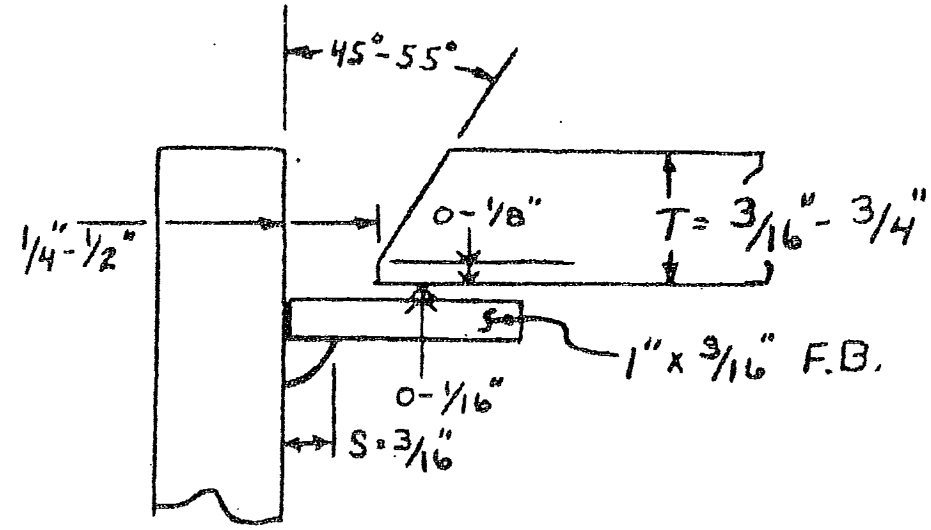
Application:
The joint is to be used for corner welds in non-critical structure where less than 100% efficiency is required. The bevel will be oriented towards the accessible side or the side to allow down hand welding.

Note: The reinforcing fillet shown may be accomplished by the normal bead laydown pattern and will be sized as follows:

Plate Thickness	Reinforcement
3/16" - 1/2"	3/16"
9/16" - 3/4"	1/4"

C1V.5

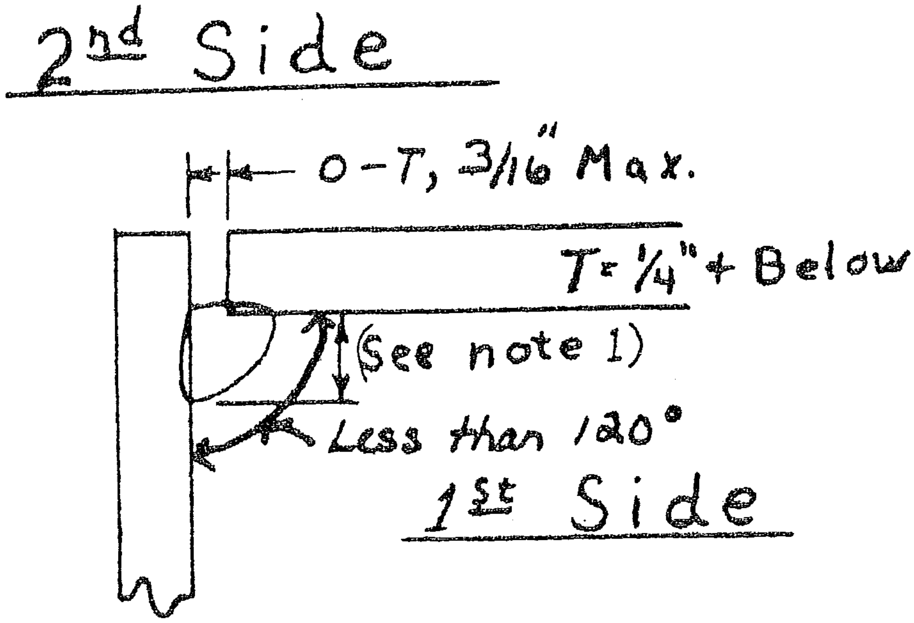
T = 3/16" - 3/4"
Closure Plates

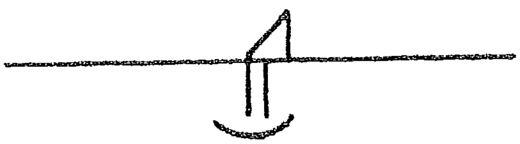


Application:
Use this joint for installing closing plates where efficient connections are required.

Note:
1) Unless otherwise specified, the fillet on the backing bar may be intermittent (2-1/2" - 10").

C2 S.1 T = 1/4" Max





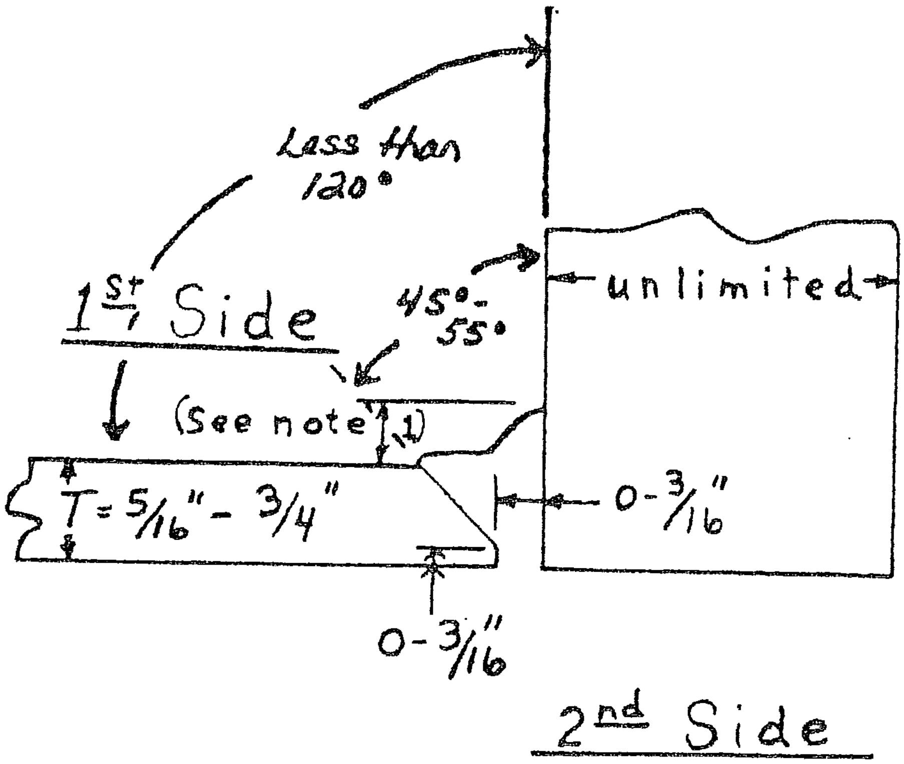
Application:
Use this joint for welded corners where thin plates form an angle less than 120 . Weld the fillet side first, followed by back gouging or back grinding on the flush side. Whenever a double fillet welded joint can be used in place of a corner weld of this type, the fillet should be used.

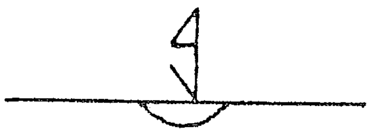
Note:
1) The reinforcing fillet will be sized as follows:

Plate Thickness	Reinforcement
Under 3/16"	Equal to plate thickness
3/16" & over	3/16"

C2 V.4

Corners; Flush Forgings and Castings to Plate T = 5/16"-3/4"





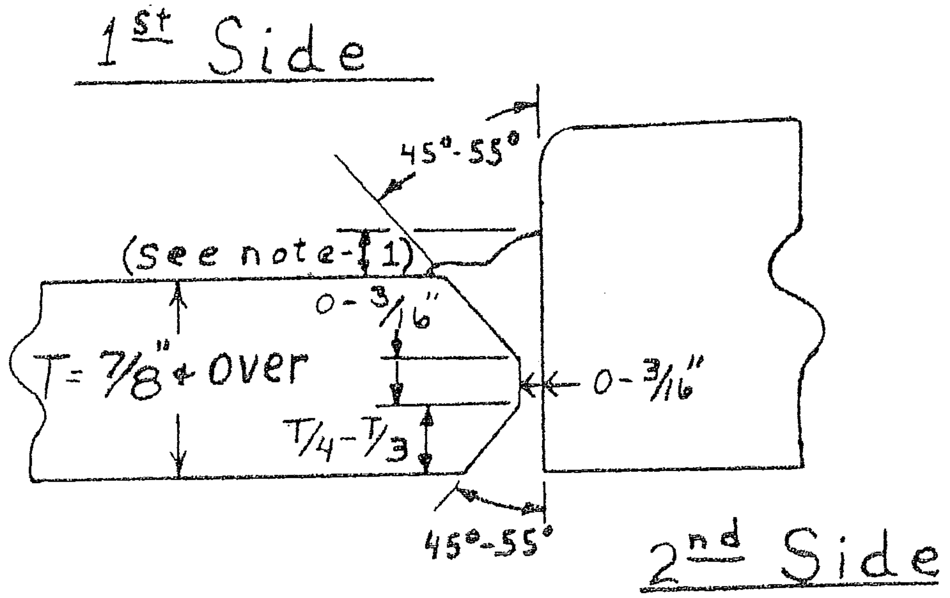
Application:
Use this joint for welded corner joints, where the plates form an angle less than 120 degree, flush mounted castings and forgings. The bevel should be applied as shown so the back gouging of the second side can be done in the open. Whenever a double fillet weld can be substituted for this corner joint, the fillet should be used.

Note:
1) The reinforcing fillet shown may be accomplished by the normal bead laydown pattern and will be sized as follows:

Plate Thickness	Reinforcement
5/16" - 1/2"	3/16"
9/16" - 3/4"	1/4"

C2 V.5

Flush Forgings
and Castings
Heavy Plate



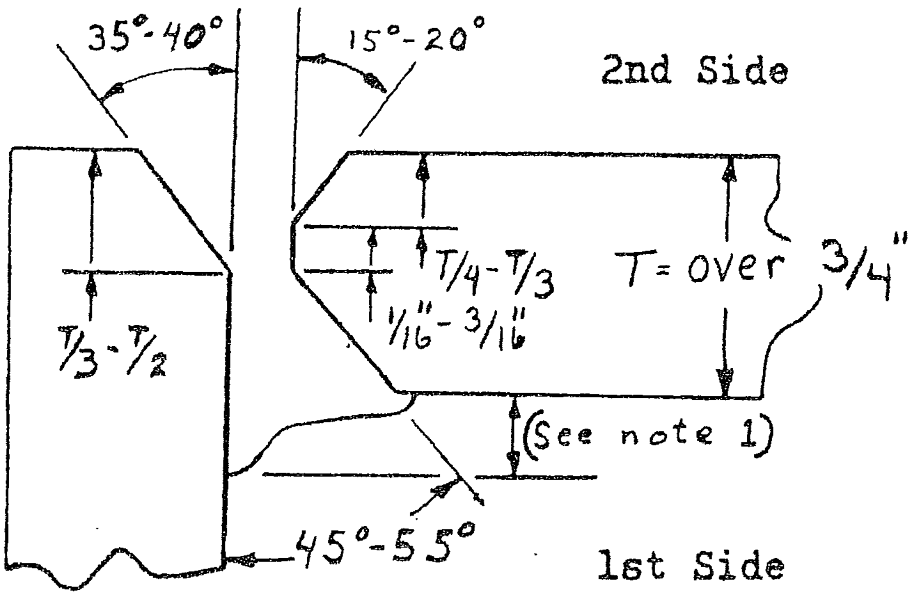
Application:
Use this joint for joining castings and forgings which install flush with heavy plate. The second side will be back gouged to clean metal prior to welding. Both bevels will be cut prior to fit up.

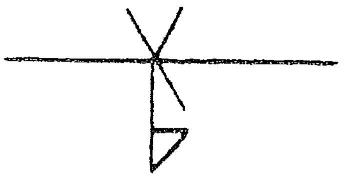
Note:
1) The reinforcing fillet shown may be accomplished by the normal bead laydown pattern and will be sized as follows:

Plate Thickness	Reinforcement
7/8" - 1-1/4"	5/16"
Over 1-1/4"	3/8"

C2 V.6

T = Over 3/4"





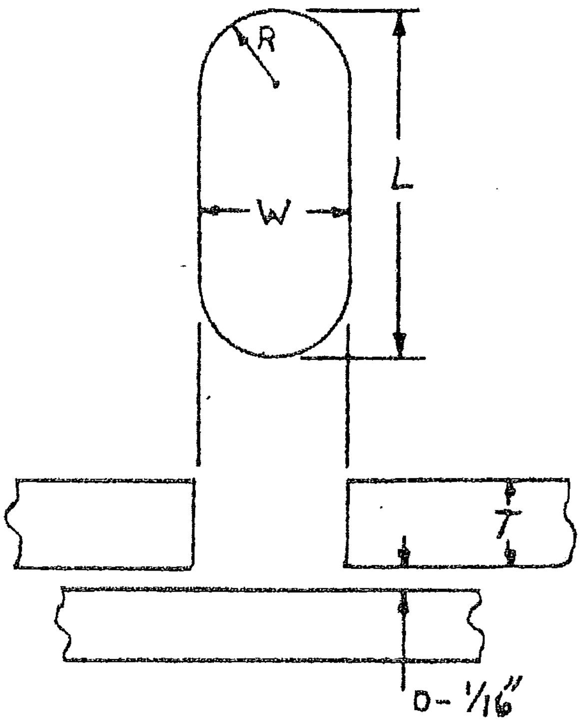
Application:
Use this point for welded corners in thick plate for flush mounted castings, or wherever lamellar tearing can be a problem. It is designed for manual welding processes on the first side and manual welding on the second side if back gouged to clean metal or automatic submerged arc on the second side without back gouging. Where the second side will be back gouged, the T/4-T/3 bevel on the double beveled plate may be omitted prior to fit-up, allowing the back gouging operation to open the bevel.

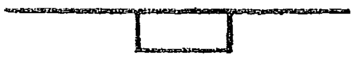
Note:
1) The reinforcing fillet shown may be accomplished by the normal bead laydown pattern and will be sized as follows:

Plate Thickness	Reinforcement
7/8" - 1-1/4"	5/16"
Over 1-1/4"	3/8"

L1 S.1

Slot Welds
T = 3/16 - 2



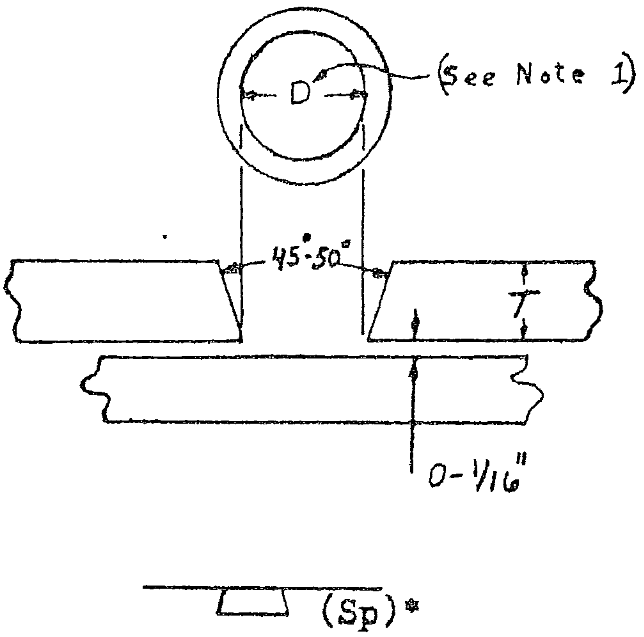


Application:
Use this joint for installing closure plates, wear plates, lap plates, doublers, etc.

Note:
1) Dimensions to be used will be shown on the drawing.
   W = 1/2" for plate thickness - below 3/8"
   W = 1-1/2" times T for plate thickness - 3/8" and above
   R = 1/2" of W
   L = 3 times W (min)
   L = 5 times W (max)
2) Unless otherwise specified, plug welds will be filled flush with the plate surface.
3) The spacing of welds will be in accordance with the applicable drawing.

L1 V.1

Plug Welds
T = 3/16" - 2"



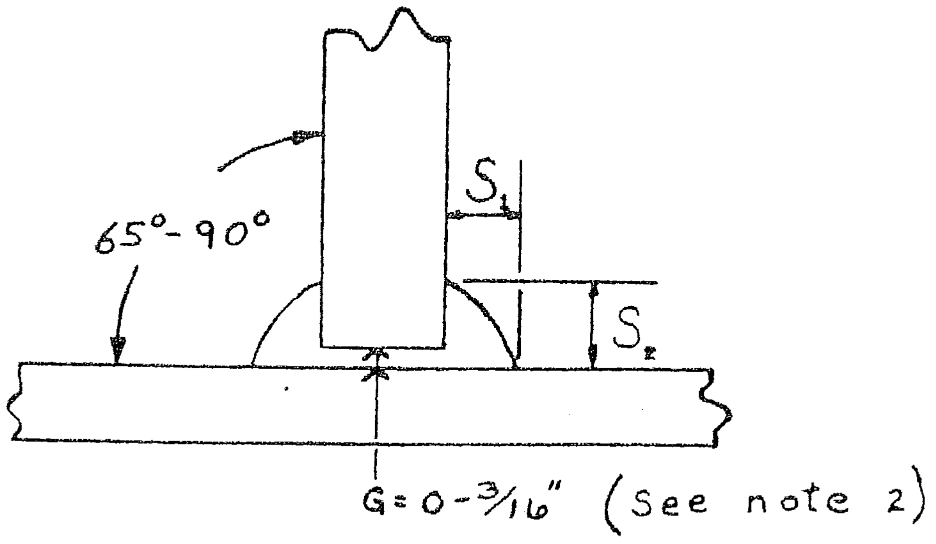
*Sp is the center
to center spacing.

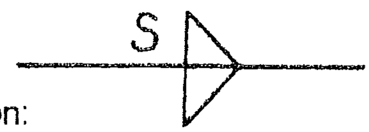
Application:
Use this joint for installing closure plates, wear plates, lap plates, doublers, etc.

Note:
1) D = 1" for plate thickness - 1/2" and below
   D = T + 1/2" for plate thickness - above 1/2"
2) Unless otherwise specified, plug welds will be filled flush with the plate surface.
3) The spacing of welds will be in accordance with the applicable drawing.

PT2 S.1

Continuous Fillet Weld Perpendicular - 25°





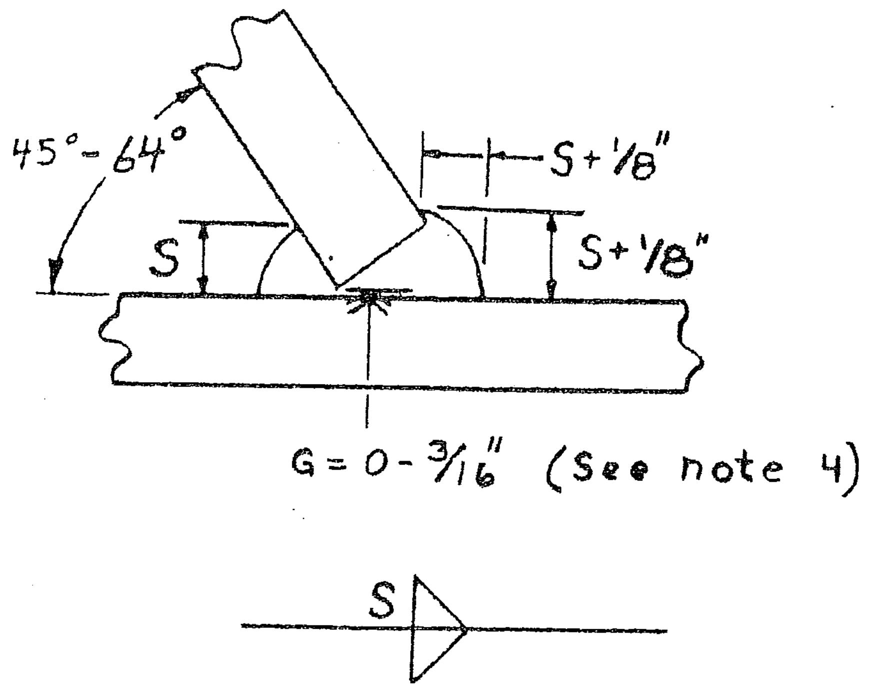
SEE ALSO:
PT2 S.1-01
T1(S) V.3
*PT2V.1

Application:
This joint will be used where double fillet welds are required and where the two members being joined are perpendicular to one another within 25 (see Note 2 where members are canted).
Where fillet welds require leg sizes in excess of 5/' to obtain proper efficiency, use PT2V.1 or other applicable joints.

Note:
1) The weld size S will be as specified on applicable drawings and S1 and S2 are to be equal except when specified on the drawings.
2) When the root gap G exceeds 1/16" due to fit-up or canted members, the weld size S will be increased by an amount equal to the excess of the opening above 1/16".
3) The weld size assumes a flat or slightly convex weld. Concave welds may be used as long as the actual throat thickness equals .7 times the specified weld size or more.
4) See general notes for weld sizing instructions.

PT2 S.1-01

Continuous Fillet Weld
Canted 26°- 45° from
Perpendicular

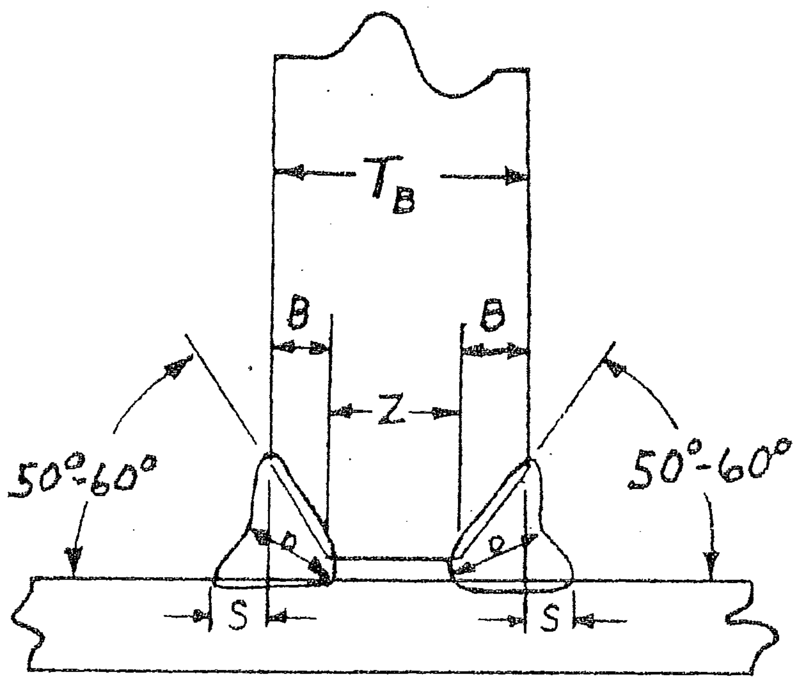


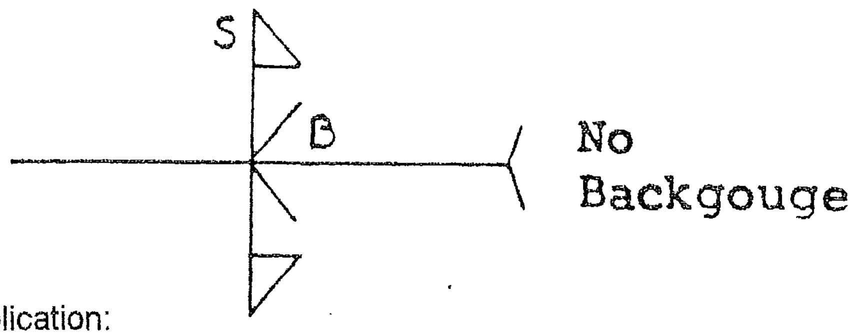
See also:
PT2 S.1
T1(S) V.3

Application:
This joint will be used where double fillet welds are required and where the two members being joined are canted to 26 - 45 from perpendicular (e.g., beam and stiffener brackets).

Note:
1) The weld size S will be specified on the applicable drawings.
2) This joint gives credit for partial penetration due to configuration.
3) Back gouging is not required.
4) Where the root gap G exceeds 1/16", the weld size S will be increased by an amount equal to the excess of the opening above 1/16".

PT2 V.1 Partial Penetration **Tee**



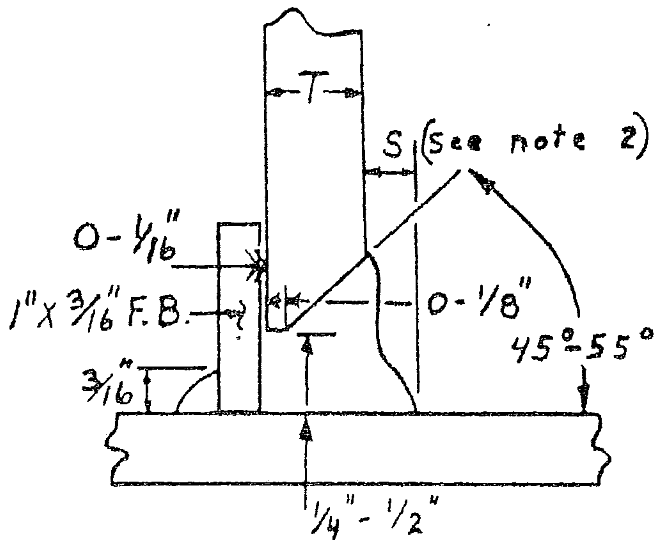


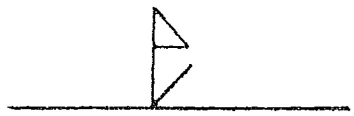
Application:
This joint will be used where conventional double fillet welds (PT2S.1) cannot be used because fillet sizes would exceed 5/8" to obtain proper joint efficiency.

Note:
1) Dimensions B & S will be clearly specified by the drawing.
2) Dimensional calculations will be done in accordance with MIL-STD -22D, paragraph 3.7.
3) Back gouging is not required.

T1 V.1

T = 3/16"-2 1/2"
Full Penetration
Closure Plates





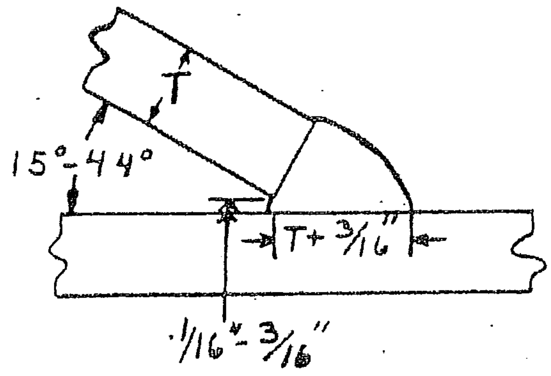
Application:
Use this joint for installing closure plates where 100% efficiency is required or where the inaccessible side is subject to bending tension.

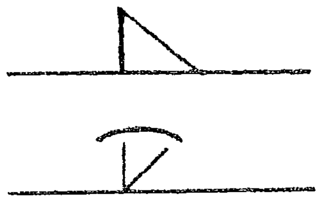
Note:
1) Unless otherwise specified, the fillet on the backing bar may be intermittent (2-1/2" - 10").
2) The reinforcing fillet shown may be accomplished by the normal bead laydown pattern and will be sized as follows:

Plate Thickness	Reinforcement
5/16" and under	3/16"
3/8" - 1/2"	1/4"
9/16" - 3/4"	5/16"
Above 3/4"	3/8"

T1 (S) V.3

Tee Connection
Canted 46° - 75° from
Perpendicular





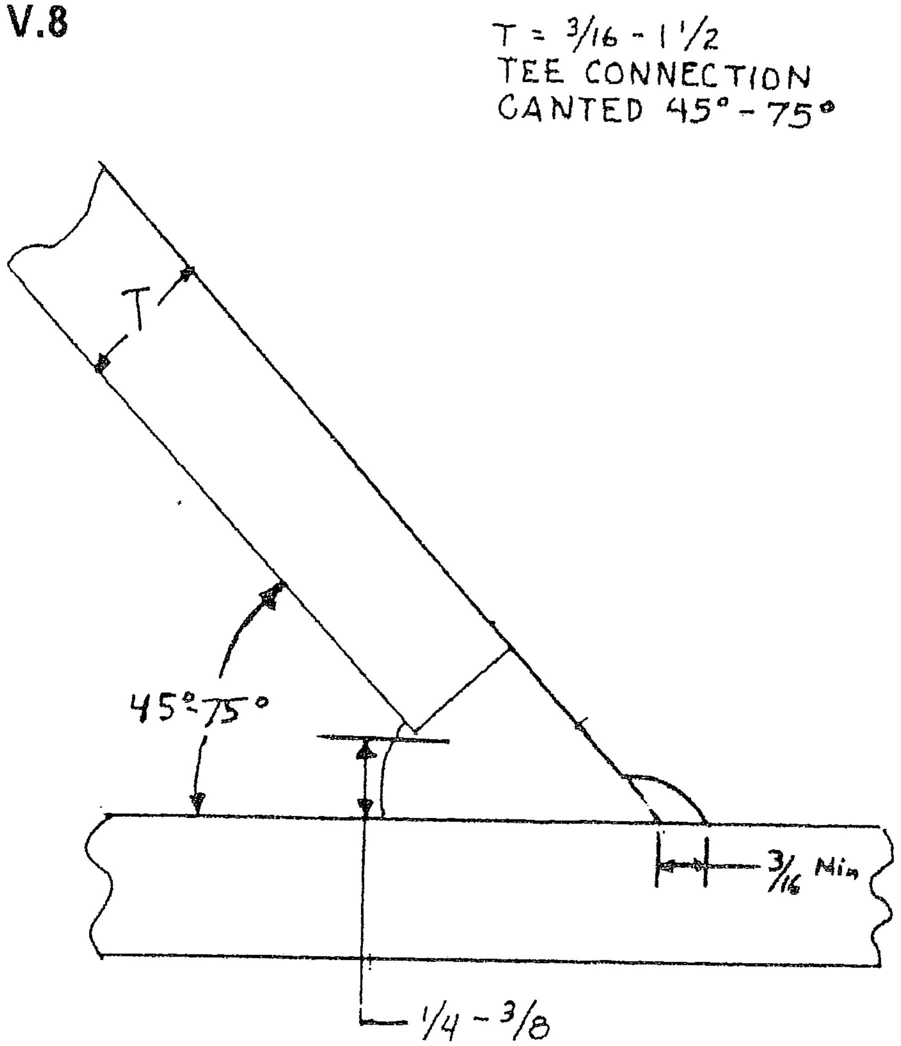
See also:
PT2 S.1
PT2 S.1-01

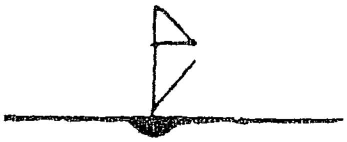
Application:
Use this joint where members joint one another at an angle of 46 - 75 perpendicular (e.g., beam and stiffener brackets).

Recommendation:
Prior to beginning to weld this joint, the welder should place a scribe mark or a small weld bead at the toe of the weld to be sure to obtain the T + 3/16" weld by dimension.

Note: No second side welding or back gouging is required, however, where accessibility allows (i.e., brackets) the second side should be seal welded for cosmetic purposes.

T1 (S) V.8



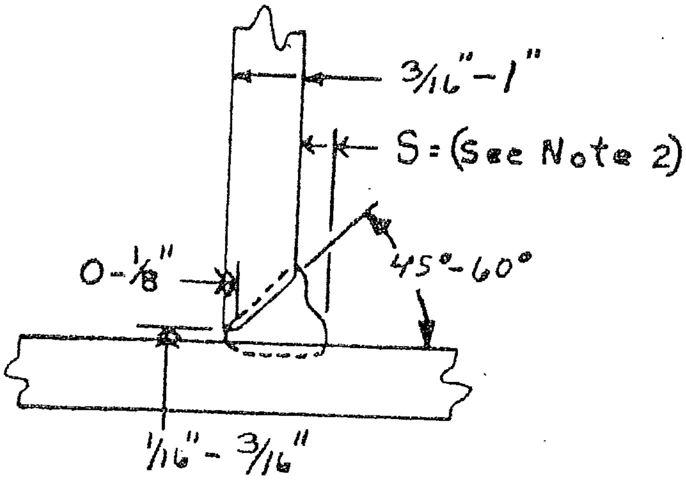


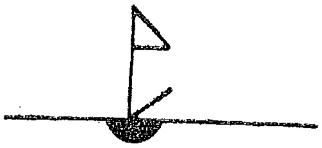
Application:
Use this joint for one side welding with gas shielded flux cored arc where the face of the weld is flat, horizontal or vertical. May be used for knee brackets, etc. where it is otherwise difficult to obtain proper contour on the back side.

Note:
1) No back gouge required, not mandatory to MT or visually inspect when used as a substitute for T1 (S) V.3

T1 V.3

Bilge Keel
Stanchions
Tubular Structure
Perpendicular to 30°





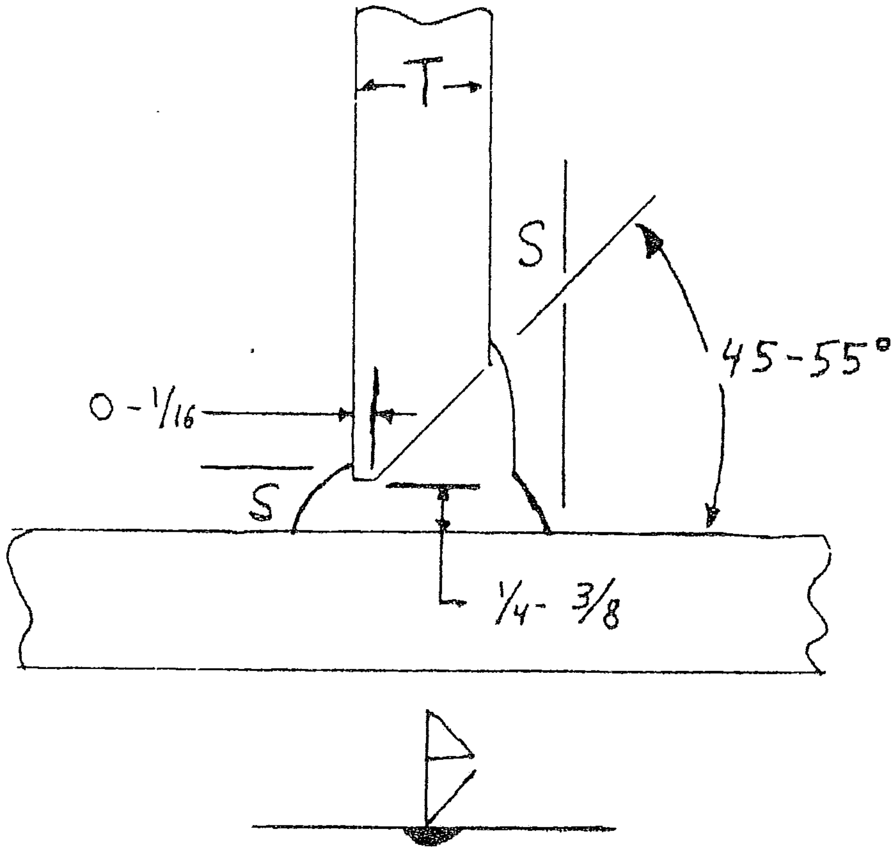
Aplication:
Use this joint where members intersect within 30 of perpendicular, and where one side is inaccessible and where less than 100% efficiency is required; e.g., tube to tube (structure), tube to plate (stanchions), bilge keel to shell. This joint shall not be used where the inaccessible side is subject to bending tension.

Note:
1) Where the tube is not perpendicular to the decks, etc., the bevel must be cut to compensate for the changing angle.
2) The size of the reinforcement S will be as follows:

Wall Thickness	Reinforcement
5/16" and under	3/16"
3/8" - 1/2"	1/4"
9/16" - 3/4"	5/16"
Above 3/4"	3/8"

T1 V.8

T = 3/16 - 1 1/2
FULL PENETRATION TEES



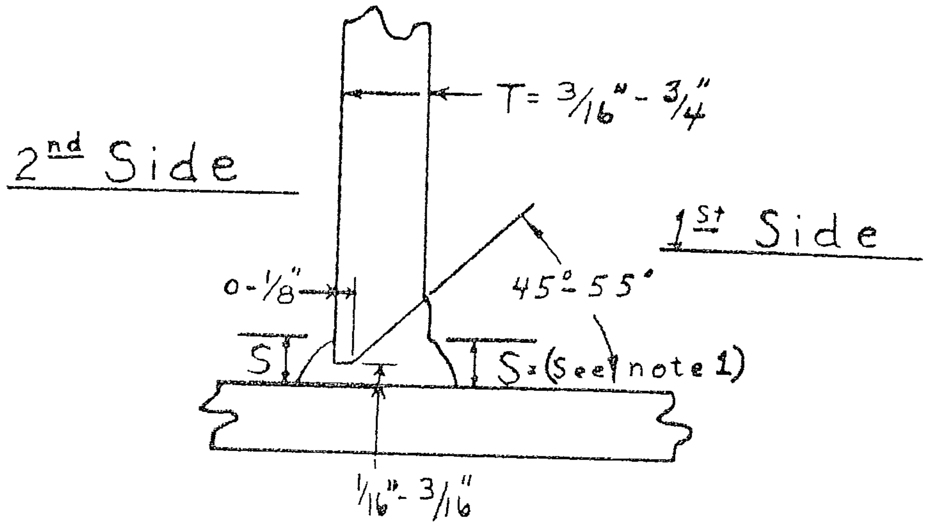
Application:
Use this joint for one side welding with gas shielded flux-cored arc where the face of the weld is flat, horizontal or vertical. Strongbacks, stiffeners, and other interruptions causing starts and stops should be on the tape side where possible. Substitute for T2 V.1 except on void closures.

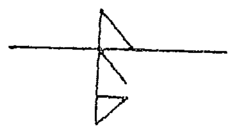
Plate Thickness	Reinforcement (S)
5/16" and under	3/16"
3/8" - 1/2"	1/4"
9/16" - 3/4"	5/16"
Over 3/4"	3/8"

Note:
1) No back gouging is required, but 100% of each root pass shall be MT or 5x visually inspected prior to weld completion.

T2 V.1

Full Penetration
T = 3/16" - 3/4"





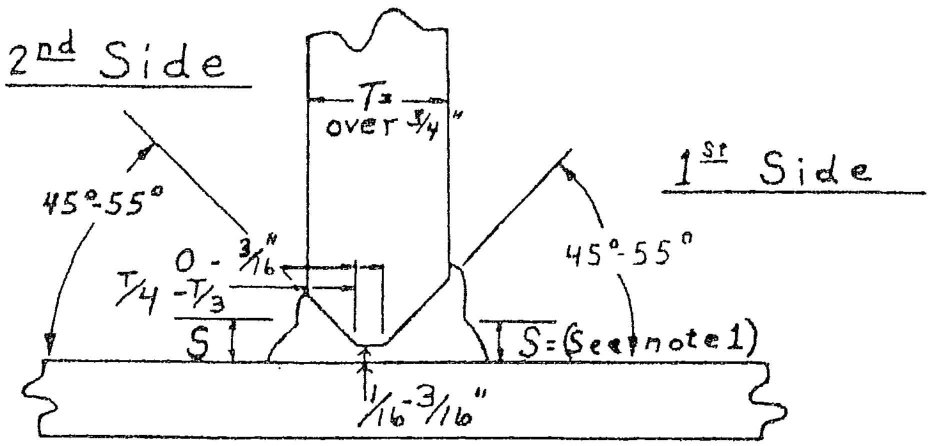
Application:
This joint should be avoided where possible. Fully efficient connections can be made using PT2 S.1 and PT2 V.1 and these are preferred. However, this joint may be used where oil tight boundaries are needed in small assemblies like sea chests, manifolds, etc. For large structures use conventional oil stops. Also, this joint should be used where fatigue is a design consideration, where partial penetration joints act as crack starters. Examples: Shell deck to main deck and critical joints in machinery foundations.

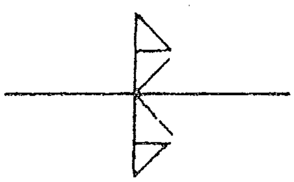
Note:
1) Unless specified by the drawing, the reinforcing fillets will be sized as follows:

Plate Thickness	Reinforcement
5/16" and under	3/16"
3/8" - 1/2"	1/4"
9/16" - 3/4"	5/16"
Over 3/4"	3/8"

T2 V.2

T = Over 3/4"
Full Penetration





Application:
Use this joint for full penetration "T" connections where the members intersect at an angle within 45 perpendicular. The major bevel should be placed on the most inaccessible side so that the back gouging can be accomplished in the open.

Note:
1) Unless otherwise specified by the drawing, the reinforcing fillets will be sized as follows:

Plate Thickness	Reinforcement
1" - 1-1/2"	5/16"
Over 1-1/2"	3/8"

16.3 INTERMITTENT WELDS

16.3.1 Where intermittent fillet welds are allowed they may be replaced with continuous double fillet welds, which are reduced in size 1/16" from that size specified for intermittent welds.

16.3.2 Where intermittent welds call for chained welds they may be replaced with staggered. When staggered welds are specified they must be used unless replaced by continuous double fillet welds. When staggering welds, the centerline of the weld increment on one side of the member must be within 1/16" of the specified distance from midpoint between the centerlines of the two closest weld increments on the other side of the member.

16.3.3 Stiffeners on water-tight and oil-tight bulkheads shall have double continuous fillet welds for one-tenth of their length at each end.

16.3.4 Stiffeners of non-tight bulkheads are to have a pair of match intermittent fillet welds at each end.

16.3.5 Bulkhead stiffeners and deck beams that pass through slotted girders or transverses are to have a pair of match intermittent fillet welds on each side of the intersection.

16.3.6 The maximum clear distance between any two welds on one side of the member will be equal to the specified increment minus the specified weld length.

16.3.7 The specified weld length is the minimum length of weld.

17.0
WELDING ELECTRODES, WIRE, FLUX AND GAS

17.1 PROCUREMENT Welding filler materials shall be procured in accordance with the applicable material specifications, except proprietary filler material qualified in procedure qualification may be procured to the limitations and controls established in the procedure qualification.

17.2 HYDROGEN CONTENT All hydrogen type covered electrodes shall be purchased to a requirement limiting moisture content. For 70XX and 80XX covered electrodes the moisture content shall not exceed 0.4% by weight. For 90XX, 100XX, 110XX and 120XX covered electrodes the moisture content shall not exceed 0.2% by weight. In both cases moisture content shall be certified for compliance by the supplier.

All submerged arc flux shall be purchased to a requirement limiting moisture content to 0.3% by weight and shall be so certified for compliance by the supplier.

All shielding gases used for welding will be supplied with a dew point of - 60 maximum.

17.3 HANDLING AND STORAGE All welding electrodes shall be handled carefully to prevent damage to their coatings. Damaged containers should have their contents examined for cracked coatings or other damage to coated electrodes and for distorted spools and/or entwined winding on spooled wire. Filler material damaged to the extent that it does not meet specification requirements shall not be used for production welding.

All types of electrodes shall be stored in a dry location. Electrodes which have been in physical contact with water shall be scrapped.

Electrode or weld wire material requiring complete traceability, labeled as "Mic Level I" or "Level I", shall e separated[from non-Level I material. Level I material shall be further separated by type and by heat/batch/traceability (H/B/T) number. Each container or spool shall have a Level I label and clearly identified H/B/T number. All Level I material not in warehouse or general stores shall be stored in a separate rod shack. This Level I area (rod shack) shall be open for use only when the rod shack attendant is present.

17.4 ELECTRODE STORAGE OVENS Holding ovens for lo-hydrogen electrodes (Mil 9018, 11018, 12018) shall be operated constantly at 225 or 300 F and shall be vented so as to evacuate the moisture-laden air. Doors shall be adequately sealed to preclude temperature differentials, which may cause condensation of water on electrodes. Holding ovens shall be equipped with calibrated oven controls or a recording thermostat which will be calibrated at least once every three months.

17.5 ELECTRODE MOISTURE CONTROL - STORAGE AND ISSUE 9018, 11018, 12018 electrodes will be issued in portable holding ovens with temperatures maintained at 150° to 300° F and which have been brought up to temperature prior to loading with electrodes. These portable holding ovens will be plugged in at all times, except during transport to and from the work site. The portable ovens will be returned to the rod shack at the end of each shift where the electrodes will be discarded or returned for a high temperature bake. Welders should not take more electrodes than they require for the job so that only a minimum number of electrodes will have to be returned. Electrodes which are removed from the portable oven to be used should be used immediately.

Other low hydrogen-type electrodes, including 7018, stainless steel and nonferrous covered electrodes should be used within 9 hours of removal from either hermetically sealed receiving containers or a vented holding oven maintained at 150 ° to 300° F. Welders should not take more electrodes than they require for the job, and they must return any left at the end of the shift to the oven.

Mild steel, cellulose coated electrodes (i.e., 6010, 6011) should be stored in a clean, dry area. These electrodes are not to be stored at temperatures exceeding 200° F. There is no exposure limit on these electrodes. Electrodes which have come in contact with water will be discarded.

Submerged arc granular flux for welding HY 80 materials shall be stored in an oven with temperature regulated to 250° - 350° F. Granular flux shall not be used unless warm to the touch.

Unused granular flux for HY 80 material may be reused subject to the following conditions:

> Flux shall be collected from clean, dry work pieces.
> Flux shall be mixed with at least 50% new flux.
> If flux is not warm to the touch, it shall be re-heated to 250° F minimum.

Granular flux for welding other materials (ferritic) shall be stored in a dry area. Unused granular flux may be re-used subject to the following conditions:

> Flux shall be collected from clean, dry work pieces.
> Flux should be mixed with new flux.

Bare electrodes or filler wire shall be stored in a dry, clean area.

Electrodes to be returned for a high temperature bake must be segregated from electrodes ready for issue, properly labeled, and protected against further contamination.

Determination of moisture content:

Low hydrogen electrodes and sub-arc flux will be tested for moisture content as directed by the Welding Engineer, according to the procedures outlined in MIL-E-22200. Shielding gas will be tested for dew point as directed by the Welding Engineer using an Alnor type 7000 dewpointer.

17.6 BAKE OVENS HIGH TEMPERATURE BAKING PROCEDURE When required electrodes shall be conditioned by backing at a temperature of 800° F + 15 using a total time at temperature of 30 minutes to 1 hour. Variations of this time and temperature may not be used, unless approved by Welding Engineer.

Low hydrogen electrodes which have been exposed beyond the previously specified limits, low hydrogen electrodes not procured in hermetically sealed containers, and low hydrogen electrodes in severely bent or punctured containers must be baked prior to issue.

17.7 PROCEDURE Electrodes shall be placed in the bake oven while the temperature exceeds 300° F. The oven heating rate shall not exceed 300 F, per hour where the oven temperatures are 500° F and above. Total elapsed time at oven temperatures above 500° F, including the holding time of one (1) hour at 800° F, shall not exceed five (5) hours. For baking, the electrodes must be spread thinly (two layers maximum) on suitable trays. Automatically controlled, forced convection or circulating ovens with a design operating range of at least 800° F must be used.

Electrodes which have been baked should be transferred to holding ovens before they have cooled to 250° F. Transfer must be accomplished in a sheltered area out of the weather.

Electrodes may be baked by the receiving activity more than once. After each bake, a usability test should be run by production.

17.8 WELDING FILLER MATERIAL IDENTIFICATION all electrodes and other welding consumables (except flux) shall be identified by type up to the point of usage. Welding flux shall be identified by type up to point of issue. All Level I consumable welding material shall have complete traceability up to point of usage.

Each coated electrode shall have distinguishable color code, type designation or classification number marking. If markings are destroyed by baking or other means, electrode shall not be used. Where applicable, the standard AWS designations will be used.

Each spool of bare electrode shall carry an identification label. Each piece of bare filler material shall have distinguishing color code, type designation, or classification number marking as above.

Each container of granular flux shall be labeled as to type.

17.9 ELECTRODE, WELDING WIRE AND CONSUMABLE INSERT CONTROL PROGRAM

Receiving: Upon receipt, Quality Assurance will inspect material or container for damage and review the applicable certifications for code conformance.

As part of receiving inspection, Level I bare wire and consumable inserts shall be chemically spot tested to verify its generic type as indicated on certification papers.

Since flux covered welding electrode cannot be meaningfully verified by chemical spot test; acceptance of Label I flux covered welding electrodes shall be based on traceable certification.

17.10 ISSUE POINTS -- GENERAL Welding electrodes, wire, etc. must be stored and issued by the contract for which it was bought in order to properly account for cost. When rod is used it also must be accounted for to ensure that there is adequate inventory on hand. The cost accounting data is taken from MR's when they are filled at the warehouse even though the rod is not then used. Welding electrodes to be returned for a high temperature bake must be protected from further moisture contamination.

18.0
WELDING PERFORMANCE QUALIFICATIONS

18.1 PURPOSE To establish a system for ensuring that Welding Operator qualification test results have been compiled, recorded and published so the qualification information will be readily available, and maintenance of qualification can be assured.

18.2 GENERAL Welding Operator qualification is based on and must be established by specific performance. Welding Operators will be certified to the MIL-STD-248 (ships) or other applicable standards for the materials and configurations being worked. For this General Purpose the terms "Welder" and "Welding Operator" are synonymous. In actuality the term "Welder" refers to a person engaged in manual or semi-automatic welding. The term "Welding Operator" refers to a person operating an automatic welding system.

18.3 WELDING TEST BOOTH The Welding Test Booth has two responsibilities: To train Welding Operators and to test Welding Operators using Todd approved welding procedures.

The Test Booth is operated by the Welding Engineering Department with Todd approved Welding Instructors training and testing the Welding Operators. Welding Engineering will determine when the Welding Operator has the ability and knowledge to test and perform the required visual examinations.

The Weld Test Booth Instructor's functions in helping a Welding Operator become proficient and knowledgeable in the welding procedure to pass a qualification test are as follows: Show the Welding Operator proper welding techniques, demonstrate setting up and taking down equipment, evaluating practice test assemblies, ensuring that the proper forms are filed, and keep records of the welder's test results.

18.4 WELDING OPERATOR PERFORMANCE QUALIFICATION TESTING Welding Operators working at Todd must be qualified for each procedure with which they are to weld in production. Each Welder or Welding Operator (except tack, fillet, spot or stud welders) shall be required to pass an annual vision test.

When the Welding Engineer is satisfied that the Welding Operator has adequately fulfilled all prerequisites for testing as defined by the test description and has the proper skills and abilities, the Test Booth Instructor will notify the Welding foreman to set up a time for qualification testing.

The Test Booth Instructor will explain the testing procedure and the test requirements to the Welding Operator prior to testing.

All Welding Operator qualification tests will be performed at the welding test area, unless otherwise permitted by the Welding Engineer in charge. All qualification tests must be performed with the Weld Test Booth Instructor in attendance.

18.5 TEST EVALUATIONS Each test assembly requires a visual examination as a minimum requirement. X-rays of the completed test assembly may also be required. For multi-pass welds, the root pass and the completed test assembly must be visually examined by the Welding Engineer. These requirements will be adhere to or the test will be invalid.

The Welding Engineer examines the test assemblies to MIL-STD-2035, Class I, "Surface Inspection Acceptance Standards for Metals" and other applicable standards.

18.6 TRANSFERAL OF QUALIFICATIONS A Welding Operator may transfer to Todd along with their procedure qualifications provided that the requirements of applicable MIL-STD-248, "Welding and Brazing Procedures and Performance Qualification" are met. Vision tests results are not transferable.

The Welding Operator's former employer must furnish Todd with the essential weld data the Welding Operator used to qualify. This would include welding process, base material and thickness, test positions, filler material and size, and date of test. In addition, the Welding Operator must have maintained their qualification(s) by using the procedure at least once every calendar quarter.

18.7 MAINTENANCE OF QUALIFICATION A Welding Operator's qualification maintenance for each thermal joining process (for example, shielded metal arc welding) must be updated or re-certified every calendar quarter if the operator is to remain qualified for that procedure (90 days). Vision tests must be updated annually. The computer program automatically keeps track of this time frame and prints out the expiration date for each qualification held.

When a qualification is within 30 days of expiring, a computer update notice will be sent by Quality Assurance Welding Engineering. Welding Engineering separates the update notices by yard and craft and distributes them to the craft supervisor, who passes them down to the craft foreman.

The craft foreman is then responsible for seeing that the certified individual uses the welding procedure described on the card before the expiration date. The foreman signs and dates the card and returns it to Quality Assurance.
When the operator is on seniority layoff, it is the operator's responsibility to return to the test booth once every calendar quarter to maintain qualification status.

Upon satisfactory visual examination of the test assembly, or assemblies, the Welding Test Booth Instructor will mark the test assemblies with the Welding Operator's name, welding position, test number, and send it to NDT or DT.

When radiographs are made of the test assemblies, NDT personnel will file a "Radiographic Inspection Report". This form is kept on permanent record is NDT and the radiographs are kept by NDT for 90 days. If the Welding Operator fails to pass the radiographic examination, one re-test can be made without further training for each test assembly that failed. All failed radiographs will be reviewed with the Welding Operator prior to re-testing.

Additional re-tests for each test assembly that failed may be made after at least eight hours of additional training and receiving permission of the Welding Engineer in charge.

19.0 GLOSSARY OF SHIPBUILDING DEFINITIONS

A-STRAKE - The garboard strake. The first strake above the keel. The plating next to the flat keel.

ABAFT - Aft of; further aft then

ABEAM - At right angles to the keel

ABOARD - On or in a ship

ABREAST - Side by side

ACCEPTABLE WELD - A weld that meets all the requirements and the acceptance criteria prescribed by the welding specifications.

ACCESS HOLES - Opening in any part of the ship'splating used as a passageway while the ship is under construction

ACTUAL THROAT - The shortest distance from the root to weld to its face.

AFT - At, near or towards the stern

AFTER - Nearer the stern

AFTER PERPENDICULAR - A line perpendicular to the base line, intersecting the after edge of the sternpost at the designed water line on fantail stern ships. On ships with a cruiser stern, it is usually taken at the en232d of the waterline. This also applies to merchant cruiser sterns. The after perpendicular usually passes through center of rudder stock when vessel does not have a sternpost.

AFTERBODY - That portion of the ship's body aft of the midship section

AIR CARBON ARC CUTTING (AAC) - An arc cutting process in which metals to be cut are melted by the heat of a carbon arc and the molten metal is removed by a blast of air.

AIR PORT - A circular opening or window through the ship's side, or deck house, for light or ventilation.

AIRTIGHT DOOR - A door so constructed that, when closed, air cannot pass through

ALOFT - In the top of the upper rigging or above the decks

AMIDSHIPS - At the near the midship section of the ship

ANCHOR - A heavy iron or steel implement attached to a vessel by means of a chain for holding the vessel in the water. When an anchor is lowered to the bottom, the drag on the chain causes the flukes to sink or engage the bottom, which provides holding power.

ANNEAL - To soften metal by heating and allowing it to cool slowly (remove stress).

ARC STRIKE - A discontinuity consisting of any localized re-melted metal, heat-affected metal or change in the surface profile of any part of a weld or base metal resulting from an arc.

ARC VOLTAGE - The voltage across the welding arc.

ARC WELDING (AW) - A group of welding processes which produces coalescence of metals by heating them with an arc, with or without the application of pressure and with or without the use of filler metal.

ARC WELDING ELECTRODE - A component of the welding circuit through which current is conducted between the electrode holder and the arc. See **ARC WELDING**.

ARC WELDING GUN - A device used in semi-automatic, machine and automatic arc welding to transfer current, guide the consumable electrode and direct shielding gas when used.

ASTERN - Signifying position, in the rear, the opposite of going ahead; backwards.

ATHWARTSHIP - Across the ship at right angles to the center line. Side to side.

AUTOGENOUS WELD - A fusion weld made without the addition of filler metal.

AUTOMATIC OXYGEN CUTTING - Oxygen cutting with equipment which performs the cutting operation without constant observation and adjustment of the controls by an operator. The equipment may or may not perform loading and unloading of the work.

AUTOMATIC WELDING - Welding with equipment which performs the welding operation without adjustment of the controls by a welding operator. The equipment may or may not perform the loading and unloading of the work. See Machine Welding.

AUXILIARIES - Various winches, pumps, motors, engines, etc., required on a ship, as distinguished from the main propulsive machinery.

AWASH - Even with the surface of the water.

BACK BEAD - See preferred term **BACK WELD**

BACK GOUGING - The removal of weld metal and base metal from the other side of a partially welded joint to assure complete penetration upon subsequent welding from that side.

BACK WELD - A weld deposited at the back of a single groove weld. (See Figure 7C)

BACKHAND WELDING - A welding technique in which the welding torch or gun is directed opposite to the progress of welding. Some times referred to as the "pull gun technique" in GMAW and FCAW. See **DRAG ANGLE**.

BACKING - A material (base metal, weld metal, carbon or granular material) placed at the root of a weld joint for the purpose of supporting molten weld metal.

BACKING BEAD - See preferred term **BACKING WELD**.

BACKING FILLER METAL - See **CONSUMABLE INSERT**.

BACKING PASS - A pass made to deposit a backing weld.

BACKING RING - Backing in the form of a ring, generally used in the welding of piping.

BACKING STRAP - See preferred term **BACKING STRIP**.

BACKING STRIP - Backing in the form of a strip.

BACKING WELD - Backing in the form of a weld (See Figure 7D).

BACKSTEP SEQUENCE - A longitudinal sequence in which the weld bead increments are deposited in the direction opposite to the progress of welding the joint. (See Figure 6A). See **BLOCK SEQUENCE, CASCADE SEQUENCE, CONTINUOUS SEQUENCE** and **LONGITUDINAL SEQUENCE**.

BALLAST - Any weight or weights used to keep the ship from becoming top heavy or to increase its draft or trim. In some designs which may be too stable and therefore ride too hard when light, ballast may be placed high in the vessel to reduce stiffness.

BALLAST TANK - Water tight compartment to hold ballast.

BALLING UP - The formation of globules of molten brazing filler metal or flux due to lack of wetting of the base metal.

BARE ELECTRODE - A filler metal electrode consisting of a single metal or alloy that has been produced into a wire, strip or bar form and that has had no coating or covering applied to it other than that which was incidental to its manufacture or preservation.

BARREL - Term applied to the cylindrical-shaped member of the strut assembly through which the propeller shaft passes.

BASE LINE - The main reference line at or near the bottom of the ship from which all heights are measured.

BASE METAL - The metal to be welded, brazed, soldered or cut. The use of this term implies that materials other than metals are also referred to, where this is appropriate.

BATTEN - Long, thin strips of wood, steel or plastic, usually of uniform rectangular shape used in the drafting room and mold loft to fair the lines of a vessel. To secure by means of battens, as to batten down the hatch.

BEAM - An athwartship member supporting a portion of a deck. Also, the width of the ship.

BEARER - That part of a structure that bears the weight as in foundations and stowages is called a bearer,

BELOW - Under or below decks.

BERTH - A term applied to a bed or place to sleep

BEVEL - The degrees of inclination of any surface from perpendicular to another surface.

BEVEL ANGLE - The angle formed between the prepared edge of a member and a plane perpendicular to the surface of the member. (See Figure 1)

BEVEL FOR WELDING - To cut an edge at an angle or slant so that a trough or vee joint will be formed for welding.

BILGE - The rounded portion of the hull between the side and bottom.

BILGE KEEL - A fore and aft member fitted to the outside of the shell plating along the bilge to prevent excessive rolling of the ship.

BILGE STRAKE - Course of plates at the bilge.

BILGES - The lowest portion of the ship inside the hull.

BITTER END - The inboard end of a vessel's anchor chain which is made fast in the chain locker.

BITTS - Heavy steel castings fitted to the weather deck for securing mooring or hawsers.

BLEEDERS - A term applied to plugs screwed into the bottom of a shop to provide for drainage of the compartments when the vessel is in dry dock.

BLIND JOINT - A joint, no portion of which is visible.

BLOCK SEQUENCE - A combined longitudinal and buildup sequence for a continuous multi-pass weld in which separated lengths are completely or partially built up in cross section before intervening lengths are deposited. (See Figure 6B) See also **BACKSTEP SEQUENCE, LONGITUDINAL SEQUENCE**, etc.

BLOWHOLE - See preferred term **POROSITY**.

BLUFF BOW - Blunt bow.

BODY PLAN - A plan consisting of two half transverse elevations or end views of a ship, both having a common vertical centerline, so that the right hand siderepresents the ship as seen from ahead, and the left hand side as seen from astern.

BOILER - Any vessel, container or receptacle that is capable of generation steam by the internal application of heat. The two general classes are fire tube and water tube.

BOLSTER PLATE - A piece of metal adjoining the hawser against the cheek of a ship's bow. A plate or support like a pillow or cushion. A temporary foundation.

BOOM - A long heavy spar pivoted at one end, usually used for hoisting cargo.

BOOT TOPPING - An outside area on a vessel's hull from bow to stern between certain water lines to which special air, water, and grease-registering paint is applied. Also the paint applied to such areas.

BOSOM - The inside of an angle bar.

BOSS - The curved swelling portion of the ship's hull around the propeller shaft.

BOSS PLATE - The plate that covers the BOSS is the boss plate.

BOW - The forward end of the ship.

BRACKET - A steel plate, commonly with a reinforcing flange used to connect two parts, such as deck beam to frame, frame to margin plate, etc.

BRAZE - To heat and solder with some alloy, especially hard solder (spelter) or brass.

BREADTH, MOLDED - The greatest breadth of a vessel measured from heel of frame on one side to heel of frame on other side.

BREAST HOOK - A horizontal plate secured across the forepeak of a vessel to tie the forepeak frames together and unite the bow.

BRIDGE, NAVIGATING - A deck from which the ship is navigated.

BROW - A watershed over an air port; a small inclined runway to allow passage of trucks over hatch coaming, or through bulkhead door, etc.

BUCKLE - A distortion, such as a bulge; to become distorted; to bend out of shape.

BULKHEAD - A vertical partition corresponding to the wall of a room, extending either athwartships or fore and aft. A steel partition in a ship.

BULWARK - The ship's side above the weather deck.

BURN-THRU - A term erroneously used to denote excessive melt-thru or a hole. See **MELT-THRU**.

BUTT - The joint formed when two parts are placed end to end.

BUTT JOINT - A joint between two members aligned approximately in the same plane.

BUTT WELD - An erroneous term for a weld in a butt joint. See **BUTT JOINT**.

BUTTERING - A surfacing variation in which one or more layers of weld metal are deposited on the groove face of one member (for example, a high alloy weld deposit on steel base metal which is to be welded to a dissimilar base metal). The buttering provides a suitable transition weld deposit for subsequent completion of the butt joint.

BUTTOCK - Any line parallel to the center line of a ship.

CAMBER - The athwartship arch or round up of a deck. It serves on weather decks to drain water to the side of a ship where it can be led overboard through scuppers.

CANT - A term signifying an inclination of an object from a perpendicular; to turn anything so that it does not stand perpendicularly or square to a given object.

CANT FRAME - A frame, the plane of which is not square to the keel.

CARBON ARC CUTTING (CAC) - An arc cutting process in which metals are severed by melting them with the heat of an arc between a carbon electrode and the base metal.

CARBON ELECTRODE - A non-filler material electrode used in arc welding or cutting, consisting of a carbon or graphite rod, which may be coated with cooper or other coatings.

CARGO HATCH - Large opening in the deck to permit loading cargo.

CASCADE SEQUENCE - A combined longitudinal and buildup sequence during which weld beads are deposited in overlapping layers. (See Figure 6C) See also **BACKSTEP SEQUENCE, BLOCK SEQUENCE, LONGITUDINAL SEQUENCE.**

CASTING - An object made by pouring molten metal into a mold and allowing it to cool.

CAULKING - The operation of jamming material into the contact area to make a joint water tight or oil tight.

CENTERLINE - The main reference line or plate from which all transverse measurements are taken. It is the plane midway between the two sides of the ship.

CHAFING PLATE - A plate fitted to take the wear due to dragging or moving gear or to protect ropes from wearing where they rub on sharp edges. Also fitted on decks under anchor chains.

CHAIN INTERMITTENT WELDS - Intermittent welds on both sides of a joint in which the weld increments on one side are approximately opposite those on the other side. (See Figure 6G)

CHAIN LOCKER - Compartment in forward lower portion of ship in which anchor chain is stowed.

CHAMFER - To cut off the sharp edge of a 90° corner. To trim to an acute angle.

CHARLIE NOBLE - The galley smoke pipe hood.

CHOCK - A term applied to oval shaped fittings, either open or closed on top, and fitted with or without roller, through which hawsers and lines are passed. Also applied to the brackets fitted to boiler saddles to prevent fore and aft motion and to small brackets on the webs of frames, beams and stiffeners to prevent tipping of the member.

CLEAT - A fitting attached to the deck, having two projections around which a rope or line may be secured.

COAMING - A frame bounding a hatch or manhole for the purpose of stiffening the edges of the opening and forming the support for the cover.

COFFERDAMS - Void or empty spaces separating two or more compartments for the purpose of insulating, or to prevent the liquid contents of one compartment from entering another in the event of the failure of the walls of one to retain their tightness.

COLLAR - A piece of plate or a shape fitted around an opening for the passage of a continuous member through a deck, bulkhead or other structure to securetightness against oil, water, air, dust, etc.

COLLISION BULKHEAD - First water tight bulkhead from bow of ship.

COMPARTMENT - A subdivision of space or room in a ship.

COMPLETE FUSION - Fusion which has occurred over the entire base material surfaces intended for welding and between all layers and weld beads. (See Figure 10)

COMPLETE JOINT PENETRATION - Joint penetration in which the weld metal completely fills the groove and is fused to the base metal throughout its total thickness. (See Figures 9F, G, I-P).

COMPLETE PENETRATION - See preferred term **COMPLETE JOINT PENETRATION**.

CONCAVE FILLET WELD - A fillet weld having a concave face. (See Figure 8B)

CONCAVE ROOT SURFACE - A root surface which is concave. (See Figure 9P)

CONCAVITY - The maximum distance from the face of a concave fillet weld perpendicular to a line joining the toes. (See Figure 8B)

CONSUMABLE GUIDE ELETROSLAG WELDING - An electroslag welding process variation in which filler metal is supplied by an electrode and its guiding member. See **ELECTROSLAG WELDING (ESW)**.

CONSUMABLE INSERT - Pre-placed filler metal which is completely fused into the root of this joint and becomes part of the weld.

CONTACT TUBE - A device which transfers current to a continuous electrode.

CONTINUOUS SEQUENCE - A longitudinal sequence in which each pass is made continuously from one of the joint to the other. See **BACKSTEP SEQUENCE, LONGITUDINAL SEQUENCE**, etc.

CONTINUOUS WELD - A weld which extends continuously from one end of a joint to the other. Where the joint is essentially circular, it extends completely around the joint.

CONVEX FILLET WELD - A fillet weld having a convex face. (See Figure 8A)

CONVEX ROOT SURFACE - A root surface which is convex. (See Figure 9N)

CONVEXITY - The maximum distance from the face of a convex fillet weld perpendicular to a line joining the toes. (See Figure 8A).

COUNTER - Overhang of the stern of the ship.

COUNTERSINK - To taper a hole for a flush rivet or bolt.

COVERED ELECTRODE - A composite filler metal electrode consisting of a core of bare electrode or metal cored electrode to which a covering sufficient to provide a slag layer on the weld metal has been applied. The covering may contain materials providing such functions as shielding from the atmosphere, deoxidation, and arc stabilization and can serve as source of metallic additions to the weld.

CRACK - A fracture type discontinuity characterized by a sharp tip and high ratio of length and width to opening displacement.

CRADLE - A support of wood or metal shaped to fit the object which is stowed upon it.

CRATER - In arc welding a depression at the termination of a weld bead or in the molten weld pool.

CRATER CRACK - A crack in the crater of a weld bead.

CROW'S NEST - A lookout station attached to or near the head of a mast.

CUP - See preferred term **NOZZLE**.

DAVIT - A hoisting device used to lower and raise ship's boats, etc.

DEAD FLAT - The midship portion of a vessel throughout the length of which a constant flat shape is maintained.

DEAD RISE - Rise of the bottom of a vessel from flat keel to bilge athwartship.

DEADWEIGHT - The total weight of cargo, fuel, water, stores, passengers and crew, and their effects, which a ship can carry.

DECK - A deck in a ship corresponds to the floor in a building.

DECK HOUSE - A term applied to a partial superstructure that does not extend from side to side of a vessel as do the bridge, poop and forecastle.

DECK STRINGER The strip of deck plating that runs along the outer edge of a deck.

DECLIVITY - Inclination of the ship's ways to provide for launching.

DEFECT - A discontinuity or discontinuities which. by nature or accumulated effect (for example, total crack length), render a part or product unable to meet minimum applicable acceptance standards or specifications. This term designates rejectability. See **DISCONTINUITY AND FLAW**.

DEGAUSS - An electrical installation used to demagnetize a vessel to repel the action of a magnetic mine.

DILUTION - The change in chemical composition of a welding fillet metal caused by the admixture of the base metal or previously deposited weld metal in the deposited weld bead. It is normally measured by the percentage of base metal or previously deposited weld metal in the weld bead. (See Figure 7L)

DIRECT CURRENT ELECTRODE NEGATIVE - The arrangement of direct current arc welding leads in which the work is the positive pole and the electrode is the negative pole of the welding arc. See also **STRAIGHT POLARITY**.

DIRECT CURRENT ELECTRODE POSITIVE - The arrangement of direct current arc welding leads in which the work is the negative pole and the electrode is the positive pole of the welding arc. See also **REVERSE POLARITY**.

DIRECT CURRENT REVERSE POLARITY (DCRP) - See **REVERSE POLARITY** and **DIRECT CURRENT ELECTRODE POSITIVE**.

DIRECT CURRENT STRAIGHT POLARITY (DCSP) - See **STRAIGHT POLARITY** and **DIRECT CURRENT ELECTRODE NEGATIVE**.

DISCONTINUITY - An interruption of the typical structure of a weldment, such as a lack of homogeneity in the mechanical, metallurgical, or physical characteristics of the material or weldment. A discontinuity is not necessarily a defect. See **DEFECT, FLAW**.

DISPLACEMENT - The total weight of the ship when afloat, including everything onboard (equals weight of water displaced) usually expressed in long tons.

DOG - (A) An erection aid used with wedges to align material. (B) A short metal rod or bar fashioned to form a clamp or clip used for holding watertight doors, manholes. (C) A bent bar of round iron used for holding shapes on the bending slab.

DOUBLE BOTTOM - Compartments at bottom of ship between inner and outer bottoms, used for ballast tanks, water, fuel, oil, etc.

DOUBLING PLATE OR DOUBLER -A plate fitted outside or inside another to give extra strength.

DRAFT - The vertical distance of the lowest part of a ship that is below the water when the ship is afloat.

DRAG ANGLE - The travel angle when the electrode is pointing backward. See also **BACKHAND WELDING**.

DROP-THRU - An undesirable sagging or surface irregularity, usually encountered when brazing or welding near the solidus of the base metal, caused by overheating with rapid diffusion or alloying between the filler metal and the base metal.

DUCHMAN - A filler or compensating piece added to a short member to permit a satisfactory fit.

DUTY CYCLE - The percentage of time during an arbitrary test period, usually 10 minutes, during which a power supply can be operated at its rated output without overloading.

EFFECTIVE THROAT - The minimum distance from the root of a weld at its face less any reinforcement. See also **JOINT PENETRATION**.

ELECTRODE HOLDER - A device used for mechanically holding the electrode while conducting current into it.

ELECTRODE LEAD - The electrical conductor between the source of arc welding current and the electrode holder.

ELECTROGAS WELDING (EGW) - An arc welding process which produces coalescence of metals by heating them with an arc between a continuous filler metal (consumable) electrode and the work. Molding shoe(s) are used to confine the molten weld metal for vertical position welding. The electrodes may be either flux cored or solid. Shielding may or may not be obtained from an externally supplied gas or mixture.

ELECTROSLAG WELDING (ESW) - A welding process producing coalescence of metals with molten slag which melts the filler metal and the surfaces of the work to be welded. The molten weld pool is shielded by this slag which moves along the full cross section of the joint as welding progresses. The process is initiated by an arc which heats the slag. The arc is then extinguished and the conducived slag is maintained in a molten condition by its resistance to electric current passing between the electrode and the work. See **CONSUMABLE GUIDE ELECTROSLAG WELDING**.

ELEVATION - A side view or front view.

ERECTION - The process of hoisting into place and joining the various parts of a ship's hull, machinery, etc.

EVEN KEEL - A ship is said to be on an even keel when the keel is level or parallel to the surface of the water.

EXPANSION JOINT - A term applied to a joint which permits linear movement to take up the expansion and contraction due to changing temperature or ship movement.

FABRICATE - To shape, punch or drill, shear and burn raw materials before assembly or erection.

FACE REINFORCEMENT - Reinforcement of weld at the side of the joint from which welding was done. (See Figures 7A and C). See also **ROOT REINFORCEMENT**.

FAIR - Smooth, as a smooth curve, without irregularities.

FAIR UP OR FAIR IN - To cause the members of a structure to coincide as near as possible with its molded lines.

FAIRWATER - Any casting or plating fitted to the hull of a vessel for the purpose of preventing a smooth flow of water.

FANTAIL - The overhanging stern section of vessels which have round or elliptical after endings to uppermost decks and which extend well abaft the after perpendicular.

FATHOM - Six feet.

FAYING SURFACE - The surface between two adjoining parts.

Fillet Weld

FIRECRACKER WELDING - A variation of the shielded metal arc welding process in which a length of covered electrode is placed along the joint in contact with the parts to be welded. During the welding operation, the stationary electrode is consumed as the arc travels the length of the electrode.

FIREROOM - A compartment containing boilers and the station for "firing" or operating same.

FISSURE - A small, crack-like discontinuity with only slight separation (opening displacement) of the fracture surfaces. The prefixes macro or micro indicate relative size.

FIXTURE - A device designed to hold parts to be joined in proper relation to each other.

FLAME SPRAYING (FLSP) - A thermal spraying process in which an oxyfuel gas flame is the source of heat for melting the coating material. Compressed gas may or may not be used for atomizing and propelling the material to the substrate.

FLANGE - The turned edge of a plate or girder which acts to resist bending. The turned edge of a plate or shape for tying in intersecting structural members.

FLARE - The spreading out from the central vertical plane of the body of a ship with increasing rapidity as the section rises from the water line to the rail.

FLAT - A small partial deck built without curvature or camber.

FLAT POSITION - The welding position used to weld from the upper side of the joint; the face of the weld is approximately horizontal. (See Figures 3A and 4A).

FLAW - A near synonym for **DISCONTINUITY** but with an undesirable connotation. See **DEFECT** and **DISCONTINUITY**.

FLOOR - A plate used vertically in the bottom of a ship running athwartship from bilge to bilge, usually on every frame to stiffen it.

FLUKE - The palm of an anchor.

FLUX - Material used to prevent, dissolve, or facilitate removal of oxides and other undesirable surface substances.

FLUX CORED ARC WELDING (FCAW) - An arc welding process which produces coalescence of metals by heating them with an arc between a continuous filler metal (consumable) electrode and the work. Shielding is provided by a flux contained within the tubular electrode. Additional shielding may or may not be obtained from an externally supplied gas or gas mixture. See **FLUX CORED ELECTRODE**.

FLUX CORED ELECTRODE - A composite filler metal electrode consisting of a metal tube or other hollow configuration containing ingredients to provide such functions as shielding atmosphere, deoxidation, arc stabilization, and slag formation. Alloying materials may be included in the core. External shielding may or may not be used.

For equal leg fillet welds, the leg lengths of the largest isosceles right triangle which can be inscribed within the fillet

FORE - A term used in indicating portions or that part of a ship at or adjacent to the bow.

FORECASTLE - A short structure at the forward end of a vessel formed by carrying up the ship's shell plating a deck height above the level of her uppermost complete deck and fitting a deck over the length of this structure.

FOREFOOT - The part of the keel which curves and rises to meet the stern.

FOREHAND WELDING - A welding technique in which the welding torch or gun is directed toward the progress of welding. See also **PUSH ANGLE**.

FOREPEAK - The extreme forward end of a vessel below decks. The forward trimming tank.

FORWARD - At, near or toward the bow.

FORWARD PERPENDICULAR - A line perpendicular to the base line and intersecting the forward side of the stern at the designed water line.

FOUNDATIONS - Supports for boilers, engines and auxiliary machinery.

FRAME - A term generally used to designate one of the transverse ribs that make up the skeleton of a ship. The frames act as stiffeners, holding the outside plating in shape and maintaining the transverse form of the ship.

FRAME LINE - A fore and aft location designated by a numeral in sequence, starting usually at the forward perpendicular.

FRAME SPACING - The fore and aft distance between adjacent frames.

FREEBOARD - The vertical distance from the upper watertight deck to waterline, when the ship is fully loaded.

FUEL GASES - Gases usually used with oxygen for heating such as acetylene, natural gas, hydrogen, propane, methylacetylene propadiene stabilized, and other synthetic fuels and hydrocarbons.

FUNNEL - Smokestack of a vessel.

FURNACED PLATE - A plate that requires heating in order to shape it as required.

GALLEY - Kitchen of a ship.

GALVANIZING - Coating metal parts with zinc for protection from rust.

GANGWAY - A gang plank, ladder or other means of boarding a ship.

GARBOARD STRAKE - The course of outside plates next to the keel or flat keel, sometimes called "A" strake.

GAS METAL ARC WELDING (GMAW) - An arc welding process which produces coalescence of metals by heating them with an arc between a continuous filler metal (consumable) electrode and the work. Shielding is obtained entirely from an externally supplied gas or gas mixture. Some variations of this process are called MIG or CO2 welding (non-preferred terms).

GAS METAL ARC WELDING - PULSED ARC (GMAW-P) - A gas metal arc welding process variation in which the current is pulsed. See **PULSED POWER WELDING**.

GAS METAL ARC WELDING - SHORT CIRCUIT ARC (GMAW-S) - A gas metal arc welding process variation in which the consumable electrode is deposited during repeated short circuits. Some times this process is referred to as MIG or CO2 welding (non-preferred terms).

GAS TUNGSTEN ARC WELDING (GTAW) - An arc welding process which produces coalescence of metals by hearing them with an arc between a tungsten (non-consumable) electrode and the work. Shielding is obtained from a gas or gas mixture. Pressure may or may not be used and filler metal may or may not be used. (This process has some times been called TIG welding, a non-preferred term.)

GIRDER - A major strength member running forward and aft, used to stiffen decks or bottom shell.

GIRTH - A distance measured around the body of a ship on any frame line. Often referred to as the width of a plate.

GLOBULAR TRANSFER - (arc welding). The transfer of molten metal from a consumable electrode across the arc in large droplets.

GOUGINGS - The forming of a bevel or groove by material removal. See also **BACK GOUGING**.

GRATING - Light platform or walkway built up of metal bars, used for access to machinery.

GROMMET - Lamp wicking of fiber usually soaked in read lead or some other substance, and used under the heads and nuts of bolts to insure tightness.

Groove Weld

GROUND CONNECTION - An electrical connection of the welding machine frame to the earth for safety. See also **WORK CONNECTION** and **WORK LEAD**.

GROUND LEAD - See preferred term **WORK LEAD**.

GUNWALE - The junction of deck and shell at top of sheer strake.

GUNWALE BAR - Angle iron which connects stringer plate of deck and sheer strake of shell plates (riveted work).

GUSSET PLATE - A horizontal bracket plate used for fastening posts, frames, beams, etc., to other objects.

HALF BREADTH - Width of a ship from the center line to the outboard edge, or half-width of a ship's beam.

HALF SIDING - The distance from the center line to the knuckle of the keel.

HARD PATCH - A plate riveted over another plate to cover a hole or break.

HARDFACING - A particular form of surfacing in which a coating or cladding is applied to a substrate for the main purpose of reducing wear or loss of material by abrasion, impact, erosion, galling and cavitation. See **SURFACING**.

HATCH - An opening in a deck for passage of cargo, etc.

HAWSE PIPES - Tubes through the deck and shell at the bow that lead the anchor chain overboard.

HAWSER - A large rope used in towing or mooring.

HEADER - A member added for local strength which is not parallel to the main strength members of the vessel. Usually used to deliver the loadfrom some strength member which has been cut to other strength members in the area.

HEAT-AFFECTED ZONE - That portion of the base metal which has not been melted, but whose mechanical properties or microstructure have been altered by the heat of welding, brazing, soldering or cutting. (See Figure 7G).

HELM - A term applied to the tiller, wheel or steering gear and also the rudder.

HOGGING - Straining of the ship which tends to make the bow and stern lower than the middle portion.

HOLD - A compartment in the lower portion of the ship for stowing cargo.

HORIZONTAL POSITION - (fillet weld). The position in which welding is performed on the upper side of an approximately horizontal surface and against an approximately vertical surface. (See Figure 4B)

HORIZONTAL POSITION - (groove weld). The position of welding in which the axis of the weld lies in an approximately horizontal plane and the face of the weld lies in an approximately vertical plane. (See Figure 3B)

HULL - The body of a ship, including shell plating, framing, decks and bulkheads.

I BEAM - A structural shape with a cross section resembling the letter I.

INADEQUATE JOINT PENETRATION - Joint penetration which is less than that specified.

INBOARD - Inside of the ship; toward or nearer the center line.

INCOMPLETE FUSION - Fusion which is less than complete.

INERT GAS - A gas which does not normally combine chemically with the base metal or filler metal.

INNER BOTTOM - Plating forming the upper surface of the double bottom. Also called tank top

INSERT PLATE - A heavier plate installed in a hole cut to shape, used for added strength.

INTERCOSTAL - The separate piece fitted in between members such as between frames, floors, etc., not continuous.

INTERMITTENT WELD - A weld in which the continuity if broken by recurring unwelded spaces. (See Figures 6G and H)

INTERPASS TEMPERATURE - In a multiple-pass weld, the temperature (minimum or maximum as specified) of the deposited weld metal before the next pass is started.

JIG - Devise used to automatically line up units of an assembly.

JOGGLE - An abrupt bend or offset in a plate, bar, or frame to eliminate the use of liners.

JOINT - The junction of members or the edges of members which are to be joined or have been joined.

JOINT DESIGN - The joint geometry together with the required dimensions of the welded joint.

JOINT EFFICIENCY - The ratio of the strength of a joint to the strength of the base metal (expressed in percent).

JOINT GEOMETRY - The shape and dimensions of a joint in cross section prior to welding.

JOINT PENETRATION - The minimum depth a groove or flange weld extends from its face into a joint, exclusive of reinforcement. Joint penetration may include root penetration. (See Figures 9A-H). See also **COMPLETE JOINT PENETRATION, ROOT PENETRATION** and **EFFECTIVE THROAT**.

KEEL - A centerline strength member running fore and aft along the bottom of the ship and often referred to as the backbone.

KEEL FLAT - The bottom shell strake on center line of ship.

KEEL, VERTICAL - Vertical plate on center line, used as reinforcement for longitudinal flat keel; some times called "center keelson".

KNOT - A nautical mile. (About one and one seventh statute miles.)

KNUCKLE - A bend in a plate or shape.

LACK OF FUSION - See preferred term **INCOMPLETE FUSION**.

LACK OF JOINT PENETRATION - See preferred term **INADEQUATE JOINT PENETRATION**.

LADDER - Vertical or inclined steps aboard ship, taking the place of stairs.

LAP JOINT - A joint in which one plate overlaps another, thus avoiding the use of butt straps.

LAYER - A stratum of weld metal or surfacing material. The layer may consist of one or more weld beads laid side by side. (See Figures 6D and E).

LAYING OUT - Placing the necessary lines and instructions on plates and shapes for shearing, planning, punching, bending, flanging, beveling, rolling, etc., from templates made in the Mold Loft or lifted from the ship or from plans or from sketches.

LENGTH BETWEEN PERPENDICULARS - The length of a ship measured from the forward side of stem to the aft side of the sternpost at the height of the designed water line.

LENGTH OVER ALL - The length of the ship measured from the foremost point of the stern to the aftermost part of the stern.

LIFT - To make a template from measurements taken from the job.

LIGHTENING HOLE - A hole cut out of any structural member to decrease the weight without unduly weakening it. The hole may serve as an access hole.

LIMBER HOLE - A hole or slot in a frame or plate for the purpose of preventing any liquid, such as water, from collecting.

LINER - A piece of metal used for the purpose of filling up a space between a bar and a plate or between two plates; a filler.

LINES - The form of a ship as represented by its molded surface.

LIST - The deviation of a vessel from the upright position, due to bilging, shifting of cargo, or other cause.

LOAD WATER LINE - The intersection of the ship's form with the plane of the water's surface when the ship is floating with her designed load on board.

LONGITUDINAL - A term applied to the fore and aft girders or stiffening members running parallel or nearly parallel to the center line of the ship.

LONGITUDINAL SEQUENCE - The order in which the increments of a continuous weld are deposited with respect to its length. See **BACKSTEP SEQUENCE, BLOCK SEQUENCE**, etc.

MACHINE WELDING - Welding with equipment which performs the welding operation under the constant observation and control of a welding operator. The equipment may or may not perform the loading and unloading of the work. See **AUTOMATIC WELDING**.

MAGAZINE - Spaces or compartments devoted to the storage of ammunition

MAIN DECK - The principal deck of a hull, usually the highest complete deck extending from stern to stern and providing strength to the main hull.

MANHOLE - A round or oval hole cut in decks, tanks, boilers, etc., for the purpose of providing access.

MANUAL WELDING - A welding operation performed and controlled completely by hand. See **AUTOMATIC WELDING, MACHINE WELDING** and **SEMI-AUTOMATIC ARC WELDING**.

MARGIN PLATE - The outer boundary of the inner bottom, connecting it to the shell plating at the bilge.

MAST - A large round piece of timber, steel or aluminum tube standing nearly vertical, at the center line of the ship on the deck.

MELT-THRU - Complete joint penetration for a joint welded from one side. Visible root reinforcement is produced. (See Figure 9)

MIDSHIP - At or near the middle point of the ship's length.

MIDSHIP SECTION - The vertical transverse action at the midpoint between the forward and after perpendiculars.

MIG WELDING - See preferred terms **GAS METAL ARC WELDING** and **FLUX CORED ARC WELDING**.

MOLD LOFT - A building with a large smooth floor for laying down the lines of a vessel to actual size to be used for making templates from them for the structural work entering the hull.

MOLDED DEPTH - The extreme height of a vessel amidships, from the top of the keel to the top of the upperdeck beam.

MOLDED LINE - A datum or working line used to guide the structural alignment of a ship in accordance with the design. It may be horizontal and straight as the molded base line, or curved as a molded deck line or frame line. .

NORMAL - Perpendicular or at right angle, 90°.

Note: When one member makes an angle with the other member greater than 105 , the leg length (size) is of less significance than the effective throat which is the controlling factor for the strength of a weld.

NOZZLE - A device which directs shielding media.

OFFSET - To move out of line or position.

OFFSETS - A table of molded dimensions for waterlines, decks, etc.

OIL TIGHT - Sealed by welding or caulking to prevent oil leakage.

OLD MAN - A rig for holding a drilling machine.

ON BOARD - On or in a ship.

ON DECK - On the upper deck, in the open air.

OPEN-CIRCUIT VOLTAGE - The voltage between the output terminals of the welding machine when no current is flowing in the welding circuit.

OR TUNNEL - to the bulkhead at which the stern tube commences. It provides access to the shafting and its bearings and also prevents any damage to the same from the cargo in the spaces through which it passes.

OUTBOARD - Away from the center of the ship, towards the outside.

OVERHANG - That portion of a vessel's bow or stern which projects beyond a perpendicular at the water line. Unsupported by water.

OVERHEAD POSITION - The position in which welding is performed from the underside of the joint. (See Figures 3D, 4D)

OVERLAP - The protrusion of weld metal beyond the toe, face or root of the weld; in resistance seam welding, the area in the preceding weld re-melted by the succeeding weld. (See Figures 12C and D)

OVERLAYING - See preferred term **SURFACING**.

OXIDATION - The combination of a substance or element like wood, iron, gasoline, etc., with oxygen. In welding, the oxygen of the air forms an oxide with the molten metal, thus injuring the quality and strength of the weld.

PAD EYE - A plate with a hole in it through which a cable, line or hook might be suitably fastened.

PANTING - An in and out movement of plating; to pulsate or throb. Panting may be caused by the lift and fall of a ship in a seaway, or by engine vibration.

PARTIAL JOINT PENETRATION - Joint penetration which is less than complete. (See Figures 9A-E). See also **COMPLETE JOINT PENETRATION**.

PASS - See preferred term **WELD PASS**.

PEENING - The mechanical working of metal with a rounded tool or hammer.

PILLAR - A vertical member or column which provides support to a deck girder (also called a stanchion).

PILOT HOUSE - An enclosed place in which the main steering wheel, controls, engine room telegraph, etc., are located.

PLASMA ARC CUTTING (PAC) - An arc cutting process which severs metal by melting a localized area with a constricted arc and removing the molten material with a high velocity jet of hot, ironized gas issuing from the orifice.

PLASMA ARC WELDING (PAW) - An arc welding process which produces coalescence of metals by heating them with a constricted arc between an electrode and the work piece (transferred arc) or the electrode and the constricting nozzle (non-transferred arc). Shielding is obtained from the hot, ironized gas issuing from the orifice which may be supplemented by an auxiliary source of shielding gas. Shielding gas may be an inert gas or a mixture of gases. Pressure may or may not be used, and filler metal may or may not be supplied.

PLATFORM - A partial deck.

PLATING - The plates of a hull, a deck, a bulkhead, etc.

PLIMSOLL MARK - A mark painted on the sides of vessel designating the depth to which the vessel may, under the maritime laws, be loaded in different bodies of water during various seasons of the year.

PLUG WELD - A circular weld made through a hole in one member of a lap or T-joint fusing that member to the other. The walls of the hole may or may not be parallel and the hole may be partially or completely filled with weld metal. (A fillet welded hole or a spot weld should not be construed as conforming to this definition.) (See Figure 2C)

POLARITY - See **DIRECT CURRENT ELECTRODE NEGATIVE, DIRECT CURRENT ELECTRODE POSITIVE, STRAIGHT POLARITY** and **REVERSE POLARITY.**

POROSITY - Cavity type discontinuities formed by gas entrapment during solidification.

PORT - A harbor; an opening in the side of a ship. The left hand side of a ship looking toward the bow.

POSITION - (See Figures 3 and 4)

POSITION OF WELDING - See **FLAT POSITION, HORIZONTAL POSITION, OVERHEAD POSITION** and **VERTICAL POSITION.**

POSITIONED WELD - A weld made in a joint which has been so placed as to facilitate making the weld.

POST WELD HEAT TREATMENT - Any heat treatment subsequent to welding.

POSTHEATING - The application of heat to an assembly after a welding, brazing, soldering, thermal spraying or cutting operation. See **POST WELD HEAT TREATMENT**.

PRE-HEAT TEMPERATURE - A specified temperature that the base metal must attain in the welding, brazing, soldering, thermal spraying or cutting area immediately before these operations are performed.

PRE-HEATING - The application of heat to the base metal immediately before welding, brazing, soldering, thermal spraying or cutting.

PREFLOW TIME - The time interval between start of shielding gas flow and arc starting.

PROCEDURE - The detailed elements (with prescribed values or ranges of values) of a process or method used to produce a specific result.

PROCEDURE QUALIFICATION - The demonstration that welds made by a specific procedure can meet prescribed standards.

PROCEDURE QUALIFICATION RECORD (PQR) - A document providing the actual welding variables used to produce an acceptable test weld and the results of tests conducted on the weld for the purpose of qualifying a welding procedure specification.

PROFILE - A side elevation of a ship's form.

PROPELLER SHAFT - Rotating bar by means of which the engine turns the propeller.

PROW - The part of the bow from the load water line to the top of the bow.

PULSED POWER WELDING - An arc welding process variation in which the power is cyclically programmed to pulse so that effective, but short duration values of a parameter can be utilized. Such short duration values are significantly different from the average value of the parameter. Equivalent terms are pulsed voltage or pulsed current welding; see also **PULSED SPRAY WELDING**.

PULSED SPRAY WELDING - An arc welding process variation in which the current is pulsed to utilize the advantages of the spray mode of metal transfer at average currents equal to or less than the globular to spray transition current.

PUNCH - A machine for punching holes in plates and shapes.

PUSH ANGLE - The travel angle when the electrode is pointing forward. See also **FOREHAND WELDING**. Note: This angle can be used to define the position of welding guns, welding torches, high energy beams, welding rods, thermal cutting and thermal spraying torches, and thermal spraying guns.

QUALIFICATIONS - See preferred terms **WELDER PERFORMANCE QUALIFICATION** and **PROCEDURE QUALIFICATION**.

QUARTERS - Living and sleeping rooms for officers and crew.

RAKE - Slope aft of a mast, kingpost or stack from vertical.

RANDOM INTERMITTENT WELDS - Intermittent welds on one or both sides of a joint in which the weld increments are deposited without regard to spacing.

RANDOM SEQUENCE - A longitudinal sequence in which the weld bead increments are deposited at random

REAMING - Enlarging a hole by the means of revolving in it a cylindrical, slightly tapered tool with cutting edges running along its sides.

REDUCER - A fitting having a larger size at one end than at the other.

REFERENCE LINE - A line fixed in position and location, from which measurements are made.

REINFORCEMENT OF WELD - Weld metal in excess of the quantity required to fill a joint. See **FACE REINFORCEMENT** and **ROOT REINFORCEMENT**.

RESIDUAL STRESS - Stress remaining in a structure or member as a result of thermal or mechanical treatment or both. Stress arises in fusion welding primarily because the weld metal contracts on cooling from the solidus to room temperature.

REVERSE POLARITY - The arrangement of direct current arc welding leads with the work as the negative pole and the electrode as the positive pole of the welding arc. A synonym for **DIRECT CURRENT ELECTRODE POSITIVE**.

RIDER PLATE - A continuous flat plate attached to the top of a center line vertical keel in a horizontal position.

RIVET - A short round metal connection used to fasten two or more members together by inserting it into holes punched or drilled in the pieces.

ROLLS - A large machine used to give curvature to plates by passage in contact with three rolls.

ROOT - See preferred terms **ROOT OF JOINT** and **ROOT OF WELD**.

ROOT BEAD - A weld deposit that extends into or includes part or all of the root of the joint.

ROOT CRACK - A crack in the weld or heat-affected zone occurring at the root of a weld.

ROOT EDGE - A root face of zero width. See **ROOT FACE**.

ROOT FACE - That portion of the groove face adjacent to the root of the joint.

ROOT GAP - See preferred term **ROOT OPENING**.

ROOT OF THE JOINT - That portion of a joint to be welded where the members approach closest to each other. In cross section, the root of the joint may be either a point, a line, or an area.

ROOT OF THE WELD - The points, as shown in cross section, at which the back of the weld intersects the base metal surfaces. (See Figure 7)

ROOT OPENING - The separation between the members to be joined at the root of the joint. (See Figure 1)

ROOT PENETRATION - The depth that a weld extends into the root of a joint measured on the centerline of the root cross section. (See Figure 9).

ROOT REINFORCEMENT - Reinforcement of weld at the side other than that from which welding was done. (See Figure 7)

ROOT SURFACE - The exposed surface of a weld on the side other than that from which welding was done. (See Figures 7B and 9N-P)

RUDDER - A device located near the after perpendicular and used in steering or maneuvering a vessel.

SAGGING - Straining of the ship which tends to make the middle portion lower than the bow or stern.

SCANTLINGS - The dimensions of various shapes.

SCARF JOINT - A lapped joint made by beveling off, notching, or otherwise cutting away the edges of two adjoining plates so that by bolting or strapping them together, they form one continuous plate, usually without increasing the thickness.

SCULLERY - A place where dishes are washed.

SCUPPERS - Drains from decks to carry off accumulations of rain or sea water.

SCUTTLE - A small opening usually circular in shape and generally fitted in decks to provide access. Often termed escape scuttles.

SCUTTLE BUTT - A container for drinking water.

SEA CHEST - A cast fitting or built-up structure located below the waterline of a vessel and used to supply sea water to condensers and pumps, and to discharge waste water from the ship into the sea.

SEAL WELD - Any weld designed primarily to provide a specific degree of tightness against leakage.

SEAM - A fore and aft joint of plating.

SEMI-AUTOMATIC ARC WELDING - Arc welding with equipment which controls only the filler metal feed. The advance of the welding is manually controlled.

SHAFT ALLEY - A watertight passage, housing the propeller shafting from the engine room

SHEARING - Cutting or trimming the edges of a steel member.

SHEARS - A large machine for cutting plates and shapes.

SHEER - Curvature of deck in a fore and aft direction as seen in profile.

SHEER STRAKE - The topmost continuous strake of shell plating on the hull.

SHELL EXPANSION - A plan showing the shapes, sizes and weight of all plates comprising the shell plating and details of their connections. The view is expanded.

SHELL PLATING - The plating forming the outer skin of a vessel.

SHIELDED METAL ARC WELDING (SMAW) - An arc welding process which produces coalescence of metals by heating them with an arc between a covered metal electrode and the work. Shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode.

SHIELDING GASES - Protective gas used to prevent atmospheric contamination.

SHORES - Pieces of timber placed in a vertical or inclined position to support some part of a ship or the ship itself, during construction or while in dry dock.

SHORT CIRCUITING TRANSFER - (arc welding). Metal transfer in which molten metal from a consumable electrode is deposited during repeated short circuits.

SIGHT EDGES - Visible edges of plating (outside shell and above decks).

SINGLE-WELDED JOINT - In arc and gas welding, any joint welded from one side only.

SIZE OF WELD

SKEG - The extreme after part of the keel, the portion that supports the rudder post.

SKIP WELD - See preferred term **INTERMITTENT WELD.**

SLAB - Heavy cast iron blocks with square or round holes for "dogging down" structural shapes that are to be bent or formed. The part devoted to assembling parts of a ship is known as the assembly slab.

SLAG INCLUSION - Non-metallic solid material entrapped in weld metal or between weld metal and base metal.

SLIDING WAY - That part of launching way which moves with the ship.

SLOT WELD - A weld made in an elongated hold in one member of a lap or T-joint joining that member to that portion of the surface of the other member which is exposed through the hole. The hole may be open at one end and may be partially or completely filled with weld metal. (A fillet welded slot should not be constructed as conforming to this definition.) (See Figure 2D)

SLUGGING - The act of adding a separate piece or pieces of material in a joint before or during welding that results in a welded joint not complying with design, drawing or specification requirements.

SNIPE - To cut shape bevel on the end of a stiffener or beam.

SOFT PATCH - A temporary plate placed over a break or hole and secured to the surrounding structure.

SOLE PLATE - A plate fitted to the top of a foundation to which the base of a machine is bolted. Also a small plate fitted at the end of a stanchion.

SOUNDING TUBE - A vertical pipe in an oil or water tank, used to guide a sounding device when measuring the depth of liquid in the tank.

SPILLING - The curve of a plate or strake as it narrows to a point.

SPONSON - An extension on the main deck which extends outboard past the side of the vessel.

SPRAY TRANSFER - (arc welding). Metal transfer in which molten metal from a consumable electrode is propelled axially across the arc in small droplets.

STAGGERED INTERMITTENT WELDS - Inermittent welds on both sides of a joint in which the weld increments on one side are alternated with respect to those on the other side.

STAGING - Plans or scaffolding on which to stand when working on sides or under decks.

STANCHION - An upright member used as a support between decks, usually made of pipe and I-beams.

STARBOARD - The right hand side of a ship looking forward.

STEALER - A strake of shell plating that does not extend completely to the bow or stern.

STEM - The bow frame forming the apex of the forward sides of ship.

STERN - The extreme after end of a vessel.

STERN TUBE - The bearing supporting the propeller shaft where it emerges from the ship.

STERNPOST - After part of stern frame to which rudder is attached; also called "rudder post".

STICK ELECTRODE - See **COVERED ELECTRODE**.

STICK ELECTRODE WELDING - See preferred term **SHIELDED METAL AND WELDING**.

STIFFENER - An angle bar, T bar, channel, etc., used to stiffen plating of a bulkhead or deck, etc.

STOP WATER OR WATER STOP - A term applied to canvas and red lead, or other suitable material placed between the frying surfaces of plates and shapes to stop the passage of oil or water.

Often one plate or shape is cut through to the adjoining member and the cutout filled with weld to form a welded sop water.

STOWAGE - A support or fastening for any gear as, anchor or boat stowage.

STRAIGHT POLARITY - The arrangement of direct current arc welding leads in which the work is the positive pole and the electrode is the negative pole of the welding arc. A synonym for **DIRECT CURRENT ELECTRODE NEGATIVE**.

STRAIN - Alteration in shape of dimensions resulting from stress.

STRAKE - A continuous row of plates running for an aft, (hull and decks).

STRESS - Force per unit area.

STRESS RELIEF HEAT TREATMENT - Uniform heating of a structure or a portion thereof to a sufficient temperature to relieve the major portion of the residual stresses, followed by uniform cooling.

STRINGER - A term applied to a fore and aft member running along the side of a ship. Also, the outboard strake of plating on any deck.

STRINGER BEAD - A type of weld bead made without appreciable weaving motion. See also **WEAVE BEAD**. (See Figure 5A)

STRONGBACK - A stiffener, either temporary or permanent or a rigid device used in straightening plates or other ship members.

STRUT - A support for a propeller shaft. A brace or compression member.

STUD ARC WELDING (SW) - An arc welding process which produces coalescence of metals by heating them with an arc between a metal stud, or similar part, and the other work part. When the surfaces to be joined are properly heated, they are brought together under pressure. Partial shielding may be obtained by the use of a ceramic ferrule surrounding the stud. Shielding gas or flux may or may not be used.

STUD WELDING - A general term for the joining of a metal stud or similar part to a work piece. Welding may be accomplished by arc, resistance, friction, or other suitable process with or without external gas shielding.

SUBMERGED ARC WELDING (SAW) - An arc welding process which produces coalescence of metals by heating them with an arc or arcs between a bare metal electrode or electrodes and the work. The arc and molten metal are shielded by a blanket of granular, fusible material on the work. Pressure is not used and filler metal is obtained from the electrode and sometimes from a supplemental source(s) (welding rod, flux, or metal granules).

SUCK-BACK - See preferred term **CONCAVE ROOT SURFACE**.

SUPERSTRUCTURE - The structure built above the uppermost complete deck.

SURFACING - The deposition of filler metal (material) on a base metal (substrate) to obtain desired properties or dimensions. See also **BUTTERING** and **HARDFACING**.

SWASH BULKHEAD - Longitudinal or transverse non-tight bulkheads fitted in a tank to decrease the swashing action of the liquid contents.

SWASH PLATE - Boffel plate in tank to prevent excessive movement of the contained liquid.

T-JOINT - A joint between two members located approximately at right angles to each other in the form of a T.

TACK-WELD - A weld made to hold parts of a weldment in proper alignment until the final welds are made.

TANK TOP - The plating over the double bottoms.

TAPS - Connections to a transformer winding which are used to vary the transformer turns ratio, thereby controlling welding, voltage and current.

TEMPLATE - A mold or pattern made to the exact size of a piece of work that is to be laid out or formed, and on which such information as the position of rivet holes, size of laps,, etc. If indicated.

TEMPORARY WELD - A weld made to attach a piece or pieces to a weldment for temporary use in handling, shipping or working on the weldment.

The distance from the beginning of the root of the joint perpendicular to the hypotenuse of the largest right triangle that can be inscribed within the fillet weld cross section. This dimension is based on the assumption that the root opening is equal to zero. (See Figure 8)

The minimum distance minus any reinforcement from the weld to its face. (See Figure 8)

The penetration (depth of bevel plus the root penetration when specified). The size of a groove weld and its effective throat are one and the same. (See Figures 9A,B and E-H)

The shortest distance from the root to weld to its face. (See Figure 8)

THERMAL SPRAYING (THSP) - A group of welding or allied processes in which finely divided metallic or non-metallic materials are deposited in a molten or semi-molten condition to form a coating. The coating material may be in the form of powder, ceramic rod, wire or molten materials. See **FLAME SPRAYING**.

THEORETICAL THROAT - The distance from the beginning of the root of the joint perpendicular to the hypotenuse of the largest right triangle that can be inscribed within the fillet weld cross section. This dimension is based on the assumption that the root opening is equal to zero.

THROAT OF A GROOVE WELD - See preferred term **SIZE OF WELD.**

THWARTSHIP - Transverse, or at right angles to the center line plane.

TIG WELDING - See preferred term **GAS TUNGSTEN ARC WELDING.**

TOE CRACK - A crack in the base metal occurring at the toe of a weld.

TOE OF WELD - The junction between the face of a weld and the base metal.

TOP SIDE - That portion of the side of the hull which is above the water line.

TRANSOM - The last transverse frame of the ship structure.

TRANSVERSE - At right angles to the ship's center line. Transverse frames are vertical athwartship members forming the ribs. Transverse bulkheads are vertical bulkheads that extend completely across the ship square to the center line.

TRIM - To shift ballast; to cause a ship to change its position in the water.

TRUNK - A small casing between decks such as used for ladders, ventilation, etc.

TUMBLE HOME - An inboard slant of a ship's side above the bilge.

UNDERBEAD CRACK - A crack in the heat-affected zone generally not extending to the surface of the base metal.

UNDERCUT - A groove melted into the base metal adjacent to the toe or root of a weld and left unfilled by weld metal.

UNDERFILL - A depression on the face of the weld or root surface extending below the surface of the adjacent base metal.

UPTAKE - Connecting trunk between boilers and smoke stack.

VEE CUT - To prepare for butt welding, by making a vee-shaped joint.

VERTICAL KEEL - The upright or vertical web or plate of the keel.

VERTICAL POSITION - The position of welding in which the axis of the weld is approximately vertical

WATERLINE - Any line parallel to the base line.

WATERTIGHT - So riveted, caulked or welded as to prevent the passage of water.

WATERWAY BAR - A flat bar or angle attached to the outer edge of the deck used to lead water into scuppers where it can be discharged.

WAYS - An inclined structure upon which a ship is built or supported for launching.

WEATHER DECK - A deck exposed to the weather.

WEAVE BEAD - A type of weld bead made with transverse oscillation.

WEB - The vertical portion of a beam.

WEB FRAME - A frame with a deep web, usually a main strength member.

WELD - A localized coalescence of metals or non-metals produced either by heating the materials to suitable temperatures, with or without the application of pressure or by the application of pressure along and with or without the use of filler material.

WELD BEAD - A weld deposit resulting from a pass: See **STRINGER BEAD** and **WEAVE BEAD**.

WELD GAGE - A device designed for checking the shape and size of welds.

WELD METAL - That portion of a weld which has been melted during welding.

WELD PASS - A single progression of a welding or surfacing operation along a joint, weld deposit or substrate. The result of a pass is a weld bead, layer or spray deposit.

WELD PENETRATION - See preferred terms **JOINT PENETRATION** and **ROOT PENETRATION.**

WELD SIZE - See preferred term **SIZE OF WELD.**

WELDABILITY - The capacity of a material to be welded under the fabrication conditions imposed into a specific, suitably designed structure and to perform satisfactorily in the intended service.

WELDER - One who performs a manual or semi-automatic welding operation. (Sometimes erroneously used to denote a welding machine.)

WELDER PERFORMANCE QUALIFICATION - The demonstration of a welder's ability to produce welds meeting prescribed standards.

WELDING LEADS - The work lead and electrode lead of an arc welding circuit.

WELDING MACHINE - Equipment used to perform the welding operation. For example, spot welding machine, arc welding machine, seam welding machine, etc.

WELDING OPERATOR - One who operates machine or automatic welding equipment.

WELDING PROCEDURE - The detailed methods and practices including all welding procedure specifications involved in the production of a weldment. See **WELDING PROCEDURES SPECIFICATION.**

WELDING PROCEDURE SPECIFICATION (WPS) - A document providing in detail the required variables for a specific application to assure repeatability by properly trained welders and welding operators.

WELDING PROCESS - A materials joining process which produces coalescence of materials by heating them to suitable temperatures, with or without the application of pressure or by the application of pressure along, and with or without the use of filler metal. (See Master Chart of Welding and Allied Processes.)

WELDING SEQUENCE - The order of making the welds in a weldment.

WELDING TECHNIQUE - The details of a welding procedure which are controlled by the welder or welding operator.

WELDMENT - An assembly whose component parts are joined by welding.

WELDOR - See preferred term **WELDER**.

WELL - A cofferdam or a sump in the double bottom.

WINCH - A small hoisting engine.

WINDLASS - The machine used to hoist the anchors.

WORK CONNECTION - The connection of the work lead to the work.

WORK LEAD - The electric conductor between the source of arc welding current and the work.

ZEE BAR - A structural shape with a cross section resembling the letter Z.

NOTES:

FRACTION & DECIMAL EQUIVALENTS

1/32 — .03125	17/32 — .53125
1/16 — .0625	9/16 — .5625
3/32 — .09375	19/32 — .59375
1/8 — .125	5/8 — .625
5/32 — .15625	21/32 — .65625
3/16 — .1875	11/16 — .6875
7/32 — .21875	23/32 — .71875
1/4 — .25	3/4 — .75
9/32 — .28125	25/32 — .78125
5/16 — .3125	13/16 — .8125
11/32 — .34375	27/32 — .84375
3/8 — .375	7/8 — .875
13/32 — .40625	29/32 — .90625
7/16 — .4375	15/16 — .9375
15/32 — .46875	31/32 — .96875
1/2 — .5	1 — 1.0