Lesson Description

• This section of the course is designed to familiarize the student with the terms, symbols, and joint designs used for welding applications and provide skills to recognize weld defects.
Terminal Objective

• By the end of this lesson the student will be able to identify the terms, symbols, and joint designs that are used during welding applications and recognize defects caused by the welding process.

REFERENCES

• Standard Welding Terms and Definitions- AWS A3.0:2001
• Standard Symbols for Welding, Brazing, and Nondestructive Examination- ANSI/AWS A2.4-98
• Hobart Institute of Welding Technology- Symbols for Welding
• Various Military Standards
BASIC WELDING TERMS
General

• Enabling Objectives
  – Upon successful completion of this topic the student will be able to identify general terms used for welding application.
  – Upon successful completion of this topic the student will be able to pass an examination identifying general terms used for in the welding application.

BASIC WELDING TERMS
General

• Air Carbon Arc Cutting- A carbon arc cutting process that removes molten metal with a jet of air.

Figure 10-76. Air carbon arc cutting diagram.
BASIC WELDING TERMS

General

- Arc Gouging- Thermal gouging that uses an arc cutting variation to form a bevel or groove.
- Carbon Arc Cutting- An arc cutting process that uses a carbon electrode.

Figure 10-15: Process diagram for air carbon arc cutting.

Carbon Arc Rods

BASIC WELDING TERMS

General

- Arc Length- The distance from the tip of the welding electrode to adjacent surface of the weld pool.

Figure 10-16: Setting the length of an arc.
BASIC WELDING TERMS

General

• Arc Plasma- A gas that has been heated by an arc to at least a partially ionized condition, enabling it to conduct an electric current.
  – Plasma Cutters
    • Automatic (shop)
    • Manual (field)

• Arc Spot Weld- A spot weld made by an arc welding process.
BASIC WELDING TERMS
(General)

• Arc Stud Welding- An arc welding process that uses an arc between a metal stud, or similar part, and the other work piece. The process is used without filler metal, or without shielding gas or flux, with or without partial shielding from a ceramic or graphite ferrule surrounding the stud, and with the application of pressure after the faying surfaces are sufficiently heated.
BASIC WELDING TERMS
(General)

Ferrule (arc stud welding) - A ceramic device that surrounds the stud base to contain the molten metal and shield the arc.
BASIC WELDING TERMS
General

• As-welded- pertaining to the condition of weld metal, welded joints, and weldments after welding, but prior to any subsequent thermal, mechanical, or chemical treatments.

BASIC WELDING TERMS
General

• Autogenous Weld- A fusion weld made without filler metal.
BASIC WELDING TERMS

General

• Backgouging- The removal of weld metal and base metal from the weld root side of a welded joint to facilitate complete fusion and complete joint penetration upon subsequent welding from that side.

BASIC WELDING TERMS

General

• Backing- A material or device placed against the back side of the joint adjacent to the joint root, or at both sides of a joint.
BASIC WELDING TERMS

General

• Backing Ring- Backing in the form of a ring, generally used in the welding of pipe.
• Bevel Angle- The angle between the bevel of a joint member and a plane perpendicular to the surface of the member.

BASIC WELDING TERMS

General

• Bevel Edge Shape- A type of edge shape in which the prepared surface lies at some angle other than perpendicular to the material surface.
• Bevel Face- The prepared surface of a bevel edge shape.
BASIC WELDING TERMS

General

• Base Material- The material that is welded, brazed, soldered, or cut (base metal).

• Design Material Thickness- The nominal or average thickness of the material of the strength member, exclusive of reinforcement or backing rings and strips.

• Minimum Material Thickness- Minimum acceptable thickness allowed.
BASIC WELDING TERMS
General

• Ferrous Metals- those metals which include iron and all iron derivatives. Also refers to a group of metals which are naturally attracted to magnets.
• Non-Ferrous Metals- metals or alloys that are free of iron or comparatively so. These metals are not magnetic.

BASIC WELDING TERMS
General

• Buildup- A surfacing variation in which surfacing material is deposited to achieve the required dimensions (buttering, cladding, and hardfacing).
BASIC WELDING TERMS
General

• Buttering- A surfacing variation that deposits surfacing metal on one or more surfaces to provide metallurgically compatible weld metal for the subsequent completion of the weld.

BASIC WELDING TERMS
General

• Cladding- A surfacing variation that deposits or applies surface material usually to improve corrosion or heat resistance.

• Hardfacing- A surfacing variation in which surfacing material is deposited to reduce wear.
BASIC WELDING TERMS

General

- Butting Member- A joint member that is prevented, by the other member, from movement in one direction perpendicular to its thickness dimension.
- Non-butting Member- A joint member that is free to move in any direction perpendicular to its thickness dimension.

BASIC WELDING TERMS

General

- Intermittent Weld- A weld in which continuity is interrupted by recurring un-welded spaces.
- Chain Intermittent Weld- An intermittent weld on both sides of a joint in which the weld increments on one side are approximately opposite those on the other side.
BASIC WELDING TERMS

General

• Consumable Insert - Filler metal that is placed at the joint root before welding, and is intended to be completely fused into the joint root to become part of the weld.

BASIC WELDING TERMS

General

• Defect - Undesirable aspects of metal processing: unacceptable discontinuities.
• Discontinuity - A break or interruption in the normal physical structure of an article.
BASIC WELDING TERMS

General

• Dissimilar Metal Welds- Welds between two metals which differ sufficiently in metallurgical and physical properties to require special consideration in qualification and inspection.

• Duty Cycle- The percentage of time during a specified test period that a power source or its accessories can be operated at rated output without overheating.

BASIC WELDING TERMS

General

• Fillet Weld- A weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap, T, or corner joint.
**BASIC WELDING TERMS**

**General**

- **Fillet Weld Leg** - The distance from the joint root to the toe of the fillet weld.

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**BASIC WELDING TERMS**

**General**

- **Effective Throat** - The minimum distance from the fillet weld face, minus any convexity, and the weld root. In the case of a fillet weld combined with a groove weld, the weld root of the groove weld shall be used.
BASIC WELDING TERMS
General

• Actual Throat- the shortest distance between the weld root and the face of a fillet weld

BASIC WELDING TERMS
General

• Filler Material- The material to be added in making a brazed, soldered, or welded joint.
BASIC WELDING TERMS
General

• Flux- A material used to hinder of prevent the formation of oxides and other undesirable substances in molten metal and on solid metal surfaces, and to dissolve or otherwise facilitate the removal of such substances.

BASIC WELDING TERMS
General

• Heat-affected Zone- The portion of base metal whose mechanical properties or microstructure have been altered by the heat of welding, brazing, soldering, or thermal cutting.
BASIC WELDING TERMS

General

• Heat Input- The energy supplied by the welding arc to the work piece. A required in process observation/measurement to be recorded for the rate and volume of welding applied to higher strength steels: HY-80, HY-100, HSLA-80, or STS. This is to be measured in joules per inch.
  – Computation of heat input (joules/inch):
    • Heat Input = \( \text{Arc voltage} \times \text{welding amps} \times \frac{60}{\text{Rate of travel (inches per minute)}} \) (joules/)

BASIC WELDING TERMS

General

• Preheat- The heat applied to the base metal or substrate to attain and maintain preheat temperatures.
BASIC WELDING TERMS
General

• Local Preheating- Preheating a specific portion of a structure.

• Interpass Temperature- In a multipass weld, the temperature of the weld area between weld passes.

Temperature Stick
BASIC WELDING TERMS

General

• Joint Efficiency - The ratio of strength of a joint to the strength of the base metal, expressed in percent.

<table>
<thead>
<tr>
<th>Joint Efficiency (percent)</th>
<th>Joint design group</th>
</tr>
</thead>
<tbody>
<tr>
<td>180</td>
<td>B</td>
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<tr>
<td>180</td>
<td>T, PT</td>
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<tr>
<td>100</td>
<td>T, PT</td>
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<td>50</td>
<td>T, PT, E</td>
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<tr>
<td>50</td>
<td>T, PT, E</td>
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</tbody>
</table>

**Note:** The table above provides joint efficiency values for different joint designs and base metals. The values are expressed in percent and indicate the ratio of joint strength to base metal strength.
BASIC WELDING TERMS
General

• Manual Welding- Welding with the torch, gun, or electrode holder held and manipulated by hand.
  – Oxygen/Acetylene Torch welding
  – SMAW- Shielded Metal Arc Welding
  – GMAW- Gas Metal Arc Welding
  – GTAW- Gas Tungsten Arc Welding
  – FCAW- Flux Core Arc Welding

BASIC WELDING TERMS
General

• Oxy/Act torch welding-In gas welding and cutting, the heat energy and high temperature needed to melt the metal is obtained by the combustion of a fuel gas with oxygen in a torch.
BASIC WELDING TERMS
General

• SMAW- Shielded Metal Arc Welding- An arc welding process employing a flux coated metal filler rod.

BASIC WELDING TERMS
General

• GMAW- Gas Metal Arc Welding- is a semi-automatic or automatic arc welding process which utilizes a welding gun through which a continuous and consumable wire electrode and a shielding gas is fed.
BASIC WELDING TERMS
General

• GTAW- Gas Tungsten Arc Welding- In this process a non-consumable tungsten electrode is used and the electric arc occurs between this electrode and the work.

BASIC WELDING TERMS
General

• FCAW- Flux Core Arc Welding- 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 piece.
BASIC WELDING TERMS
General

• Open Root Joint- An unwelded joint without backing or consumable insert.
• Peening- The mechanical working of metals using impact blows.

BASIC WELDING TERMS
General

• Piping Welds- All circumferential strength welds (including welds between component nozzles and piping) in the fluid boundary other than pressure vessel welds.
BASIC WELDING TERMS
General

• Root Reinforcement- Weld reinforcement opposite the side from which welding was done.

• Root Surface- The exposed surface of a weld opposite the side from which welding was done.

BASIC WELDING TERMS
General

• Slugging- An unauthorized addition of metal, such as a length of rod, to a joint before welding or between passes, often resulting in a weld with incomplete fusion.
BASIC WELDING TERMS
General

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

BASIC WELDING TERMS
General

• Stringer Bead- A weld bead formed without appreciable weaving.
• Weaving- A welding technique in which the energy source is oscillated transversely as it progresses along the weld path. (Weave Bead)
BASIC WELDING TERMS
General

• Weldability- The capacity of material to be welded under the imposed fabrication conditions into a specific, suitably designed structure and to perform satisfactorily in the intended service.

• Weld Contour- The surface profile of a weld in the as deposited condition or after preparation to meet workmanship or NDT requirements.

BASIC WELDING TERMS
General

• Weld Contouring- The deliberate shaping of weld surfaces for hydrodynamic or fatigue considerations or as otherwise permitted by standards.

• Weld Face- The exposed surface of a weld on the side from which welding was done.
BASIC WELDING TERMS

General

• Weld Pass- A single longitudinal progression of a welding bead along a joint or weld deposit for the length of one block or more and may consist of more than one start or stop.

• Weld Reinforcement- Weld metal in excess of the quantity required to fill a weld groove.

BASIC WELDING TERMS

General

• Weld Toe- The junction of the weld face and the base metal.
BASIC WELDING TERMS
General (Review)

• Types of Welding Equipment
• Welding Processes
• Types of Welds
• Parts of the Weld
• Other Welding Related Terms

BASIC WELDING TERMS
Defects

• Enabling Objectives
  – Upon successful completion of this topic the student will be able to identify terms and recognize the types of defects found in welds.
BASIC WELDING TERMS

Defects

• Arc Strike (Arc Burn)- Any localized heat affected zone or change in the contour of the surface of the finished weld or adjacent base metal resulting from an arc or heat generated by the passage or electrical energy between the weld or base material.
BASIC WELDING TERMS
Defects

- **Burn Through**: A void or open hole extending into a backing or strip, fused root, of adjacent base metal.

BASIC WELDING TERMS
Defects

- **Crack or Tear**: A linear rupture of metal under stress.
- **Crater Crack**: A crack emanating from the center of a crater pit.
BASIC WELDING TERMS

Defects

• Crater Pit- An approximately circular surface condition extending into the weld in an irregular manner, such as from the inside diameter surface or a fused root insert.

• Excessive Grinding- grinding base metal down to below minimum wall thickness requirements while attempting to remove rejectable undercut.
CRATER CRACK AND CRATERPIT

EXCESSIVE GRINDING
BASIC WELDING TERMS

Defects

• Heat Checks- Fissure or tears in the weld heat affected zone of material containing low melting point alloying elements.

• Incomplete Fusion (Lack of Fusion)- Lack of complete fusion of some portion of the metal in a weld joint with adjacent metal. The adjacent metal may be either base metal or the previously deposited weld metal.

HEAT CRACKS
BASIC WELDING TERMS
Defects

- Incomplete Penetration- Lack of penetration of the weld through the thickness of the joint, or penetration which is less than specified.

- Melt Through- A convex or concave irregularity on the surface of a backing ring or strip, fused root, or adjacent base metal resulting from fusion completely through a localized region but without development of a void or open hole.
MELT THROUGH

BASIC WELDING TERMS
Defects

• Oxidation- A condition resulting from partial or complete lack of inert gas shielding of a surface which is heated during welding resulting in formation of oxide on the surface. This condition may range from slight oxidation to a rough surface having a crystalline appearance.
OXIDATION

BASIC WELDING TERMS
Defects

• Porosity- Gas pockets or voids in a weld or casting.
BASIC WELDING TERMS
Defects

• Wormhole Porosity- An elongated cavity type discontinuity formed by gas entrapment during solidification, generally where the length is three times greater than the width and where the alignment of the void is normal to the solidification front.

BASIC WELDING TERMS
Defects

• Reentrant Angle- A reentrant angle is one which the angle formed between the base material and the weld edge is less than 90 degrees.
BASIC WELDING TERMS
Defects

• Root Surface Convexity- Reinforcement on the root surface of a weld.

BASIC WELDING TERMS
Defects

• Root Surface Concavity- A depression on the root surface of a weld which may be due to gravity, internal purge, or shrinkage.
BASIC WELDING TERMS
Defects

• Root Undercut- A groove in the internal surface of a base metal or backing ring or strip along the edge of the root of the weld.

• Slag- Non metallic solid material entrapped between beads of weld metal or between weld and base metal or in a casting.
BASIC WELDING TERMS
Defects

• Root Surface Center-line Crease or Shrinkage- An intermittent or continuous peripheral center-line concavity formed on the root surface.

• Stress Corrosion Cracking- Weld cracking caused by the presence of both tensile stress of sufficient magnitude and a corrosive medium

• Tungsten Inclusion- Tungsten entrapped in the weld deposit.

BASIC WELDING TERMS
Defects

• Undercut- A groove melted into the base metal at the toe of the weld and left unfilled by weld metal.
BASIC WELDING TERMS
Defects

• Weld Spatter-
  Material particles
  which deposit on the
  surface of the weld or
  adjacent base metal
  during welding and
  which do not form a
  part of the weld.

BASIC WELDING TERMS
Defects (Review)

• Various Defects (Arc Strike, Burn Through,
  Melt Through, Undercut)
• Causes of Defects
• Correction of Defects
AWS SYMBOLS

• Enabling Objectives
  – Upon successful completion of this topic the student will know the difference between a weld symbol and a welding symbol.
  – Upon successful completion of this topic the student will be able to identify the different types of weld symbols.
  – Upon successful completion of this topic the student will be able to identify the different types of NDT symbols.

AWS SYMBOLS
Welding

• Welding symbol consists of several elements. Only the reference line and arrow are required elements, but additional elements may be included to convey specific welding information.
• Weld symbol indicates the type of weld and when used, is a part of the welding symbol.
AWS SYMBOLS
Welding

- Location Significance of Arrow-
  Information applicable to the arrow side of
  a joint shall be placed below the reference
  line. Information applicable to the other
  side of a joint shall be placed above the
  reference line.
AWS SYMBOLS

Welding

- **Arrow Side** - Welds on the arrow side of the joint shall be specified by placing the weld symbol below the reference line.
- **Other Side** - Welds on the other side of the joint shall be specified by placing the weld symbol above the reference line.
- **Both Sides** - Welds on both sides of the joint shall be specified by placing weld symbols both below and above the reference line.
AWS SYMBOLS
Welding

• Symbols with No Side Significance- Some weld symbols have no arrow-side or other-side significance, although supplementary symbols used in conjunction with them may have such significance.

Symbols with No Side Significance

![Symbols with No Side Significance]
AWS SYMBOLS
Welding

• Fillet, Groove, and Edge Weld Symbols-
For these symbols, the arrow shall connect the welding symbol reference line to one side of the joint, and this side shall be considered the arrow side of the joint. The side opposite the arrow side of the joint shall be considered the other side of the joint.
Groove Weld Symbols

Fillet Weld Symbols
Edge Weld Symbols

AWS SYMBOLS
Welding

• Plug, Slot, Spot, Projection, and Seam Weld Symbols- For these symbols, the arrow shall connect the welding symbol reference line to the outer surface of one of the joint members at the centerline of the desired weld. The member toward which the arrow points shall be considered the *arrow side member*. The other joint shall be considered the *other side member*. 
AWS SYMBOLS
Welding
Plug, Slot, Spot, Projection, and Seam Weld

<table>
<thead>
<tr>
<th>PLUG OR SLOT</th>
<th>STUD</th>
<th>SPOT OR PROJECTION</th>
<th>SEAM</th>
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Plug Weld Symbols

(A) WELD SIZE

WELD CROSS SECTION
Plug Weld Symbols

Slot Weld Symbols
Slot Weld Symbols

[Diagram of slot weld symbols]

Spot Weld Symbols

[Diagram of spot weld symbols]
Spot Weld Symbols

Projection Weld Symbols
Seam Weld Symbols

(A) ARROW-SIDE SEAM WELD SYMBOL

Seam Weld Symbols

(A) SIZE, LENGTH AND PITCH OF INTERMITTENT SEAM WELDS
AWS SYMBOLS
Welding

- Supplementary Symbols- Symbols used in connection with the welding symbol to annotate additional requirements.
  - Contour
  - Field Weld
  - Weld All-Around
  - Backing
  - Consumable Insert
  - Melt Through

[Diagram of supplementary symbols]
AWS SYMBOLS
Welding

• Alternatively, welding information may be conveyed by other means such as by drawing notes or details, specifications, standards, codes or other drawings which eliminates the need to include the corresponding elements in the welding symbol.

AWS SYMBOLS
Welding

• Symmetrical Weld Symbols- If the weld symbols used, on both sides of the reference line, have axes of symmetry that are perpendicular, or normal, to the reference line, then these axes of the symbols shall be directly aligned across the reference line. Staggered intermittent welds are an exception.
Symmetrical Weld Symbols

AWS SYMBOLS
Welding

• Nonsymmetrical Weld Symbols- If either of the weld symbols used lacks an axis of symmetry perpendicular, or normal, to the reference line, then the left sides of the weld symbol shall be directly aligned across the reference line. Staggered intermittent welds are an exception.
Nonsymmetrical Weld Symbols

AWS SYMBOLS
Welding

- Orientation of Specific Weld Symbols-
  Fillet, bevel-groove, J-groove, and flare-
  bevel-groove weld symbols shall be drawn
  with the perpendicular leg always to the
  left.

- Combined Weld Symbols- For joints
  requiring more than one weld type, a
  symbol shall be used to specify each weld.
Orientation of Specific Weld Symbols

Combined Weld Symbols
AWS SYMBOLS
Welding

• Break in Arrow- When only one joint member is to have a bevel, or J-groove, the arrow shall have a break, and point toward that member. The arrow need not be broken if it is obvious which member is to have a bevel or J-groove. It shall not be broken if there is no preference as to which member is to have a bevel or J-groove.

Break in Arrow
AWS SYMBOLS

Welding

• Multiple Arrow Lines - Two or more arrows may be used with a single reference line to point to locations where identical welds are specified.

• Sequence of Operations - Two or more reference lines may be used to indicate a sequence of operations. The first operation is specified on the reference line nearest the arrow.

• Multiple Arrow Lines

• Sequence of Operations
AWS SYMBOLS
Welding

• Supplementary Data- The tail of additional reference lines may be used to specify data supplementary to welding symbol information.

• Field Weld Symbol- Welds not made in a shop or at the place of initial construction shall be specified by adding the field weld symbol. The flag shall be placed at a right angle to, and on either side of, the reference line at the junction with the arrow.
AWS SYMBOLS
Welding

• Weld All-Around Symbol- The weld all-around symbol shall be placed at the junction of the arrow and reference line for each operation to which it applies. The field weld symbol may also be applied to the same location.

Weld All-Around Symbol
AWS SYMBOLS
Welding

• Tail of the Welding Symbol- May specify different requirements including but not limited to:
  – Process of weld (SMAW, GTAW, GMAW)
  – References (specifications or codes)
  – Repetitions of identical welding symbols on a drawing (TYP- 5 Places)
  – Special types of welds (Seal, stud)

Tail of the Welding Symbol

![Diagram of Welding Symbols]

GTAW- AU
A-2
TYP- 5 PLACES
DET A
SK NO 52
AWS SYMBOLS
Welding

• Contours Obtained by Finishing- Welds to be mechanically finished approximately flush, flat, convex, or concave shall be specified by adding the appropriate contour symbol and the finishing symbol.

• Finishing Methods- Chipping (C), Grinding (G), Hammering (H), Machining (M), and Rolling (R).

Contours Obtained by Finishing

C = CHIPPING
G = GRINDING
H = HAMMERING
M = MACHINING
R = ROLLING
AWS SYMBOLS
NDT

• Examination Symbol- consists of the following elements
  – Reference line
  – Arrow
  – Examination method letter designation
  – Extent and number of examinations
  – Supplementary symbols
  – Tail (specifications, codes, or other references)

Examination Symbol
AWS SYMBOLS
NDT

• Examination Method Letter Designation- Nondestructive examination methods shall be specified by use of the letter designations below:
  – Acoustic emission AET
  – Electromagnetic ET
  – Leak LT
  – Magnetic particle MT
  – Neutron radiographic NRT
  – Penetrant PT
  – Proof PRT
  – Radiographic RT
  – Ultrasonic UT
  – Visual VT

AWS SYMBOLS
NDT

• Location Significance of Arrow, Location on Arrow Side, Location on Other Side, and Location on Both Sides- is the same as for the weld symbol discussed earlier in this course.
• Location Centered on Reference Line- When there is no preference from which side the examination is to be made, the letter designation shall be centered on the reference line.
• Examination Combinations- Letter designations for two or more examination methods, to be placed on the same side of the reference line or centered on the reference line, shall be separated by a plus (+) sign.
• Welding and NDE (NDT) Symbols- Nondestructive examination symbols and welding symbols may be combined.
• Length Shown- To specify examination of welds or parts where only the length of a section need be considered, the length dimension shall be placed to the right of the letter designation.

• Location Shown- To specify the exact location of a section to be examined, as well as the length, dimension lines shall be used.
Partial Examination - When less than one hundred percent of the length of a weld or part is to be examined, with locations determined by a specified procedure, the length to be examined is specified by placing the appropriate percentage to the right of the letter designation. The selected procedure may be specified by reference in the tail of the nondestructive examination symbol.
AWS SYMBOLS
NDT

• Number of Examinations- To specify a number of examinations to be conducted on a joint or part at random locations, the number of required examinations shall be placed in parentheses either above or below the letter designation away from the reference line.
AWS Symbols Review

• Welding Symbol
• Weld Symbols
• NDT Symbols

JOINT DESIGNS

• Enabling Objectives
  – Upon successful completion of this topic the student will be able to identify the different types of joint designs.
  – Upon successful completion of this topic the student will be able to identify the different types of welds.
Joint Designs

• Number of sides welded
  – One side welded- 1
  – Two sides welded- 2

• Types of Configuration Joints
  – Square groove- S
  – Bevel or V-groove- V
  – U-groove- U
  – J-groove- J

Joint Designs

• B2U.1- Butt joint welded both sides with a U-groove.
• C1S.2- Corner joint welded one side with a square configuration.
• E1V.1- Edge joint welded one side with a bevel or V-groove.
Joint Designs

• L2S.1- Lap joint welded both sides square configuration.
• PT2J.1- Partial Penetration joint welded both sides with a J-groove.
• T1J.1- T-joint welded one side with a J-groove.

Joint Designs

• Types of Joints
  – Butt- between two members aligned approximately in the same plane.
  – Corner- between two members located approximately at right angles to each other in the form of an L.
  – Edge- between the edges of two or more parallel or nearly parallel members
Joint Designs

• Butt Joint
  – Plate
  – Pipe

Joint Designs

• Corner Joint
Joint Designs

• Edge Joint

Joint Designs

• Types of Joints
  – Lap- between two overlapping members in parallel planes.
  – Partial Penetration- between two members where complete penetration is not required.
  – T- between two members located approximately at right angles to each other in the form of a T.
Joint Designs

• Lap Joint

**NOTE:** Size of fillet shall be as governed by design requirements.

Joint Designs

• Partial Penetration Joint
Joint Designs

• T-Joint

![T-Joint Diagram](image1)

Joint Designs

• Pipe/Penetration Joint

![Pipe/Penetration Joint Diagram](image2)
Joint Designs

• Socket Joint

Joint Designs

• Branch Connection
Joint Designs

- Branch Connection with Pilot

Joint Designs

- Consumable Insert
Joint Designs

• Backing Ring

Joint Designs

• Types of Welds
  – Butt Weld- when welding plate or pipe with a butt joint and in a manner that the welding joining the parts is between the surface planes of both pieces.
Joint Designs

• Types of Welds
  – Seam Weld- welding a lengthwise seam in sheet metal either by abutting or overlapping joints.

Joint Designs

• Types of Welds
  – Fillet Weld- a weld of approximately cross section, joining two surfaces at approximately right angles to each other.
Joint Designs

• Types of Welds
  – Plug Weld- a weld made in a hole of one member. The hole maybe partially or completely filled with weld metal.

Joint Designs

• Types of Welds
  – Slot Weld- a weld made in an elongated hole in one member of a lap or tee joint. The hole may be opened at one end and it may be partially or completely filled with weld metal.
Joint Designs

• Types of Welds
  – Seal Weld- a weld used primarily to obtain and to prevent leakage.

Joint Designs

ABS

• Hull Constructions
  – Part 2 Chapter 4 Section 1
  – The welding process, filler metal and joint design are to be shown on the detail drawings or in separate specifications submitted for approval which should distinguish between manual and automatic welding. The shipbuilders are to prepare and file with the Surveyor a planned procedure to be followed in the erection and welding of the important structural members.
Joint Designs
ABS

• **Full Penetration Butt Joints**
  – Part 2 Chapter 4 Section 1 Hull Construction (SMAW, GMAW, FCAW)
  – ¼” and less not beveling required
  – Above ¼” appropriate edge preparation, root opening, and root face (land) to provide welding from one side or both sides.
  – Welds made from both sides will have the root of the first side welded removed to sound metal.

Joint Designs
ABS

• **Full Penetration Butt Joints**
  – Part 2 Chapter 4 Section 4 Piping
  – Full penetration butt joints for pipes are to have welds deposited on properly prepared single vee, double vee or other suitable types of grooves, with or without backing rings.
  – The edge preparation and fit-up tolerances are to be as indicated in 2-4-4/5.1.2 and 2-4-4/5.1.3.
Joint Designs
ABS

• Full Penetration Butt Joints
  – Part 2 Chapter 4 Section 4   2-4-4/5.1.2
  – Dimensions of the edge-preparation are to be in accordance with recognized standards or that used in the welding procedure qualified by the responsible fabricator. The preparation of the edges shall preferably be carried out by mechanical means. When flame cutting is used, care should be taken to remove the oxide scales and any notch due to irregular cutting by matching grinding or chipping back to sound metal.

Joint Designs
ABS

• Full Penetration Butt Joints
  – Part 2 Chapter 4 Section 4   2-4-4/5.1.3
  – For pipes to be butt-welded, the alignment of the pipes at the prepared edge is to be within the following maximum offsets:
    • i) Pipes of all diameters and thickness welded with permanently fitted backing ring: 0.5 mm (0.02 in.).
Joint Designs
ABS

• **Full Penetration Butt Joints**
  – Part 2 Chapter 4 Section 4  2-4-4/5.1.3
  – For pipes to be butt-welded, the alignment of the pipes at the prepared edge is to be within the following maximum offsets:
    • Pipes welded without fitted backing ring:

<table>
<thead>
<tr>
<th>Nominal pipe size, ( d )</th>
<th>Pipe wall thickness, ( t )</th>
<th>Alignment tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>( d \leq 150 \text{ mm } (6 \text{ in.}) ) or ( t \leq 6.0 \text{ mm } (0.24 \text{ in.}) )</td>
<td></td>
<td>lesser of 1.0 mm (0.04 in.) or ( d/4 )</td>
</tr>
<tr>
<td>( 150 \text{ mm } (6 \text{ in.}) &lt; d \leq 300 \text{ mm } (12 \text{ in.}) ) or ( 6.0 \text{ mm } (0.24 \text{ in.}) &lt; t \leq 9.5 \text{ mm } (0.37 \text{ in.}) )</td>
<td></td>
<td>lesser of 1.5 mm (0.06 in.) or ( d/4 )</td>
</tr>
<tr>
<td>( d &gt; 300 \text{ mm } (12 \text{ in.}) ) or ( t &gt; 9.5 \text{ mm } (0.37 \text{ in.}) )</td>
<td></td>
<td>lesser of 2.0 mm (0.08 in.) or ( d/4 )</td>
</tr>
</tbody>
</table>

Joint Designs
ABS

• **Fillet Welded Joints**
  – Part 2 Chapter 4 Section 4
  – Socket welded joints employing sockets complying with recognized standards are to be welded to the pipe by single fillet weld with leg size not less than 1.1 times the nominal thickness of the pipe.
  – See also 4-6-2/5.5.2 (SVR) for limitation of its use and 4-6-2/Figure 1 (SVR) for fit up details.
Joint Designs
ABS

• Slip On Welded Sleeve Joints
  – Part 2 Chapter 4 Section 4
  – Sleeves meeting dimensional and fit-up requirements in 4-6-2/5.5.3 (SVR) and 4-6-2/Figure 1 (SVR) may be used for joining pipes with limitations as indicated therein.

Joint Designs
Review

• Types of Joints
• Types of Configurations
• Welded Sides
• Different Joint Designs
• MIL STD/ABS
Course Review

- Basic Welding Terms (general)
- Basic Welding Terms (defects)
- AWS Welding/NDT Symbols
- Joint Designs
MARITIME WELDER
WORKMANSHIP SPECIFICATIONS

PURPOSE

To ensure each student understands the workmanship requirements in accordance with the appropriate specifications.
AGENDA

- Qualification Requirements IAW NAVSEA S9074-AQ-GIB-010/248
- Workmanship Requirements IAW MIL STD 1689A
- Visual Requirements IAW NAVSEA S9074-AR-GIB-010/278
- Workmanship Requirements IAW NAVSEA T9074-AD-GIB-010/1688
- Visual Acceptance Requirements IAW MIL STD 2035A
- Summary

OBJECTIVES

- Each student will understand the qualification requirements in accordance with NAVSEA S9074-AQ-GIB-010/248.
- Each student will understand the visual and workmanship requirements in accordance with the MIL STD 1689A, NAVSEA S9074-AR-GIB-010/278, NAVSEA T9074-AD-GIB-010/1688, and MIL STD 2035A.
Qualification Requirements IAW
NAVSEA S9074-AQ-GIB-010/248

Welder Qualification Verification:

- Base Material
- Filler Material
- Thickness Range
- Qualification Expiration Date
- Eye Exam Expiration Date
- 3 Yr Re-test Expiration Date

MIL STD 1689A FABRICATION, WELDING & INSPECTION OF SHIPS STRUCTURES

- Workmanship Inspection (Take PRIDE in your work)
- NDT Visual Inspection-all completed welds.
  - Size adequacy
  - Surface uniformity
  - Surface cleanliness
  - Contour re-entrant angle
  - Contour grinding
  - Weld face plus ½” of adjacent base mat.
MIL STD 1689A FABRICATION, WELDING & INSPECTION OF SHIPS STRUCTURES

VT inspected IAW section 7
- Welds-after slag removal, final surface condition.
- Base metal-clean and free of scale.

Acceptance IAW Section 8
- Free of slag, paint, cracks, and weld spatter greater than 1/8”.
- Seal-off and wrap around-closed loop where surfaces are to be wetted, where practical if not to be wetted.

Visual Workmanship Requirements IAW MIL STD 1689A

Weld Joint Design- Correct joint design used, joint preparation is IAW joint design.
Verify base materials with ships prints or drawings prior to welding.
Ensure you have the proper filler material.
Weld Joint Preparation- Plate edges prepared by machining, grinding or burring, chipping, oxyfuel gas cutting, carbon arc-air gouging, plasma arc cutting or automatic oxyfuel gouging.
Visual Workmanship Requirements IAW MIL STD 1689A

- **Weld Joint Surface Preparation**: Surfaces to be welded and adjacent material for a distance of approximately ½” from weld area shall be clean, dry and free of surface matter or defects such as paint, oil, grease, moisture, scale, oxide or rust, and objectionable nicks, gouges and irregularities, to an extent that weld soundness will not be detrimentally affected.

- **Aluminum alloys**: Surfaces shall be free of oil, grease and markings. Oxide film shall be removed from joint within ½” of weld joint. Welding shall take place within 16 hours of removal of oxide.

- **Weld contour and cleaning**: Mechanical means shall be used in lieu of welding to reduce surface irregularity to an acceptable contour, where possible.

- **Weld edges**: Those undercut in excess of acceptance standards shall be repaired by grinding or welding.

- **Aluminum butt welds**: Shall not have undercut at the toes of the weld.
Visual Workmanship Requirements IAW MIL STD 1689A

- **Material Surface Correction-** Grinding shall produce a smooth depression blended into the surrounding surfaces. In no case shall such grinding exceed a depth of 1/32” for primary hull structures and 1/16” for other structures without weld repair.
- **Exceeded Depth Correction-** Weld bead or beads in undercut or ground area and fair in.
- **Weld Spatter-** Greater than 1/8” shall be removed.
- **Exceed Depth of Weld Attachment Area-** Shall be repaired by welding. Repairs shall be ground flush on exterior hull surfaces and on un-insulated interior living space surfaces.

Visual Workmanship Requirements IAW MIL STD 1689A

- **Removal of Welded Attachments Other than HY-80/100-** Removed by chipping, oxyfuel gas cutting, gouging, and grinding. Surface defects shall be faired out by grinding but not to exceed 1/32” for primary hull structures or 1/16” for other structures.
- **Removal of Welded Attachments for HY-80/100-** Removed a minimum of 1/16” away from the permanent member to which they are attached by chipping, carbon arc-gouging, or oxyfuel cutting, followed by grinding or chipping to restore the plate surface. Surface defects shall be fared out not to exceed 1/32” for primary hull structures or 1/16” for other surfaces.
Visual Workmanship Requirements IAW MIL STD 1689A

- Flame or arc cut surfaces shall be in accordance with NAVSEA 0900-LP-999-9000.
- Use of torch heating- for HY80, HY100 and high hardenable material should be confined to tack or temporary welding or to those applications involving welding within a localized area.
- Zinc coatings- 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 ½” from the edges of finished welds in these cases:
  - Connections of main transverse watertight bulkheads to shell.

Visual Workmanship Requirements IAW MIL STD 1689A

- Zinc coatings-
  - Main condenser induction and induction sea chests and their connections to the hull.
  - Connections of main propulsion machinery foundations to shell or innerbottom plating.
  - Deck seamanship installations and fittings.
  - Weight handling equipment.
  - Attachments to armor, stainless steel, HY80/100, HSLA 80, high hardenable materials or nonferrous metals except copper-zinc alloys.
- Zinc coating removal- may be accomplished by blasting, grinding, chemicals, or localized heating with subsequent removal of molten zinc by wire brushing.
Visual Workmanship Requirements IAW MIL STD 1689A

- Zinc coating removal- localized heating technique shall not be used for removing zinc coatings from HY80/100, HSLA80, STS, or similar analysis.
- Fillet welds- when the opening between elements of a fillet welded joint exceeds 1/16” but not more than 3/16” as a nominal condition along the joint, fillet size shall be increased by an amount equal to the excess of the opening above 1/16”. If gap exceeds 3/16” procedures are subjected to approval.
- Peening- shall be done with power-driven equipment with round or blunt nosed tools of circular or oblong cross section. Peening of root layer is prohibited.

Visual Workmanship Requirements IAW MIL STD 1689A

- Peening- 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 material or unfused areas in the weld. Last lay shall be ground to remove evidence of peening.
- Plate edge laminations- shall be VT inspected to determine extent of lamination. Rejectable laminations shall be excavated to a depth of approximately 3/8” or 1/2” material thickness, whichever is less, from the plate edge and welded over.
Visual Workmanship Requirements IAW MIL STD 1689A

- Fillet welds on primer coated surfaces- shall not exhibit porosity or wormholes in excess of the following:
  - Single-pass- one indication 1/32” or greater in any 6” length exclusive of weld crater porosity
  - Multipass-Class 1 Figure 4 medium, shall apply for gouged surfaces. If VT inspection of the first pass deposited is performed in lieu of gouging, the acceptance standard for the first pass shall be as defined above.

NAVSEA S9074-AR-GIB-010/278 MACHINERY, PIPING AND PRESSURE VESSELS

- P-1- exceeds 300lb/in² or 650°F or both.
- P-2- not exceeding 300lb/in² or 650°F.
- P-LT- greater 50lb/in² and 20°F and below.
- P-3- all brazed piping of unlimited pressures and 425°F maximum design temperature.
- M-1- moving parts such as gears, rotors or impellers.
- M-2- stationary non-pressurized assemblies or structures such as sub-bases for engines or turbines.
- Class A- pressure vessels.
- Class T- turbine components or parts.
Visual Workmanship Requirements
IAW NAVSEA S9074-AR-GIB-010/278

- Cleaning prior to and during welding - Minimum 1 inch from weld edge, free of mill scale, metallic oxides, and slag.
- Peening is authorized to help control distortions, relieve stresses or to improve weld quality. All evidence of peening or smeared metal shall be removed.
- Butt welds - Complete penetration for full length when required. Undercutting, overlapping, and sharp-ridged or deep-valleyed surface conditions shall be avoided. Reinforcement need not be removed except to meet weld specifications.

- Butt welds - Doubled side welded joints shall have the back side prepared for welding by chipping, grinding, machining, or arc-air gouging to remove all unsound weld metal (back gouge).
- Alignment of joint members - Joints shall be fitted and aligned in position. Tack welds may be used. Tack welds shall be removed by suitable methods unless they are made using approved welding procedures.
- Weld defects - shall be removed and repaired only to the extent necessary to render the area acceptable.
Visual Workmanship Requirements
IAW NAVSEA S9074-AR-GIB-010/278

- Excavations- Shall blend smoothly and gradually with the adjacent weld metal or base material, if repair welding is not required.
- Excavations- Shall be MT/PT examined or VT 5X prior to repair welding, if MT/PT is required for class of welding.
- Marking- Vibro-etched or electro-etched joints for identification and establishing responsibilities for workmanship and quality of welding. Shall not interfere with material thickness requirements.

Defect Removal- Grinding, machining or filing with clean tools.

Arc strike and removal sites of welded attachments- Shall be ground to fair smoothly into base material surfaces.

Tack welds- tack welds to be incorporated in to the final weld shall be visually examined and defects, such as cracks, excessive undercut, entrapped slag, and excessive surface roughness, shall be corrected to the extent necessary to assure that final weld quality requirements will be met.
Visual Workmanship Requirements IAW NAVSEA S9074-AR-GIB-010/278

- Tack welds— all cracks shall be removed except cracked or broken tack welds need not be removed provided:
  - Made by the GTA process
  - Will not permit movement of joint components which causes the joint to exceed fit-up requirements
  - Will be completely re-melted in deposition of the first layer
  - First layer is made with the GTA process

- Inspection requirements— use TABLE VIII for Machinery, TABLE IX for Piping, and TABLE X for Pressure Vessels

Visual Workmanship Requirements IAW NAVSEA T9074-AD-GIB-010/1688

- Weld Joint Surface Preparation—Surfaces to be welded and adjacent material for a distance of approximately ½” from weld area shall be clean, dry and free of surface matter or defects such as paint, oil, grease, moisture, scale, oxide or rust, objectionable nicks, gouges and irregularities, Zinc, galvanizing or thermal spray aluminum, and excess slag.
Visual Workmanship Requirements IAW NAVSEA T9074-AD-GIB-010/1688

- Aluminum alloys- Surfaces shall be free of oil, grease and markings. Oxide film shall be removed from joint within ½” of weld joint. Welding shall take place within 16 hours of removal of oxide.
- Zinc coating removal- may be accomplished by blasting, grinding, chemicals, or localized heating with subsequent removal of molten zinc by wire brushing.
- Zinc coating removal- localized heating technique shall not be used for removing zinc coatings from HY80/100, or HSLA80.

- Flame or arc cut surfaces shall be in accordance with AWS C4.1, unless otherwise specified surface finish shall meet the acceptance of sample 2 or better.
- Weld Spatter- Greater than 1/8” shall be removed.
- Peening- When required by specification or procedure the method describe in section 14.5.1 shall be used.
Removal of welds and welded attachments—For HY or HSLA members, removed at least 1/16” away from the member by chipping, air carbon arc gouging, or oxy-fuel cutting, followed by grinding.

Removal of austenitic or nonferrous weld attachment sites—From pressure hull structure complete removal shall be verified with an etchant that has been demonstrated to distinguish materials.

Removal of austenitic or nonferrous weld attachment sites—From non-pressure hull structure complete removal shall be verified with an etchant that has been demonstrated to distinguish materials only when it is necessary to make ferritic welds over these areas.

Material identification—materials to be welded shall be positively identified.
Visual Workmanship Requirements IAW NAVSEA T9074-AD-GIB-010/1688

- **Weld Joint Design**: Correct joint design used, joint preparation is IAW joint design.
- **Verify base materials**: With ships prints or drawings prior to welding.
- **Ensure proper filler material**:
- **Weld Joint Preparation**: Plate edges prepared by machining, grinding or burring, chipping, oxyfuel gas cutting, carbon arc-air gouging, plasma arc cutting or automatic oxyfuel gouging.

- **Hand-held torch heating**: For HY and HSLA material shall be confined to tack or temporary welding operations or to those applications involving welding within a localized area.
- **All completed welds**: Shall be VT inspected to ensure completeness and compliance with detailed working drawings and section 7.
Visual Workmanship Requirements IAW NAVSEA T9074-AD-GIB-010/1688

Completed welds shall meet class 2 requirements of MIL STD 2035 with exceptions listed in section 7.4.

Visual Requirements IAW MIL STD 2035A

Welds- Any grinding or other mechanical operation performed on welds shall be performed so that the thickness of the weld and its adjacent base metal are not reduced below the minimum design thickness or the minimum drawing thickness, whichever is greater.

Undercut- Class 1- The maximum depth from the unground adjacent base metal surface shall not exceed 1/64” or 10% of the minimum thickness, whichever is less.

Undercut- Class 2&3- The maximum shall be 1/32” or 10% of the minimum thickness, whichever is less.
Visual Requirements IAW MIL STD 2035A

Gouges, grind marks and surface roughness—localized discontinuities within the allowances specified below are acceptable provided that minimum thickness requirements are met, and the bottom of the depression is visible and rounded or free of notches. The length of the discontinuity shall be limited to 12” maximum except for piping and pressure vessels where the maximum length shall be 12” or ¼ of the circumference, whichever is less.

Visual Requirements IAW MIL STD 2035A

Shape of weld face- Shall be free of sharp irregularities between weld beads and shall blend smoothly and gradually into the base metal at the weld edges without exceeding the undercut or re-entrant angle limits of this specification.

Fillet weld size (piping only)- Shall be not less than Tx1-3/4T unless otherwise specified by drawing.

Fillet weld size (other than piping)- Shall not be less than drawing specified size.

Free of cracks, burn through, and incomplete fusion.
SUMMARY

- Welder qualifications
  NAVSEA S9074-AQ-GIB-010/248
- Structural workmanship visual inspection requirements MIL STD 1689A
- Piping workmanship visual inspection requirements
  NAVSEA S9074-AR-GIB-010/278
- Weld visual acceptance requirements MIL STD 2035A