Concepts of Welding & Hot Cutting

Objective

At the end trainees will be able to

- Explain meaning of 5 weld related terms
- Explain role of welding parameters
- Read any welding drawing
- Use proper welding aids
- Avoid unsafe practices

Introduction

- Widely used metal forming in Rlys.
- Unlike Casting, we can have
  - Dissimilar metals
  - Sharp changes in section thickness
  - Structure with very thin sheets
- Much less infrastructural requirement
- No major problem with design change
- Much more in –situ

Limitations

- Least technical knowledge in Rlys.
- Formation of Heat Affected Zone (HAZ)
  - Susceptible to Property alteration
  - Prone to failure
- Distortion and Warping, to control needs
  - Weld sequencing
  - Use of fixtures & clamping
- Residual stress
  - Needs destressing in complicated welding
- Hazard of Shock, Fire, Toxicity Etc.

Basic Concepts

Glossary of terms

- Parent/Base Metal → Metals being welded
- Filler Metal → Metal to fill up gap at edge
- Weld Pool → A Liq. Pool of Filler metal & Parent metal in ≈7:3 ratio at edge
- HAZ → Area adjacent to welding interface where metal properties have changed due to application of heat
- Shielding→ Protecting liq./hot metal from oxidation during welding

Concepts of Consumables

- Bare wire → A solid wire, coated/uncoated to provide filler metal at weld interface
- Fluxes → A mixture of different minerals, organics, metals etc. to provide shielding, alloying etc. - Fused or Agglomerated
- Shield gas → Separate Gas for shielding
- Electrode → Filler wire & flux integrated
- Flux Cored wire → Tubular filler wire filled with granular flux

Welding Defects

- Due to wrong selection of welding process & parameters, defects can occur, namely
- Cracks, both Immediate & Delayed
- Undercut
- Lack of penetration
- Lack of Fusion
- Slag inclusion
- Blow holes & porosity

Weldabilty

- No crack during welding or in service
- Factors affecting weldability
  - Base & weld metal composition
  - Base metal thickness
  - Welding Process & procedure
- $CE = C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15$

WELDING EQUIPMENT & PARAMETERS

Welding Equipments

- Transformers (AC), Rectifiers(DC),
- Static Characteristics – CC or CV
  - Transformer – only CC type
  - Rectifier – Both CC, CV or dual
- For Manual welding CC is preferred
- For Auto or Semi-auto CV can be used
- Rectifier control can be Diode, Thyristor or Transistor based

Modern Welding Equipments

- IGBT Type pulse-synchronised
  - Inverted Gate Bi-polar Transistor
  - Pulse type square wave form synchronised with metal transfer
- Programmable – Multi programme storage
  - Input→ Metal type & thickness, wire type & dia and Shield Gas
  - Auto-set→ Current, Voltage, Travel speed, gas flow rate etc.

Transformer Vs. Rectifier

Transformer (AC)

- No choice in polarity
- Not suitable for basic coated and some non-ferrous electrode
- Suitable where arc blow is problem
- Suitable where distance between power source & job is high

Rectifier (DC)

- Choice of polarity
- Arc stability better
- Shorter arc possible
- Better for positional welding
- Suitable for all types of electrodes
- More control over parameters

Welding Parameters

- Major parameters are
  - Welding Voltage (V)
  - Welding current (I)
  - Polarity
  - Traverse speed & Wire feed rate
  - Weaving of bead & Arc length
- In manual welding, left with welder
- In automatic welding, pre set
- Together, they are responsible for defects

Parameters – V & I

- OCV between 40-90 Volts
- In CC, OCV imp. for starting arc & stability
  - Recommended Voltage through coding
- I as per dia & type of electrode/wire
  - Recommended current given on packet
  - Thumb rule - 35/25 times for MS/SS wire dia
- Together they decide heat input and Metal Deposition Rate (MDR)

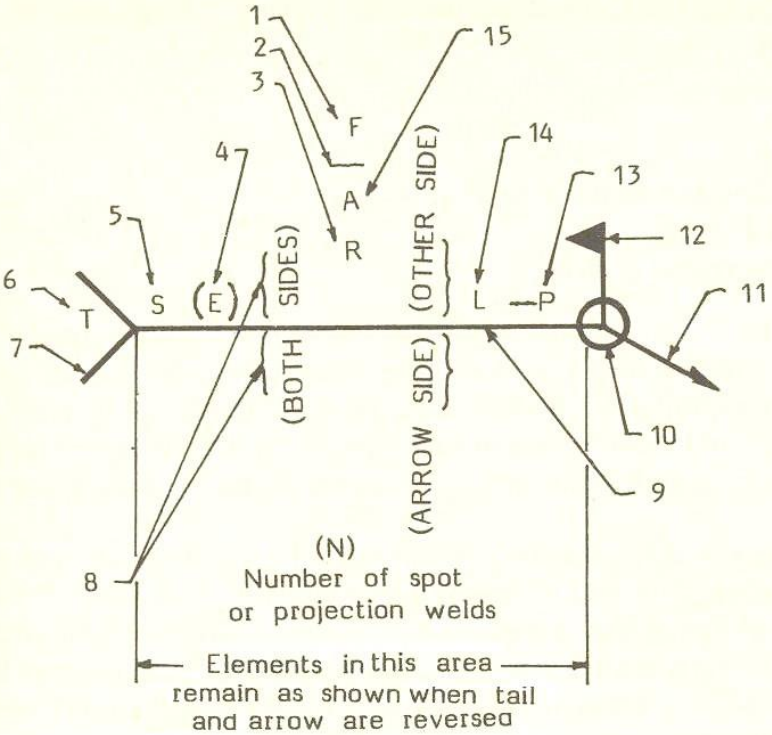
Polarity

- In rectifier we have choice of polarity
  - Straight polarity or Electrode negative (DCEN)
  - Reverse polarity or Electrode positive (DCEP)
- For consumable electrode processes, more heat in electrode when DCEN
- For non- consumable electrode processes, more heat in electrode when DCEP

Other parameters

- Traverse speed→ Speed at which electrode is moving over job
  - Directly related to heat input rate
- Wire feed rate→ Rate at which consumable is fed from the wire spool
  - Directly related to MDR
- Weaving→ Movement of electrode perpendicular to weld line
- Arc length→ Gap of electrode tip & job

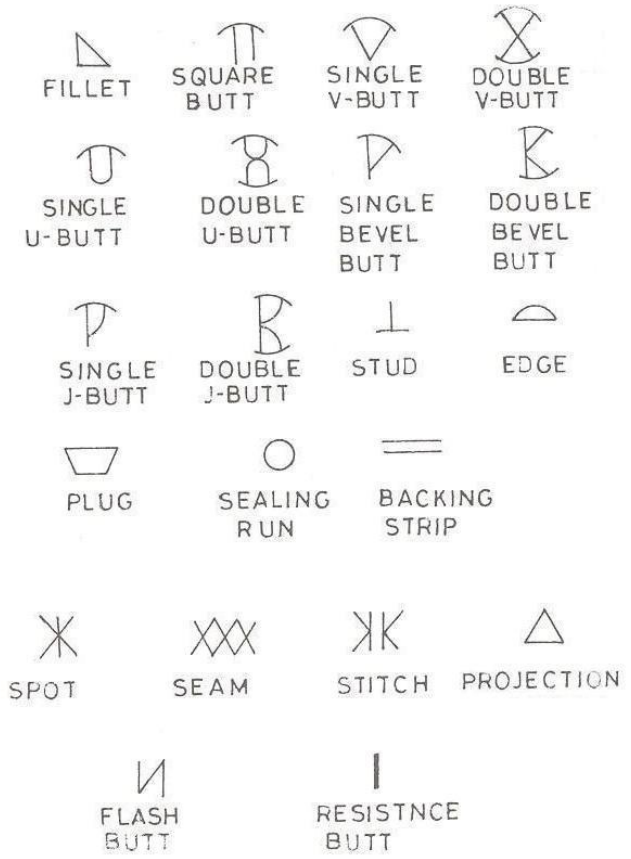
Complete Welding Symbol



1 Finish symbol
2 Contour symbol
3 Root opening; depth of filling for plug and slot welds
4 Effective throat
5 Depth of preparation; size or strength for certain welds
6 Specification, process, or other reference
7 Tail (Tail omitted when reference is not used)
8 Basic weld symbol or detail reference
9 Reference line
10 Weld-all-around symbo
11 Arrow connecting reference line to arrow side member of joint
12 Field weld symbol
13 Pitch (centre-to-centre spacing) of welds
14 Length of weld
15 Groove angle; included angle of countersink for plug welds

Standard location of elements of a welding symbol

Basic Welding Symbols



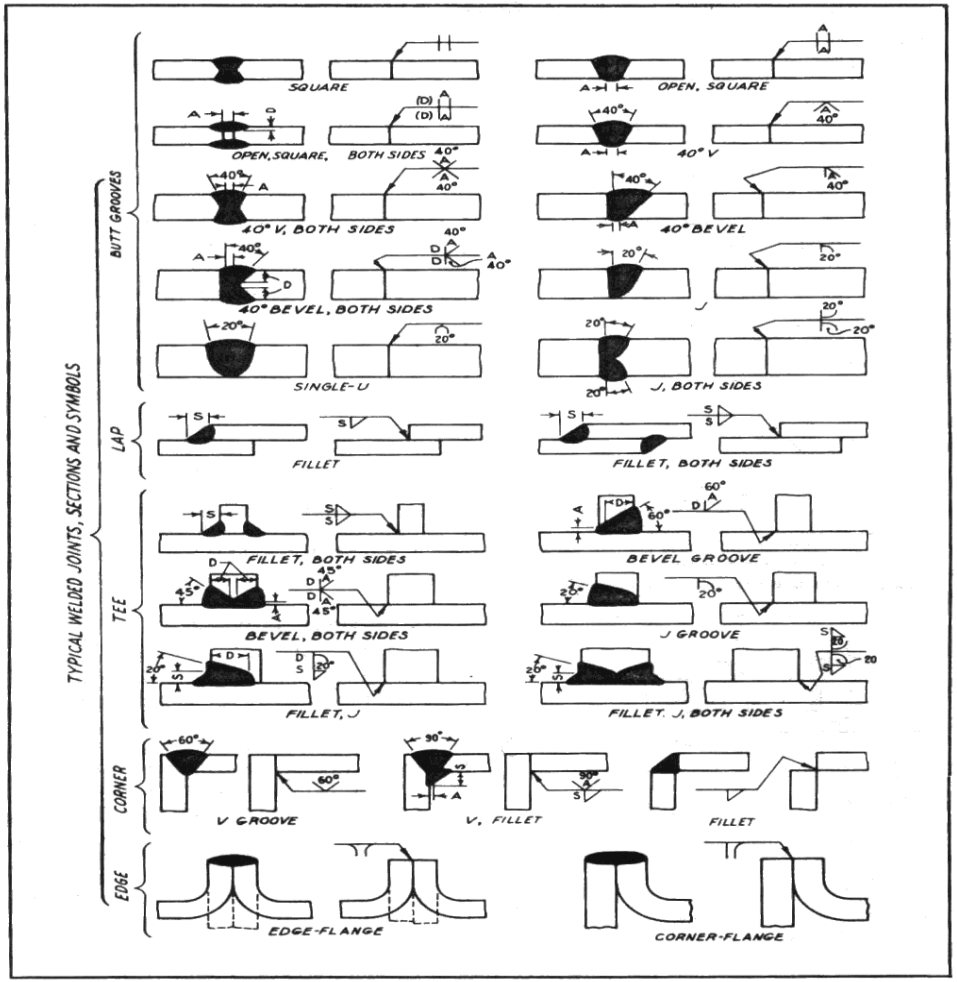
Basic Symbols.

SYMBOL	DRAWING REPRESENTATION	
○		WELD ALL-ROUND
A	A	SITE WELD (ASSEMBLY WELD)
E	E	SITE WELD (ERECTION WELD)
⌒		CONCAVE CONTOUR
—		FLUSH CONTOUR
⌓		CONVEX CONTOUR
M	M	MACHINING FINISH
C	C	CHIPPING FINISH
G	G	GRINDING FINISH

Supplementary symbols.

Type of Joints & Edge preparation

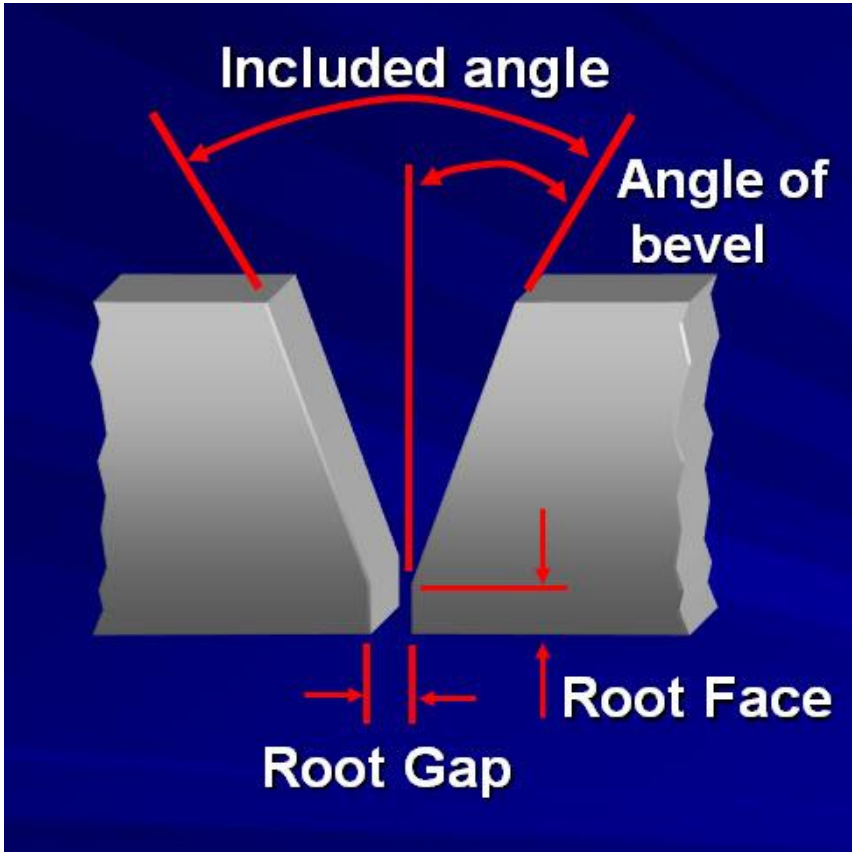
- Butt
  - Square
  - Single or Double V
  - Single or Double U
  - Single or Double J
- Lap
- Fillet; Single/double
- Corner
- Edge



Classification of welded joints.

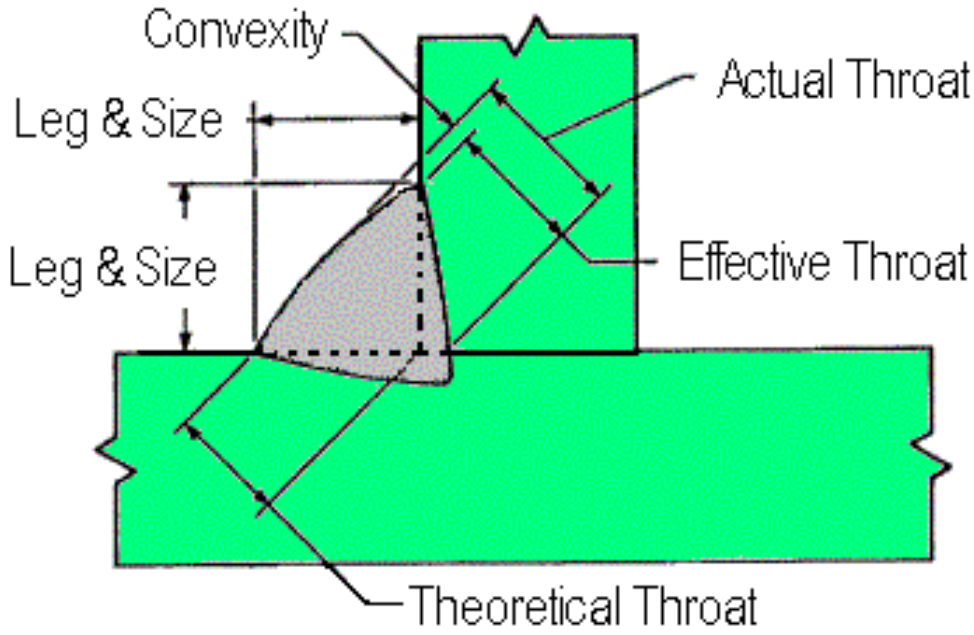
Nomenclature – Butt

- **Root Face**
- **Root gap**
- **Included Angle**
- **Angle of Bevel**
- **Weld reinforcement**



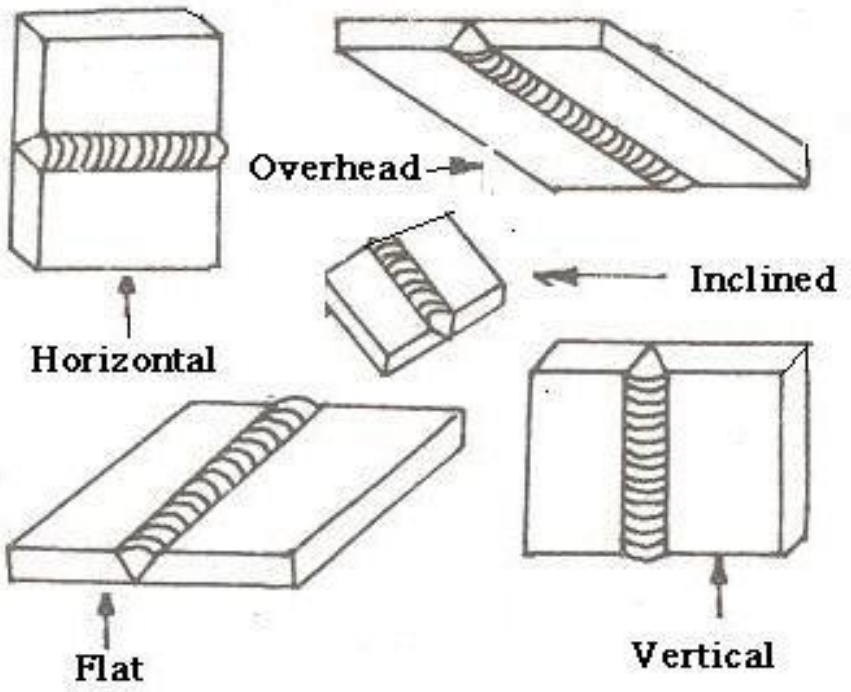
Nomenclature – Fillet

- Leg
- Actual Throat
- Effective throat
- Concave/Convex
- Root



Welding Positions

- Flat/Downhand
- Horizontal
- Vertical up/down
- Overhead
- Combinations of above



Welding positions.

WELDING AIDS & SAFETY

Welding Aids

- Improves quality and aesthetics of weld
  - Applicable to semi –automatic welding
- Clamping device for trough floor welding
  - Simultaneous clamping & welding
- Vertical weld guide
  - Applicable for welding MS & Ferritic SS
  - Guide rail clings on vertical wall
  - Weld head moves over guide rail
- Similar for inside welding of BOX section

Welding Aid Photos

Clamping Machine

Vertical welding Machine

Welding Quality Photos

V. Welding w/o aid

V. Welding with aid

Welding Automation

- Costly but cost-effective in long run
- Robot welding (fully automatic), no welder
  - Complex contour welding
  - Difficult to access locations
- Semi–automatic (MIG/MAG, SAW)
  - Straight long welds
  - Less welder fatigue, defects & rework
  - Less dependence on welder’s skill

Hazards in Welding & Cutting

- Explosion, Fire, Shock
  - Leaking gas pipe, Back fire, Damaged cable, Short circuit, Welding very close to oil/grease, closed vessel with inflammable liq./gas etc.
- Eye injury – Ray, Spatter, Metal particle
  - Use safety glass of proper DIN, Welding type specific & Photochromatic
- Body burn – Liquid metal, Spatter etc.
  - Use proper PPEs like Helmet, Gloves, Aprons, Leather sole shoes etc.

Pulmonary Hazards

- Welding Gasses
  - C_2H_2/LPG/CO_2/Ar – Reduces available O_2
- Welding Fumes
  - CO – Positively injurious & lethal
  - Metal oxide dust – Destroys cilias
  - Some metals & oxides are toxic
- Always weld in well ventilated space
- When welding inside tank etc., use either
  - Mobile fume extractor or Breathing apparatus

Thank U