

QA/QC

- 1) BPVC code & Standard
- 2) Material code & Standard & grade.
- 3) Welding code & Standard
- 4) Drawing.
- 5) Structure drawing.
- 6) ASME Sec. IX
- 7) ASME Sec. 2 Part A
Part B
Part C
- 8) Process piping.

WELDING &
QA/QC

ASME Section / BPVC Section.

ASME Sec. I Rules for construction of Power Boilers.

ASME Sec. II Materials.

Part A → Ferrous materials.

Part B → Non-ferrous "

Part C → Specification of materials & S.W.

Part D → Mech. Property.

ASME Sec. III Rule for construction of Nuclear components.

ASME Sec. IV Rules for construction of Heating Boilers.

ASME Sec. V Non-destructive testing.

ASME Sec. VI Rules for care & operation of heating boilers.

ASME Sec. VII Rule of care of Power boiler.

ASME Sec. VIII Rule for construction of Pressure vessels

div-1, 0 to 3000 Psi

div-2, 3000 to 10k Psi

div-3, >10k Psi.

ASME Sec. IX Welding & Brazing qualification.

ASME Sec. X Plastic & fiber pressure vessel

ASME Sec. XI Inspection of Nuclear Power

ASME Sec. XII Rule for construction of transmission tank.

ASME SECTION II Part C

↳ DEALS WITH SPECIFICATION 808-

- 1) welding rods
- 2) welding electrodes
- 3) filler metals
- 4) welding flux.

↳ AWS SPECIFICATION

	<u>SMAW</u>	<u>GTAW</u>	<u>FCAW</u>	<u>SAW</u>
1) CS	AS.1	AS.18	AS.2	AS.17
2) SS	AS.4	AS.9	AS.22	AS.9
3) CAS	AS.5	AS.28	AS.29	AS.23
4) NI	AS.11	AS.14		AS.14
5) AL	AS.3	AS.1		

↳ AWS SPECIFICATIONS

Specific filler wire Analysis (SFA)

1) SFA-5.01 → filler metal

2) SFA-5.12 → tungsten & it's alloy electrode for Arc welding & cutting.

3) SFA-5.13 → electrode for SMAW

4) SFA-5.15 → electrode & rods for cast iron.

5) SFA-5.21 → Base electrode & rods

6) SFA-5.16 → titanium & it's alloys welding electrode & rods

7) SFA-5.7 → copper & it's alloys electrode & rods.

4 AWS Classification for Electrode (CS)

E7018 E → Electrode
70 → Tensile strength PSI
1 → Welding position all
8 → Slur composition.
18 → Polarity (DCEP)

4 for Electrode (LAS)

E8018-B2 E → Electrode
80 → Tensile strength PSI
1 → Welding position All.
8 → Slur composition.
18 → Polarity (DCEP)
B2 → Composition %

4 Electrode (CS)

E7018-15	DCEP	All position.
E7018-25	DCEP	H, F
E7018-16	DCEP & AC	All

4 Electrodes & filled wire SMAW (CS)

ER70S-2 ER → Filled wire
70 → PSI
S → Solid filled metal.
2 → Composition of filled wire.

NOTE We GTAW & welding of root only by it. (for CS)

4 Electrode & filler metal (LAS)

ER80S-Ni2

Ni2 → composition of filler wire.

4 FCAW (CS)

E71T-1

E → electrode

70 → PSI

1 → Position All.

T → flux coated electrode

1 → CO₂ gas

Polarity (DCRP)

4 FCAW (LAS)

E71T1-A1

T1 → electrode is flux coated.

1 → Classified with CO₂ gas.

A1 → Polarity.

4 SAW (CS)

Flux → F7A2

F → Flux

7 → tensile strength PSI
7x10 = 70 KPSI

A → AS welded
'P' PWHT

2 → low temp. impact value.

Sheet wide → EM12K

E → electrode

M → Mn content

M - medium

12 → carbon content

K → Si killed steel.

4 SAW (LAS)

Flux → F7A2

filled wire → EB3R

B3 → Chromium %
R → supplementary design.

4 Electrode & filled wire (S-S)

E308L / E309L → S-S to C-S

ER308L / ER309L → S-S to C-S

(use for dissimilar metal)

4 GMAW

ER70S-6

NOTE

ASTM A106 gr A (330 MPa)

" " " B (415 MPa)

" " " C (485 MPa)

" " "

NOTE

AWS D1.1 → Structural Steel

AWS D1.2 → Structural Aluminium.

API 1104 → Pipeline.

ASME B31 code for Pressure Piping.

- 1) ASME B31.1 → Power Piping.
- 2) ASME B31.2 → Fuel Gas Piping.
- 3) ASME B31.3 → Process Piping.
- 4) ASME B31.4 → Pipeline (Hydrocarbon)
- 5) ASME B31.5 → Refrigeration Piping.
- 6) ASME B31.8 → Gas transmission & distribution Piping Syst.
- 7) ASME B31.9 → Building Service Piping.
- 8) ASME B31.11 → Slurry transportation Piping System.

ASME Sec. IX

welding, Brazing qualification.

1) QG → general requirement welding.

2) QW → welding.

3) QB → Brazing.

4) QF → forged Plastic welding.

↳ WGT for sec. IX Piping & pressure vessel

Article 1 welding general requirement

Article 2 welding procedure qualif. (WPS)

Article 3 welding performance qualif.

Article 4 welding data.

Article 5 Standard welding procedure Specification (SWPS)

- 1) Procedure Specification (QG 101)
- 2) Procedure qualification record (QG 102)
- 3) Performance qualification (QG 103)
- 4) Performance qualification record (QG 104)

5) Variables (QG 105)

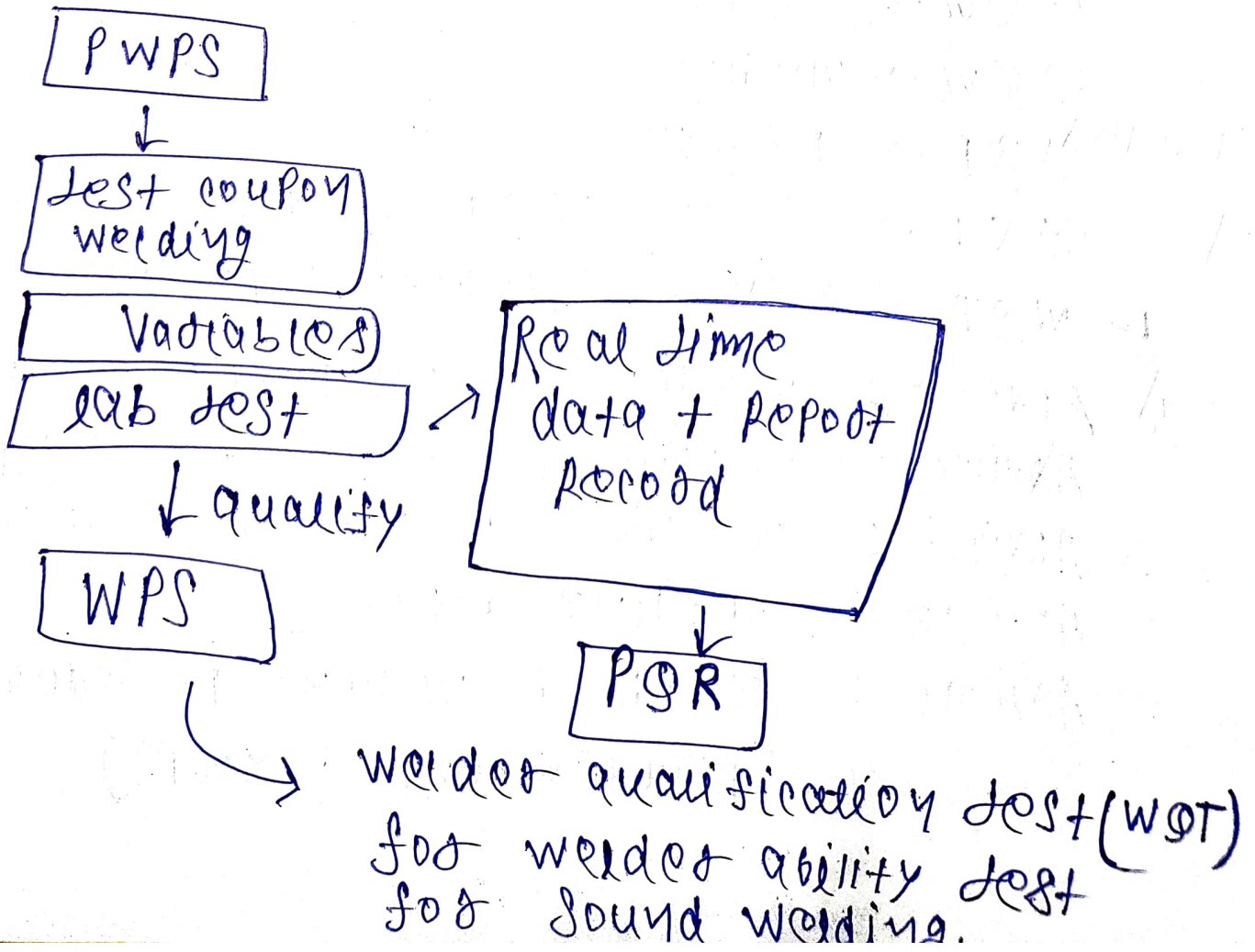
- i) essential variable → mech. property Δ
- ii) non-essential variable → no change
- iii) supplementary variable → toughness Δ

6) Organisation responsibilities.

7) Ownership transfer.

8) Definitions.

4 WPS (Welding Procedure Specification)



ASTM code & Standard for following pipe

pipe

1) Carbon Steel (CS) Pipe

ASTM A53 gr. A/B

ASTM A106 gr. A/B/C

ASTM A333 gr. 1 & 5

gr. A → 0.25 %C

gr. B → 0.30 %C

gr. C → 0.35 %C

2) Stainless Steel (S.S) Pipe

ER 308L used

ASTM A312 TP 304 / TP 304L / TP 304H /

TP 308 / TP 310 / TP 316 / TP 316L

(L → low carbon %)

ER 316L used

(H → high carbon %)

TP 304 → 0.08 %C

TP 304L → 0.035 %C

TP 316 → 0.08 %C

TP 316L → 0.035 %C

3) Alloy Steel Piping.

ASTM A335 grade. P1 / P2 / P5 / P11 / P22

4) Nickel Steel Piping.

ASTM A333 gr. 3 & gr. 8

tube

1) CS → ASTM A178 / 179 / 192

ASTM A334 gr. 1 & gr. 6

2) S.S → ASTM A213 TP 304 / TP 304L / TP 304H /
TP 310 / TP 316 / TP 316L

wrought iron fitting (Butt weld)

1) CS → ASTM A234 gr. WPA/B

ASTM A420 gr. WPL6

2) S.S → ASTM A403 WP 304 / WP 304L /

WP 304H / WP 310 / WP 316

3) Alloy Steel → ASTM A234 WP1 / WP5 / WP7

Forged fittings (Socket weld)

- 1) C.S → ASTM A181, ASTM A105
ASTM A350 LF 112.
- 2) S.S → ASTM A182 F6 / F304 / F304L
F304H / F310 / F316 / F316L
- 3) alloy steel → ASTM A182 F1 / F2 / F10

casting fitting (valves)

- 1) C.S → ASTM A216, ASTM A352 CB/C
- 2) S.S → ASTM A217 CA15, ASTM A296 CA15
- 3) Alloy steel → ASTM A217 WC1 / WC6 / WC9

Plates

- 1) C.S → ASTM A285, ASTM A515, ASTM A516
Gr. 60, 70 Gr. 60, 70
- 2) S.S → ASTM A240 TP410 / TP405 / TP430 /
TP304 / TP304L / TP316 / TP316L
- 3) Alloy steel → ASTM A387 Gr. 2 / Gr. 5 / Gr. 7
Gr. 9 / Gr. 11 / Gr. 12 / Gr. 22
- 4) Nickel Alloy → ASTM A203 Gr. D / Gr. E
ASTM A353.

Types of flanges (Pipe Attachment base)

- 1) Slip-on
- 2) Socket weld
- 3) Welding neck
- 4) Blind flanges
- 5) Reducing flanges
- 6) Integral flanges
- 7) Lap joint
- 8) Screwed flanges.

→ Pressure temperature rating based.

- 1) 150, 300, 400, 600, 900, 1500, 2500, 3000 class.

→ Based on facing.

- 1) Flat face
- 2) Raised face
- 3) Tongue & groove face
- 4) Male & female face
- 5) Ring type joint.

Types of gaskets

- 1) Full face
- 2) Spiral metallic
- 3) Ring type
- 4) Metal jacket
- 5) Inside bolt circle.
- 6) Sheet gaskets.

→ Compressed Asbestos fibre. Commonly used material gasket.

Types of valves

- 1) Gate valve
- 2) Globe valve
- 3) Ball valve
- 4) Butterfly valve
- 5) Plug valve
- 6) Piston valve
- 7) Check valve (NRV)
- 8) Pin valve.

types of support

- 1) Shoe support
- 2) Hanger support
- 3) Spring anchor support
- 4) Dummy support
- 5) T/L support

Types of pipe

- 1) Seamless pipe
- 2) Seam pipe (welded)
 - 1) SAW pipe
 - 2) Electric resistance welding pipe (ERW)
 - 3) Spiral pipe.
- 3) Plain end pipe
- 4) Bevel end pipe
- 5) Thread end pipe.

4 ASME Sec II Part A

deals with ferrous materials.

- 1) Carbon steel
- 2) Stainless steel
- 3) Cast iron

4 ASME Sec. II Part B

deals with non-

- i) Nickel alloys
- ii) Lead
- iii) Zinc.

4 ASME Sec. II Part D

deals with mechanical properties.

1) Modulus of elasticity

$$E = \frac{\sigma}{\epsilon} \text{ N/mm}^2$$

2) Thermal expansion

3) Poisson's ratio

$$m =$$

4) density. $\rho = \frac{M}{V}$

Welding Defects

- 1) Porosity / clustered porosity.
- 2) Undercut.
- 3) Blow holes / Pin holes
- 4) Spitted
- 5) slag inclusion
- 6) Distortion
- 7) Cracks
- 8) lack of penetration.
- 9) Arc strike.
- 10) Tungsten inclusion.
- 11) lack of fusion.
- 12) Burn through.
- 13) Crater lake.
- 14)

ASME SEC. IX

Welder Qualification Test (WQT)

1) Thickness Range upto 2T

if welder qualify in thickness T (20MM) then these welder automated qualified in thickness 2T (40MM) job.

2) Thickness range more than 13MM in min. 3 Pass

if welder welded more than 13MM thickness in minimum 3 Pass (layer) then these welder qualified unlimited.

3) OD Range

i) OD less than 25MM

if welder qualify upto 25MM OD then automated qualified less than 25MM OD unlimited.

ii) 25MM to 73MM OD

if welder qualify upto 73MM OD then automated qualified between 25MM to 73MM OD dia. pipe unlimited.

iii) More than 73MM OD

if welder qualify in more than 73MM OD then automated qualified in more than 73MM OD unlimited.

1) SMAW

- ✓ E7018 (3.15, 4, 2.5 mm)
- ✓ DCEP
- ✓ A - 110 to 130 A
- ✓ V - 22 to 28 V
- ✓ P.O - 150/110 A
- ✓ M.O - 250 to 300 A

2) SAW

- ✓ E - EM12K / EM10K (4 mm)
- ✓ F - F7A4/P4 (Neutral) / F8A4/P4
- ✓ I - 550 to 600 A
- ✓ V - 28 to 30 V
- ✓ T.S - 330 mm/min. / 27 cm/min.
- ✓ NPD - 15 mm to 25 mm.

3) GMAW

- ✓ E - ER70S-6 (1.2 mm)
- ✓ G - CO₂ & 20 Lbs.
- ✓ I - 130 A
- ✓ V - 22 to 24 V
- ✓ T.S -

WELDING TECHNOLOGY

Welding Process

1) SAW (Submerged Arc Welding)

- ✓ High thickness welded - 15 to 100 mm.
- ✓ $V \rightarrow 10 \text{ to } 50 \text{ V}$, $I \rightarrow 200 \text{ to } 2000 \text{ A}$ (AC/DC)
- ✓ High deposition rate $\rightarrow 20 \text{ kg/hr}$. 16 A/mm^2
- ✓ Copper coated wire electrode are used due to copper good conductor of electricity
- ✓ Consumable electrode (4 mm, 2 to 10 mm)
- ✓ Solid granular flux used
- ✓ Arc is under flux. (Non-visible)
- ✓ Min. heat loss & max. focus on WIP
- ✓ DCRP with high current is used (DCEP)
- ✓ Spitter not produce.
- ✓ High strength by it.
- ✓ $HR = MCAT + ML$ $\eta = \frac{HR}{HS}$
 $HS = I^2 RT$
- ✓ Copper coated wire electrode used
i) good conductor of electricity so provide better current to electrode
ii) Prevent of mild steel from rusting.

✓ Application

SHIP building, Pressure vessel, Domestic LPG
low carbon & low alloy steel, S.S, Cu, Al
Medium carbon steel, Nickel

✓ $100\% \text{ Duty Cycle} = \frac{\text{Arc. on time}}{\text{Arc on time} + \text{Ideal time}}$

↳ NPD → Nozzle to Plate distance (3 to 5mm)

↳ Components

Power source (AC/DC), Hooped flux delivery syst., cupped electrode (sinter wire), granular flux.

↳ Advantage

High deposition rate, high duty cycle, Productivity ↑
controllable penetration, Automated,
flux reused.

↳ Disadvantage

only flat position welded, long welding,
post weld slag removal.

↳ Flux

AC stability, deposited weld metal -
mechanical properties improve.

Granular flux (fusible) → oxide of Mn, Si,
Ca, Mg, Al, titanium, zirconium, calcium
fluoride.

i) Bonded flux

↳ Bonded with low melting compound (K_2SiO_3)
 Na_2SiO_3

↳ Metallic deoxidiser (prevent weld porosity)

↳ Ferrasilicon, Ferromagnese → S-S/C-S

Magnese → use in steel making.

Si, Ca carbide → steel production.

titanium → steel.

ii) Fused flux

↳ produce by mixing ingredients (Si, Fe_2O_3 ,
 Mg_2O_3) then melting, cooling &
grinding.

↳ provide smooth AC stable at 2000 A

↳ should be baked at 900°C to remove
moisture.

2) GTAW (Gas tungsten Arc welding) TIG

- ✓ Shielding gas used (He, Ar, CO₂)
- ✓ DCEN (Straight Polarity) used for all except Al & Mg. (DCEP)
- ✓ DCEP (Reverse Polarity) known as the cathodic cleaning
- ✓ AC source is use for Al & Mg. (340°C)
- ✓ Non-consumable tungsten electrode is used (1.6 mm, 2 mm, 2.4 mm, C.S)
- ✓ Sheet wide use (T > 5 mm Plate) → ER70S2
- ER308L, 304L, 316L → S.S { 1.6, 2.0, 2.4, }
ER 309L → S.S to C.S dissimilar joint { 2.5, 3.15 mm }
- ✓ Electrode (S.S)
E7018, E7018, E6013 → S.S
C.S M.S { 2, 2.4, 3.15 mm }
- ✓ I = 200 to 650 A (100 A)
V = 10 to 35 V
- ✓ all position welding process.
- ✓ 60% duty cycle.
- ✓ ceramic nozzle are used.
- ✓ thin plate are welded.
- ✓ Application
S.S, M.S, Al, Mg, Cu, Ni, titanium,
Aircraft, Atomic energy, car body,
instrument industry, Aerospace,
Automobile industries, Chemical industries
- ✓ inert gas (Ar, He) are blow around electrode & weld pool.
- ✓ zirconium & thorium use for ↑ M.P of tungsten electrode.

3) GMAW (Gas Metal Arc welding) MIG/MAG

- ↳ Droplet transfer at low current \rightarrow only G.F
- ↳ Spray transfer at high current \rightarrow both gravity + magnetic force (Pinch effect)
- ↳ Solid wire in form of consumable electrode is used (1.2, 2.0, 3 mm) 2.5 mm ER 70S, ER 308L, ER 309L
- ↳ Shielding gas used (He, Ar, CO₂)
- ↳ Solid wire is bare or lightly coated.
- ↳ Consumable electrode used.
- ↳ AC or DC used.
- ↳ Reverse Polarity used (DCEP)
- ↳ All position welding process
- ↳ High deposition rate.
- ↳ 60% duty cycle.
- ↳ Speed 2.5 to 25 m/min.
- ↳ $I = 200$ to 750 A, $V = 10$ to 35 V
- ↳ Nozzle rate 4 to 40 L/min.
- ↳ Application

Sections of Non-ferrous metal, Car bodies, Shipbuilding, Pressure vessel, Tanks, Pipe, Aircraft, Al, Mg, S.S