ASME SEC IX - Welding Procedure and performance qualification

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Welding Procedure Specification

It is a written document that provides direction to the welder for making production welds in accordance with code requirements.

Any WPS must be qualified by the manufacturer.

WPS specifies the condition (ranges) under which welding must be performed called variables.

WPS addresses essential, supplementary essential and non essential variables

Purpose of WPS Qualification

To determine that the weldment is capable of providing the required properties for the intended application.

WPS establishes the properties of the weldment and not the skill of the welder.

Procedure Qualification Record

It documents what occurred during welding the test coupon and the results of the test coupon.

PQR documents the essential variables and other specific information and the results of the required testing. In addition, when notch toughness is required for procedure qualification, the applicable supplementary essential variables shall be recorded.

Procedure Qualification

PQR is a record of welding data to weld a test coupon. It also contains test results.

Completed PQR shall document all essential variables including ranges.

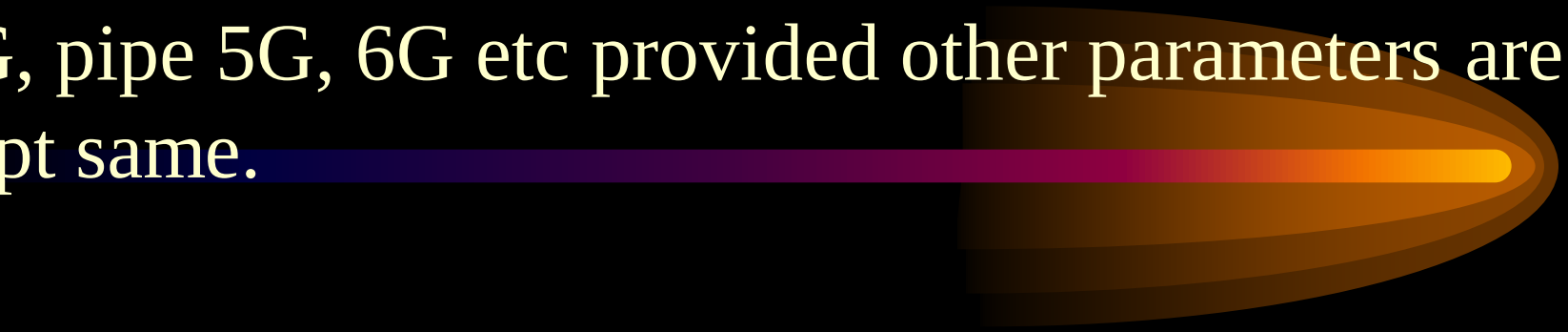
PQR to be certified accurate and shall not be subcontracted.

If more than one process then weld deposit thickness for each process and filler metal to be recorded.

Procedure Qualification

Several WPSs may be prepared from one PQR.

eg. 1G plate PQR may support WPSs in 2G, 3G, 4G, pipe 5G, 6G etc provided other parameters are kept same.



A single WPS may cover several PQRs

eg. A single WPS may cover 1.6 mm to 32 mm thickness if PQRs for 1.6 to 4.8 mm and 4.8 mm to 32 mm thickness ranges.

Weld Orientation

Plate groove positions 1G, 2G, 3G, 4G

Pipe groove positions 1G, 2G, 5G, 6G

Plate fillet positions 1F, 2F, 3F, 4F

Pipe fillet positions 1F, 2F, 2FR, 4F, 5F

1F - 0 to 30

2F - +15 -10 wrt 45

4F - 0 - 125

3F - 125 - 235

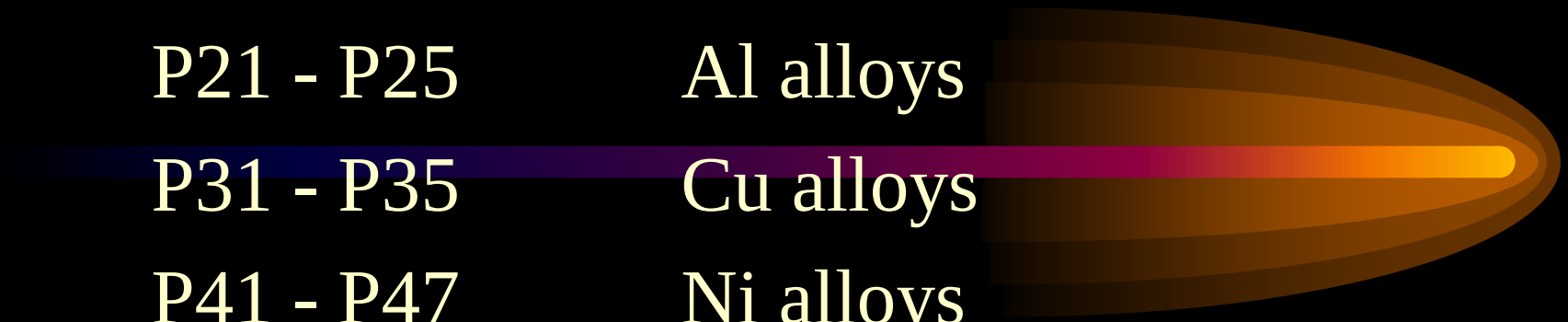
Base Metal Classification

P nos depend on composition, weldability & mechanical properites.

Group nos classify metals within P nos for procedure qualification where notch toughness requirements are specified. But base metals can not be indiscriminately substituted.

Base Metal P Numbers

P1 - P11	Steel
P21 - P25	Al alloys
P31 - P35	Cu alloys
P41 - P47	Ni alloys
P51 - P53	Ti alloys
P61 - P62	Zr alloys



Base Metal P Numbers

Examples of P nos

P1	C Steel
P3	1/2 Mo steels
P4	1 Cr 1/2 Mo steels
P5A	2 1/4 Cr 1 Mo steels
P6	13 Cr steel
P7	17 Cr steel
P8	ASS
P9A	2 1/2 Ni steels
P10A	Mn - 1/2 Ni - V steels
P11	9 Ni steels

Base Metal for WPS

Test Coupon	Base Metal qualified
Px - Px	Px
Px - Py	Px to Py
P3 - P3	P3 - P3, P3 - P1
P4 - P4	P4 - P4, P4 - P3, P4 - P1
P5A - P5A	P5A - P5A, P4 - P4, P4 - P3, P4 - P1
P4 - P3, P4 - P1	P4 - P3, P4 - P1
P5A - P4, P5A - P3}	P5A - P4, P5A - P3
P5A - P1 }	P5A - P1

Filler Metal F Numbers

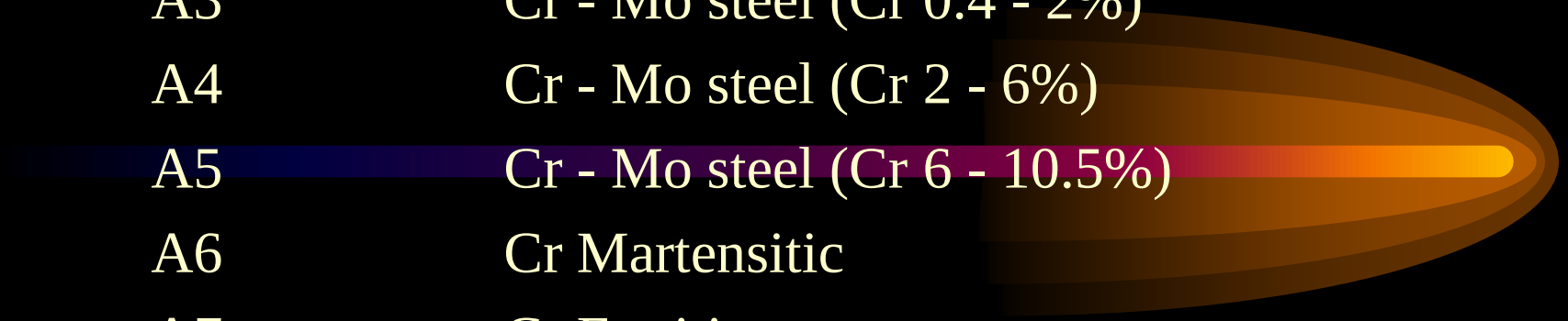
Based on usability characteristics i.e ability of welders to make satisfactory welds with given filler

F1	E XX20
F2	E XX12, E XX13
F3	E XX10, E XX11
F4	E XX18
F5	ASS, Duplex SS
F6	Bare rods

Filler Metal A Numbers

Based on chemical composition

A1	Mild steel
A2	C - Mo steel
A3	Cr - Mo steel (Cr 0.4 - 2%)
A4	Cr - Mo steel (Cr 2 - 6%)
A5	Cr - Mo steel (Cr 6 - 10.5%)
A6	Cr Martensitic
A7	Cr Ferritic
A8	Cr Ni steels (Cr 14.5 - 30% Ni 7.5 - 15%)
A9	Cr Ni steels (Cr 19 - 30% Ni 15 - 37%)
A10	Ni steels (Ni 0.8 - 4%)
A11	Mn Mo steels(Mn 1.25-2.25 Mo 0.25-0.75%)
A12	Ni Cr Mo steels (Cr 1.5% Mo 0.25-0.8% Ni 1.25 -2.8%)



Procedure Qualification

When two or more procedures (diff processes or other essential variables) are used in one joint, use table for determining the applicable range of thickness qualified. Carry out tension test for each weld metal.

One or more processes from a combination may be deleted provided remaining metal meets the requirements.

Procedure Qualification Thickness limits

T	Range of T	max t	Tests (transverse bend)
<1/16”	T - 2T	2t	2T, 2 FB, 2 RB
1/16-3/8”	1/16 - 2T	2t	-do-
3/8-3/4”	3/16 - 2T	2t	-do-
3/4-1.5”	3/16 - 2T	2t if t<3/4 2T if t>3/4	2T, 4 SB
>1.5”	3/16 - 8”	2t if t<3/4” 8 if t>3/4”	-do-

Procedure Qualification Thickness limits

T	Range of T	max t	Tests (longtdnl bend)
<1/16”	T - 2T	2t	2T, 2 FB, 2 RB
1/16-3/8”	1/16 - 2T	2t	-do-
> 3/8”	3/16 - 2T	2t	-do-

WPS for SMAW

Essential variables

- Change in qualified Thickness
- Change in P no
- Change in F no of filler metal
- Change in A no of filler metal
- Change in deposited metal thickness
- Decrease of more than 100 F in preheat
- Change in PWHT

WPS for SMAW

Supplementary Essential variables

- Change in Group no of base metal
- Change in T limits for impact test
- Change in dia of filler metal > 1/4”
- Change in AWS class of filler metal
- Change in welding position
- Increase of more than 100 F in preheat
- Change in PWHT Time and temp range
- Change in current or polarity

WPS for SMAW

Non Essential variables

- Change in Groove design, backing, root spacing, retainers etc
- Change in dia of filler metal
- Change in AWS class of filler metal
- Change in welding position
- Change in preheat maintenance
- Change in current or polarity
- Change in string/weave, cleaning, back gouging, peening, manual/automatic

WPS for GTAW

Essential variables

- Change in qualified Thickness
- Change in P no
- Change in F no & A no of filler metal
- Addition/deletion of filler metal
- Change in size of filler metal, product form
- Decrease of more than 100 F in preheat
- Change in PWHT

WPS for GTAW

Essential variables (cond)

- Change in single, mixture %ge gas
- Deletion of backing gas
- Change in shielding / trailing gas
- Change in Closed to out chamber technique

WPS for GTAW

Supplementary Essential variables

- Change in Group no of base metal
- Change in T limits
- Change in AWS class of filler metal
- Change in welding position
- Increase of more than 100 F in preheat
- Change in PWHT Time and temp range
- Change in current/polarity, incr. in heat input
- Change in multi to single pass, electrodes

Performance Qualification

The basic criterion for welder's qualification is to determine the welder's ability to deposit sound weld metal. The purpose of performance qualification test is to determine the welding operator's mechanical ability to operate the welding equipment.

Welding Performance Qualification

The performance qualification tests are intended to determine the ability of welders to make sound welds

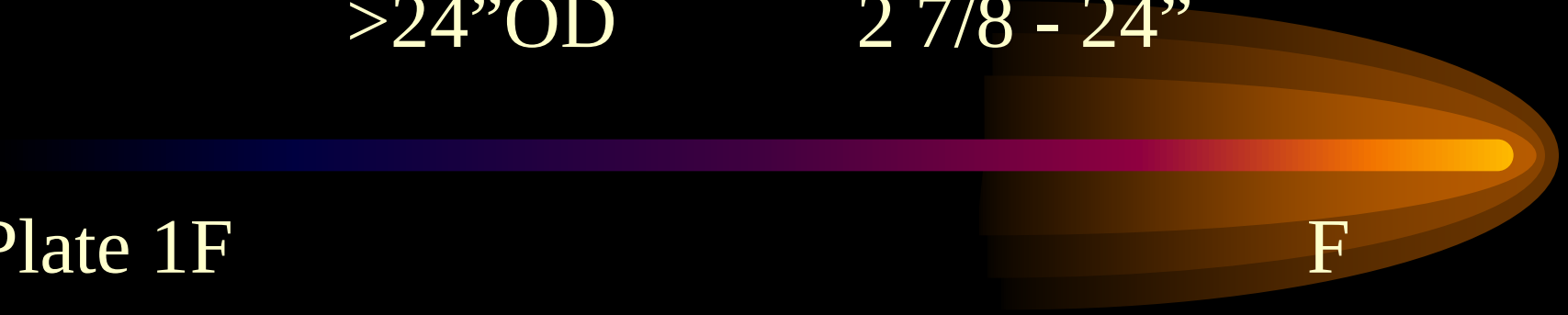
A welder is qualified by radiography of a test coupon or by radiography of initial production welding or by bend tests taken from a test coupon

Welding Performance Qualification

Weld	Plate & pipe >24”OD	Pipe of OD 2 7/8 - 24”	Fillet
Plate 1G	F	F	F
Plate 2G	F, H	F, H	F, H
Plate 3G	F, V	F	F, H, V
Plate 4G	F, O	F	F, H, O

Welding Performance Qualification

Weld	Plate & pipe >24”OD	Pipe of OD 2 7/8 - 24”	Fillet
Plate 1F			F
Plate 2F			F, H
Plate 3F			F, H, V
Plate 4F			F, H, O

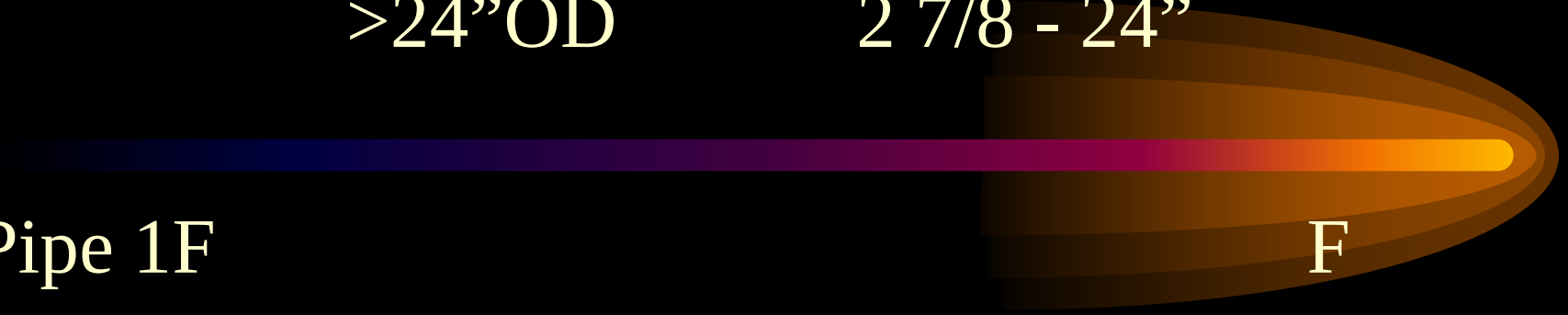


Welding Performance Qualification

Weld	Plate & pipe >24”OD	Pipe of OD 2 7/8 - 24”	Fillet
Pipe 1G	F	F	F
Pipe 2G	F, H	F, H	F, H
Pipe 5G	F, V, O	F, V, O	All
Pipe 6G	All	All	All
Pipe 2G + 5G	All	All	All

Welding Performance Qualification

Weld	Plate & pipe >24”OD	Pipe of OD 2 7/8 - 24”	Fillet
Pipe 1F			F
Pipe 2F			F, H
Pipe 2FR			F, H
Pipe 4F			F, H, O
Pipe 5F			All



Welding Performance Qualification

Thk	Max tk of dep. Metal	Test
3/8”	2t	1FB, 1RB
>3/8”	2t	1FB, 1RB
>1/2”	Max to be welded	2SB

OD of test coupon	Range of OD qualified
<1”	Size welded - unlimtd
1 - 2 7/8”	1” - unlimited
> 2 7/8”	2 7/8” - unlimited

Welding Performance Qualification

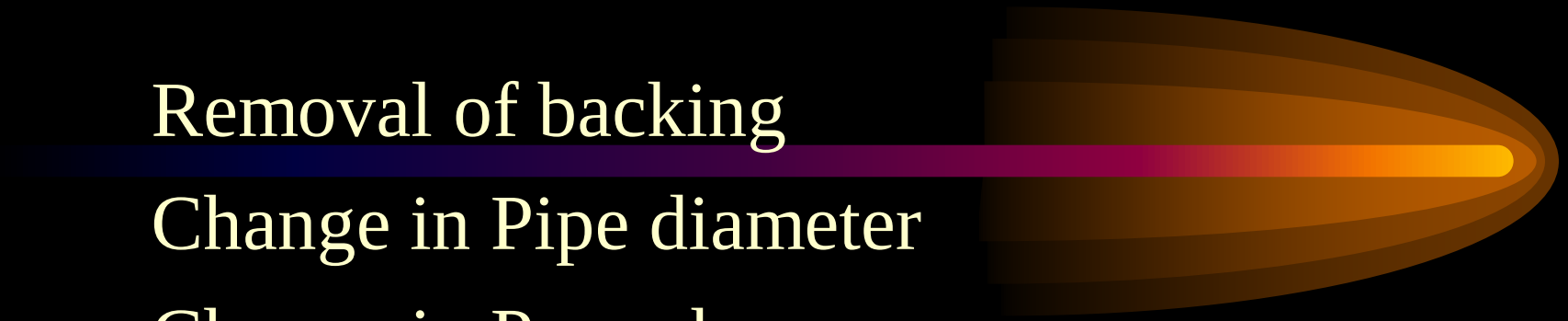
Test coupon More than 2 welders different procedure can do a single test coupon. Failure then both are failed.

Retest - 2 consecutive test coupons to pass

Renewal if no welding for 6 months. Single test coupon plate/pipe, any thickness, material, position. If passed then complete previous qualification is restored.

Welding Performance Qualification

Variables for SMAW



- Removal of backing
- Change in Pipe diameter
- Change in P number
- Change in F Number
- Change in thickness of weld deposit
- Change in welding position

Welding Performance Qualification

Variables for GTAW

- Removal of backing
- Change in Pipe diameter
- Addition / deletion of filler metal
- Addition / deletion of insert
- Change in P number
- Change in F Number
- Change in solid filler to flux cored filler metal
- Change in thickness of weld deposit
- Change in welding position
- Removal of inert gas backing
- Change in current or polarity

Welding Performance Qualification

F No qualification with backing	
F1 with backing	F1 with backing
F1 without backing	F1 with & without backing
F2 with backing	F1 & F2 with backing
F2 without backing	F2 with & without backing, F1 with backing
F3 with backing	F1, F2 & F3 with backing
F3 without backing	F3 with & without backing, F1, F2 with backing
F4 with backing	F1, F2, F3 & F4 with backing
F4 without backing	F4 with & without backing, F1, F2, F3 with backing
F5 with backing	F1 & F5 with backing
F5 without backing	F5 with & without backing, F1 with backing

Tests for Qualification

Tension test	Minimum values for specified tensile strength
	For dissimilar joint, lesser of the two values
	If break outside weld, if tensile st. value not < 5% of the base metal
Bend test	No open discontinuity > 1/8” in any direction
Impact test	In accordance with the section

Tests for Qualification

Radiography

No crack or LOP or LOF

Any elongated slag >1/8” for t <3/8”

1/3 t for t 3/8 - 2 1/4”

3/4 “ for t>2 1/4”

Any group of slag in a line with aggregate length t in 12 t unless separated by 6L

Max permissible dimension for rounded indication smaller of 20% of t or 1/8”

For thickness<1/8”, max no of accepted rounded indication 12 in 6” length

For thickness>1/8”, charts for max acceptable types of rounded indication

Welder's Performance Qualification as per

Indian Boiler Regulations

Welder's Performance Qualification as per IBR

Initial qualification of welders - Certificate valid for 24 months provided welder has been employed with reasonable continuity

If preceding three months, no welding carried out or if there is any doubt on welder's stability then requalification needed

Welder's Performance Qualification as per IBR

Requalification of welders must for the following

- Omission of backing strip
- Change in class of electrode
- Change in base metal to be welded
- Change in welding process
- Change from dc to ac and vice versa

Tests for Initial Qualification

- Theoretical examination
- Groove welds in plate - single or double vee 299 x 381 x 16 mm min size in flat, horizontal or vertical. Vertical or horizontal position also qualifies for all
- Fillet weld in plate - 16 x 381 mm min in flat, horizontal, vertical or overhead. Horizontal or vertical also qualifies for flat. Vertical position also qualifies for flat, horizontal or vertical.

Tests for Initial Qualification

Pipe welding in the following positions (i) Horizontally rolled (ii) Horizontal turned (iii) Vertical fixed (iv) Horizontal fixed. Qualification in (ii) or (iii) also qualifies (i). Qualification in (iv) also qualifies (i) or (ii).

Branch to pipe welding

Pipe size 127 OD x 10 tk. Tube 89 OD x 6 tk.

Tube welding with axis vertical and tubes of same size fixed in adjoining positions.

Tests for Requalification

- No theoretical examination
- Plate welding 152 length x 229 x 16 tk in 45 deg position. Weld to be done from underside.
- Pipe welding with axis of pipe horizontal.
- Branch to pipe as earlier
- Tube welding axis vertical and tubes of same size in adjoining position.
- Regular production weld to the satisfaction of competent authority may be accepted as alternative to the above tests

Examination of the weld for initial Qualification

PLATE QUALIFICATION

- Visual examination
- Radiography
- 2 no of Tensile test
- 2 no each of Bend test - face and root bend (3t for both C steel and alloy steel 180 deg bend)
- 1 no Micro examination
- 1 no Macro examination

Examination of the weld for initial Qualification

PIPE QUALIFICATION

- Visual examination
- Macro examination
- 2 no each of Bend test - face and root bend (3t for C steel and 4t for alloy steel 90 deg bend)

Examination of the weld for Requalification

PLATE QUALIFICATION

- Radiography
- 1 no each of Bend test - face and root bend

PIPE QUALIFICATION

- 1 no each of bend test - face and root bend
- Macro examination