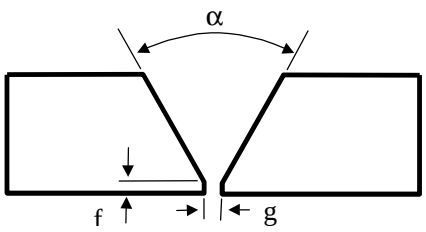
Welding Procedure Specification (WPS)

Welding Procedure No: CH9MVN-01

Consumables		Base Material	
Welding process (root):	TIG (GTAW)	Parent Material:	A335 P91
- Consumable:	**9CrMoV-N**		ASME IX P-Number 5B
- Specification:	BS EN: W CrMo 91 AWS: ER90S-B9		
Welding process (fill):	MMA (SMAW)		
- Consumable:	**Chromet 9MV-N**	Thickness:	15-60mm
- Specification:	BS EN, E CrMo 91 B	Outside Diameter:	16″ NB (406mm OD)
Joint Details		**Joint Position**	
Joint Type:	Butt single sided	Welding Position:	ASME: 5G
Manual/Mechanised:	Manual		BS EN: PF

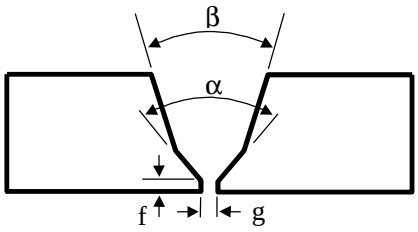
Joint Sketch

Joint for thickness < 20mm



f = 1-3mm; g = 2-4mm; α = 70°

Joint for thickness > 20mm



f = 1-3mm; g = 2-4mm; α = 70°; β = 20°

Welding Details

Run	Process	Consumable	Diameter mm	Current A	Voltage V	Type of current / Polarity	Wire Feed Speed m/min	Heat Input kJ/mm
1	TIG	**9CrMoV-N**	2.4	70-110	~12	DC-	NA	~1.2
2-3	TIG	**9CrMoV-N**	2.4	80-140	~12	DC-	NA	~ 1.2
4-7	MMA	**Chromet 9MV-N**	3.2	90-130	~24	DC+	NA	~ 1.0
Rem	MMA	**Chromet 9MV-N**	4.0	120-170	~25	DC+	NA	~ 1.2

Electrode Baking or Drying:	300-350°C/1-2h
Gas – root (TIG) shielding:	Pure Ar
purge:	Pure Ar (note 1)
Gas Flow Rate (TIG) – Shielding:	8-15 l/min
Purge:	4-10 l/min
Tungsten Electrode Type/Size:	2% Th/2.4mm
Details of Back Gouging/Backing:	NA

Preheat Temperature:	200°C min (note 2)
Interpass Temperature:	300°C max

Post-Weld Heat Treatment:	Note 3.
Temperature:	760°C ± 10°C
Time:	1h/25mm (2 hours min)
	Note 4.

Notes:

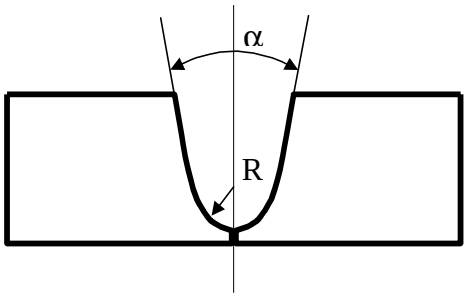
1. Maintain purge for runs 1-3.
2. Preheat 150°C min for TIG.
3. Cool to ~100°C before PWHT.
4. Heating & cooling rate <100°C/h (above 300°C).
5. Stringer beads, maximum weave 3 x ø.

Welding Procedure Specification (WPS)

Welding Procedure No: CH9MVN-02

Consumables		Base Material	
Welding process (root):	NA	Parent Material:	A335 A217 C12A ((cast)
- Consumable:	-		ASME IX P-Number 5B
- Specification:	-		
Welding process (fill):	MMA (SMAW)		
- Consumable:	**Chromet 9MV-N**	Thickness:	15-60mm
- Specification:	BS EN, E CrMo 91 B	Outside Diameter:	-
Joint Details		**Joint Position**	
Joint Type:	Butt/groove	Welding Position:	ASME, 1G
Manual/Mechanised:	Manual		BS EN, PA

Joint Sketch



R =8-12mm; α = 20-30°

Welding Details

Run	Process	Consumable	Diameter mm	Current A	Voltage V	Type of current / Polarity	Wire Feed Speed m/min	Heat Input kJ/mm
	MMA	**Chromet 9MV-N**	3.2	90-135	~23	DC+	NA	~ 1.2
	MMA	**Chromet 9MV-N**	4.0	130-180	~24	DC+	NA	~ 1.4
	MMA	**Chromet 9MV-N**	5.0	160-240	~25	DC+	NA	~ 1.8

Electrode Baking or Drying:	300-350°C/1-2h
Gas – root (TIG) shielding:	NA
purge:	NA
Gas Flow Rate (TIG) – Shielding:	NA
Purge:	NA
Tungsten Electrode Type/Size:	NA
Details of Back Gouging/Backing:	NA

Preheat Temperature:	200°C min
Interpass Temperature:	300°C max

Post-Weld Heat Treatment:	Note 1.
Temperature:	745°C ± 10°C
Time:	8 hours
	Note 2.

Notes:

1. Cool to ~100°C before PWHT.

2. Heating & cooling rate <100°C/h (above 300°C).

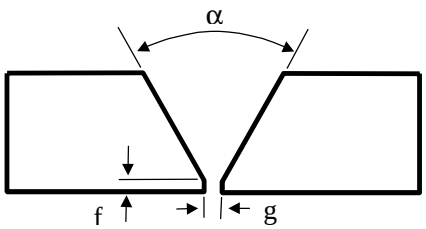
Welding Procedure Specification (WPS)

Welding Procedure No: CH9B9-01

Consumables		Base Material	
Welding process (root):	TIG (GTAW)	Parent Material:	A335 P91
- Consumable:	**9CrMoV-N**		ASME IX P-Number 5B
- Specification:	AWS ER90S-B9 (note 1).		
Welding process (fill):	MMA (SMAW)		
- Consumable:	**Chromet 9-B9**	Thickness:	15-60mm
- Specification:	AWS E9015-B9 (note 2).	Outside Diameter:	16″ NB (406mm OD)
Joint Details		**Joint Position**	
Joint Type:	Butt single sided	Welding Position:	ASME, 5G
Manual/Mechanised:	Manual		BS EN, PF

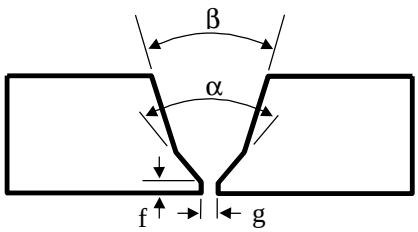
Joint Sketch

Joint for thickness < 20mm



f = 1-3mm; g = 2-4mm; α = 70°

Joint for thickness > 20mm



f = 1-3mm; g = 2-4mm; α = 70°; β = 20°

Welding Details

Run	Process	Consumable	Diameter mm	Current A	Voltage V	Type of current / Polarity	Wire Feed Speed m/min	Heat Input kJ/mm
1	TIG	**9CrMoV-N**	2.4	70-110	~12	DC-	NA	~ 1.2
2-3	TIG	**9CrMoV-N**	2.4	80-140	~12	DC-	NA	~ 1.2
4-7	MMA	**Chromet 9-B9**	3.2	90-130	~24	DC+	NA	~ 1.0
Rem	MMA	**Chromet 9-B9**	4.0	120-170	~25	DC+	NA	~ 1.2

Electrode Baking or Drying:	300-350°C/1-2h
Gas – root (TIG) shielding:	Pure Ar
purge:	Pure Ar (note 3)
Gas Flow Rate (TIG) – Shielding:	8-15 l/min
Purge:	4-10 l/min
Tungsten Electrode Type/Size:	2% Th/2.4mm
Details of Back Gouging/Backing:	NA

Preheat Temperature:	200°C min (note 4)
Interpass Temperature:	300°C max

Post-Weld Heat Treatment:	Note 5.
Temperature:	760°C ± 10°C
Time:	1h/25mm (2 hours min)
	Note 6.

Notes:

1. ASME IX, QW-432 F-number 4.
2. ASME IX, QW-442 A-number 5.
3. Maintain purge for runs 1-3.
4. Preheat 150°C min for TIG.
5. Cool to ~100°C before PWHT.
6. Heating & cooling rate <100°C/h (above 300°C).

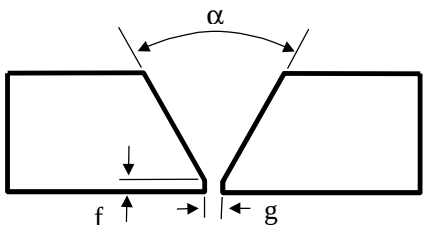
Welding Procedure Specification (WPS)

Welding Procedure No: CMM91-01

Consumables		Base Material	
Welding process (root):	TIG (GTAW)	Parent Material:	A335 P91
- Consumable:	**9CrMoV-N**		ASME IX P-Number 5B
- Specification:	BS EN: W CrMo 91		
Welding process (fill):	MIG (GMAW)		
- Consumable:	**Cormet M91 (MCW)**	Thickness:	15-60mm
- Specification:	AWS: ER90C-G	Outside Diameter:	-
Joint Details		**Joint Position**	
Joint Type:	Butt single sided	Welding Position:	ASME, 1G
Manual/Mechanised:	Manual		BS EN, PA

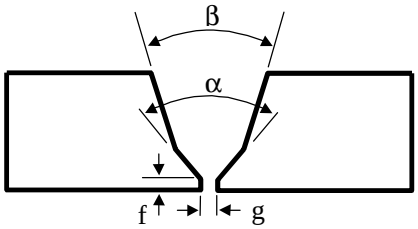
Joint Sketch

Joint for thickness < 20mm



f = 1-3mm; g = 2-4mm; α = 70°

Joint for thickness > 20mm



f = 1-3mm; g = 2-4mm; α = 70°; β = 20°

Welding Details

Run	Process	Consumable	Diameter mm	Current A	Voltage V	Type of current / Polarity	Wire Feed Speed m/min	Heat Input kJ/mm
1–5	TIG	**9CrMoV-N**	2.4	70-110	~12	DC-	NA	~1.2
-	MCW	**Cormet M91**	1.2	240-280	~28	DC+ (note 1)	~10	~ 1.6
-	MCW	**Cormet M91**	1.6	270-330	~29	DC+ (note 2)	~7	~ 2.0

Electrode Baking or Drying:	NA
Gas – (Cormet M91) shielding:	Ar-2.5%CO_2
purge:	Ar
Gas Flow Rate – Shielding:	15-25 l/min
Purge:	4-10 l/min
Tungsten Electrode Type/Size:	2% Th/2.4mm
Details of Back Gouging/Backing:	NA

Preheat Temperature:	200^{o}C min (note 3)
Interpass Temperature:	300^{o}C max

Post-Weld Heat Treatment:	Note 4.
Temperature:	760^{o}C ± 10^{o}C
Time:	1h/25mm (2 hours min)
	Note 5.

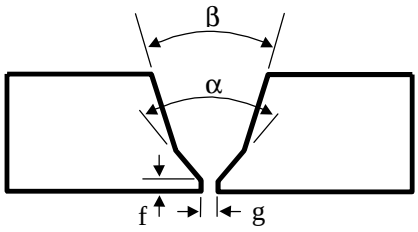
Notes:

1. Electrode stickout 10-20mm.
2. Electrode stickout 15-25mm.
3. Preheat 150^{o}C min for TIG.
4. Cool to ~100^{o}C before PWHT.
5. Heating & cooling rate <100^{o}C/h (above 300°C).

Welding Procedure Specification (WPS)

Welding Procedure No: SCF91-01

Consumables		Base Material	
Welding process (root):	TIG (GTAW)	Parent Material:	A335 P91
- Consumable:	**9CrMoV-N**		ASME IX P-Number 5B
- Specification:	AWS: ER90S-B9	Thickness:	15-60mm
Welding process (fill):	MMA	**Joint Details**	
- Consumable:	**Chromet 9MV-N**	Joint Type:	Single side butt weld
- Specification:	AWS: E9015-B9	Manual/Mechanised:	Manual
Welding process (fill):	FCAW	**Joint Position**	
- Consumable:	**Supercore F91** (Note 1)	Welding Position:	ASME: 6G
- Specification:	_		BS EN: HL045
Joint Sketch		**Welding Sequences**	



f = 1-2mm; g = 3-4mm; α = 75°; β = 10-20°

Welding Details

Run	Process	Consumable	Diameter mm	Current A	Voltage V	Type of current / Polarity	Wire Feed Speed m/min	Heat Input kJ/mm
1	TIG	**9CrMoV-N**	2.4	80-120	~12	DC-	NA	~1.4
2-6	MMA	**Chromet 9MV-N**	3.2	90-110	~22	DC+	NA	~1.0
Fill	FCW	**Supercore F91**	1.2	160-190	25-27	DC+ (Note 2)	~6-8	~1.2

Electrode Baking or Drying:	300-350°C/1-2h
Gas – root (TIG) shielding:	Argon
purge:	Argon (Note 3)
Gas Flow Rate (TIG) – Shielding:	8-12 l/min
Purge:	4-10 l/min
Tungsten Electrode Type/Size:	2% Th / 2.4mm
Details of Back Gouging/Backing:	NA

Preheat Temperature:	200°C min (note 4)
Interpass Temperature:	300°C

Post-Weld Heat Treatment:	Note 5.
Temperature:	760°C ± 10°C
Time:	1 h/25mm (min 3 hours)
	Note 6.

Notes:

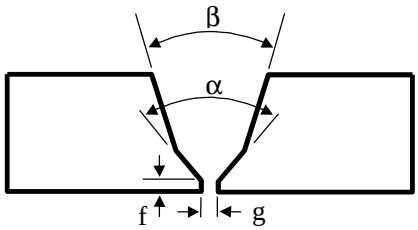
1. Shielding gas Ar-20%CO_2 at 15-25 l/min.
2. Electrode stickout 15-25mm.
3. Maintain purge for at least first two runs.
4. Preheat 150°C min for TIG.
5. Cool to ~100°C before PWHT.
6. Heating & cooling rate <100°C/h (above 300°C).

Welding Procedure Specification (WPS)

Welding Procedure No: SAW-P91-01

Consumables		Base Material		
Welding process (root):	TIG (GTAW)	Parent Material:	A335 P91	ASME IX P-No. 5B
- Consumable:	**9CrMoV-N**	Thickness:	25-75mm	
- Specification:	BS EN, W CrMo 91	Outside diameter:		
Welding process (hot pass):	MMA (SMAW)	**Joint Details**		
- Consumable:	**Chromet 9MV-N**	Joint Type:	Butt single sided	
- Specification:	BS EN E CrMo 91 B	Manual/Mechanised:	Manual & mechanised	
Welding process (fill):	SAW	**Joint Position**		
- Consumable:	**9CrMoV-N + LA491** (flux)	Welding Position:	ASME, 1G (1GR; note 6).	
- Specification:	BS EN S CrMo 91 (wire).		BS EN, PA (note 6).	

Joint Sketch



f = 1–3mm; g = 2-4mm; α = 70°; β = 20°

Welding Details

Run	Process	Consumable	Diameter mm	Current A	Voltage V	Type of current / Polarity	Travel Speed mm/min	Heat Input kJ/mm
1	TIG	**9CrMoV-N**	2.4	70-110	~12	DC-	NA	~ 1.0
2-3	TIG	**9CrMoV-N**	2.4	80-140	~12	DC-	NA	~ 1.2
4-7	MMA	**Chromet 9MV-N**	3.2	90-130	~24	DC+	NA	~ 1.2
Rem	SAW (note 1)	**9CrMoV-N**	2.4	350-450	~30	DC+	400-500	~ 2.0

Electrode & Flux Drying:	300-350°C/1-2h
Gas – root (TIG) shielding:	Pure Ar
purge:	Pure Ar (note 2)
Gas Flow Rate (TIG) – Shielding:	8-15 l/min
Purge:	4-10 l/min
Tungsten Electrode Type/Size:	2% Th/2.4mm
Details of Back Gouging/Backing:	NA

Preheat Temperature:	200°C min (note 3)
Interpass Temperature:	300°C max

Post-Weld Heat Treatment:	Note 4.
Temperature:	760°C ± 10°C
Time:	1h/25mm (2 hours min)
	Note 5.

Notes:

1. SAW flux LA491.

   ~20mm wire extension, ~30mm flux depth.
2. Maintain purge for runs 1-3.
3. Preheat 150°C min for TIG.
4. Cool to <100°C before PWHT.
5. Heating & cooling rate <100°C/h (above 300°C).
6. For rotated pipe, head to be 10° before TDC perpendicular to pipe.