طرح نگهداشت و افزایش تولید ۲۷ مخزن

SPECIFICATION FOR WELDING PROCEDURE

نگهداشت و افزایش تولید میدان نفتی بینک

D00	APR. 2022	IFC	P.Imani	M.Fakharian	M.Mehrshad	
Rev.	**Date**	**Purpose of Issue/Status**	**Prepared by:**	**Checked by:**	**Approved by:**	**CLIENT Approval**

Class: 2

CLINT Doc. Number: F0Z707302

Status:

IDC: Inter-Discipline Check
IFC: Issued For Comment
IFA: Issued For Approval
AFD: Approved For Design
AFC: Approved For Construction
AFP: Approved For Purchase
AFQ: Approved For Quotation
IFI: Issued For Information
AB-R: As-Built for CLIENT Review
AB-A: As-Built –Approved

REVISION RECORD SHEET

PAGE	D00	D01	D02	D03	D04
1	X				
2	X				
3	X				
4	X				
5	X				
6	X				
7	X				
8	X				
9	X				
10	X				
11	X				
12	X				
13	X				
14	X				
15	X				
16	X				
17	X				
18	X				
19	X				
20	X				
21	X				
22	X				
23	X				
24	X				
25	X				
26	X				
27	X				
28	X				
29	X				
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45					
46					
47					
48					
49					
50					
51					
52					
53					
54					
55					
56					
57					
58					
59					
60					
61					
62					
63					
64					
65					

PAGE	D00	D01	D02	D03	D04
66					
67					
68					
69					
70					
71					
72					
73					
74					
75					
76					
77					
78					
79					
80					
81					
82					
83					
84					
85					
86					
87					
88					
89					
90					
91					
92					
93					
94					
95					
96					
97					
98					
99					
100					
101					
102					
103					
104					
105					
106					
107					
108					
109					
110					
111					
112					
113					
114					
115					
116					
117					
118					
119					
120					
121					
122					
123					
124					
125					
126					
127					
128					
129					
130					

CONTENTS

1. INTRODUCTION

Binak oilfield in Bushehr province is a part of the southern oilfields of Iran, is located 20 km northwest of Genaveh city.

With the aim of increasing production of oil from Binak oilfield, an EPC/EPD Project has been defined by NIOC/NISOC and awarded to Petro Iran Development Company (PEDCO). Also PEDCO (as General Contractor) has assigned the EPC-packages of the Project to "Hirgan Energy - Design and Inspection" JV.

GENERAL DEFINITION

The following terms shall be used in this document.

CLIENT:	National Iranian South Oilfields Company (NISOC)
PROJECT:	Binak Oilfield Development – General Facilities
EPD/EPC CONTRACTOR (GC):	Petro Iran Development Company (PEDCO)
EPC CONTRACTOR:	Joint Venture of : Hirgan Energy – Design & Inspection(D&I) Companies
VENDOR:	The firm or person who will fabricate the equipment or material.
EXECUTOR:	Executor is the party which carries out all or part of construction and/or commissioning for the project.
THIRD PARTY INSPECTOR (TPI):	The firm appointed by EPD/EPC CONTRACTOR (GC) and approved by CLIENT (in writing) for the inspection of goods.
SHALL:	Is used where a provision is mandatory.
SHOULD:	Is used where a provision is advisory only.
WILL:	Is normally used in connection with the action by CLIENT rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR.
MAY:	Is used where a provision is completely discretionary.

2. SCOPE

This guide has been prepared to assist welding personnel with the preparation of welding procedures required as part of their company certification to ASME & API Standards. The following three documents will be described:

(a) Welding Engineering Standards

(b) Pre-Welding Procedure Specifications (PWPS)

c) Welding Procedure Data Sheets (WPS)

There will be a brief description of the first two documents; however, this guide will focus on the preparation of welding procedure data sheets. Each item on the welding procedure data sheet will be described and guidance will be provided to complete each section.

It shall be used in conjunction with data/requisition sheets for present document subject.

3. NORMATIVE REFERENCES

3.1 Local Codes and Standards

- IPS-C-PI-270 — Construction Standard for Welding of Transportation Pipeline
- IPS-C-PI-190 — Material and equipment dtandard for Pipeline
- IPS-C-PI-370 — Construction Standard for Transportation Pipeline (onshore) Pressure Testing

3.2 International Codes and Standards

- API 1104 — Welding of Pipeline and Related Facilities
- API 5L — Line Pipe
- ASME BPVC Sec.II-PART A — Ferrous Materials Specifications
- ASME BPVC Sec.II-PART C — Specifications for Welding Materials
- ASME BPVC Sec.V — Nondestructive Examination
- ASME BPVC Sec. IX — Welding, Brazing, and Fusing Qualifications

3.3 The Project Documents

- BK-GNRAL-PEDCO-000-PL-SP-0012 — Specification For Pipeline Construction
- BK-GNRAL-PEDCO-000-QC-PR-0029 — PIPELINE PWPS (Preliminary Welding Procedure Specification)

- BK-GNRAL-PEDCO-000-QC-PR-0030 PIPELINE WPS (Welding Procedure Specification)
- BK-GNRAL-PEDCO-000-QC-PR-0031 PIPELINE PQR (Procedure Qualification Record)
- BK-GNRAL-PEDCO-000-QC-PR-0032 PIPELINE PWPS (Preliminary Welding Procedure Specification) for Repair Welding
- BK-GNRAL-PEDCO-000-QC-PR-0033 PIPELINE WPS (Preliminary Welding Procedure Specification) for Repair Welding
- BK-GNRAL-PEDCO-000-QC-PR-0034 PIPELINE PQR (Procedure Qualification Record) for Repair Welding
- BK-SSGRL-PEDCO-110-PL-SP-0001 Pipeline (Flowline) Material Specification
- BK-PPL-PEDCO-320-PL-SP-0001 Pipeline Material Specification

3.4 Order of Precedence

In case of any conflict between the contents of this document or any discrepancy between this document and other project documents or reference standards, this issue must be reported to the CLIENT. The final decision in this situation will be made by CLIENT.

4. WELDING ENGINEERING STANDARDS

Welding engineering standards cover the design of welded joints encountered by the fabricator and prepared primarily for the fabricator's engineering and drafting personnel.

The welding engineering standards typically include:

(a) Illustrated profiles of each typical joint intended for use, showing:

(i) The type of joint (eg, butt, lap, tee, corner, edge);

(ii) The type of weld;

(iii) The geometry of the preparation and fit-up;

(iv) The standard welding symbol;

(v) The range of thickness;

(b) Minimum permissible sizes of fillet and partial penetration groove welds.

Welding symbols shall be as shown in AWS Standard A2.4.

5. PRE-WELDING PROCEDURE SPECIFICATION (PWPS)

All companies applying or certified to ASME & API Standards are required to prepare and submit welding procedure specifications to the ASME & API. for acceptance A welding procedure specification (WPS) sets broad guidelines for the shop and field welding practice of the fabricator for each anticipated combination of essential variables. Welding parameters and ranges are specified and used to prepare the associated welding procedure specification.

EPC Contractor shall have welding procedure specifications for each welding process in use, outlining the general welding procedure to be followed in the construction of weldments built in accordance with the governing design or manufacturing standard, or both. Welding procedure specifications submitted for acceptance should cover as a minimum the items specified in ASME & API Standard, as applicable.

6. WELDING PROCEDURE SPECIFICATION (WPS)

A welding procedure specification (WPS) is a document, used in conjunction with a PWPS, detailing the welding parameters and ranges for welding a specific joint, over a range of thicknesses and weld sizes, as illustrated on the data sheet. Also is a written document providing direction to the welder (or welding operator). It contains all the necessary parameters v & I, joints, base metals, filler metals, positions, preheat, PWHT, gas etc. (including ranges, if any) under which the welding process must be performed. These parameters are known as variables (as per ASME Section IX). Three types of variables are mentioned in the code, these are;

- Essential Variable
- Non essential Variable
- Supplementary Essential variable

Essential Variables (For WPS – QG-105.1 & QW-251.2): A change in essential variable is considered to affect the mechanical properties (other than toughness) of the welded joint. Hence the WPS must be requalified, if the essential variable is changed.

Supplementary Essential Variables (QG-105.3 & QW-401.1): A change in the supplementary essential variable will affect the toughness properties of the joint, heat-affected zone, or base material. Hence supplementary essential variables become additional essential variables in situations where procedure qualification requires toughness testing. When procedure qualification does not require the addition of toughness testing, supplementary essential variables are not applicable.

Nonessential Variables (QG-105.4 & QW-251.3): Nonessential variables are those in which a change can be made without requalification of the existing WPS, since it is not considered to affect the mechanical properties of the joint. Though a change in the nonessential variable doesn’t require requalification of the WPS but still it should be properly addressed in the welding procedure specification (WPS).

A welding procedure specification shall contain, as a minimum, the specific essential and

nonessential variables that are applicable to the welding process. When the referencing Code, standard, or specification requires toughness qualification of the welded joint, then applicable supplementary essential variables shall also be provided in the WPS.

These variables are listed in tables from QW-252 to QW-257. Please note that for each welding process, there is a separate table containing the list of all variables. For example, list of variables (essential, nonessential and supplementary essential) for Shielded Metal Arc Welding (SMAW) is given in table QW-253.

Please see the below table (Table-1) for a complete list of welding processes and their corresponding tables for variables (as per ASME Section IX).

S.No.	Welding Process	Table
1	Oxyfuel Gas Welding (OFW)	QW-252 & QW-252.1
2	Shielded Metal Arc Welding (SMAW)	QW-253 & QW-253.1
3	Submerged-Arc Welding (SAW)	QW-254 & QW-254.1
4	Gas Metal-Arc Welding (GMAW and FCAW)	QW-255 & QW-255.1
5	Gas Tungsten-Arc Welding (GTAW)	QW-256 & QW-256.1
6	Plasma-Arc Welding (PAW)	QW-257 & QW-257.1
7	Electroslag Welding (ESW)	QW-258 & QW-258.1
8	Electrogas Welding (EGW)	QW-259
9	Electron Beam Welding (EBW)	QW-260
10	Stud Welding	QW-261
11	Inertia and Continuous Drive Friction Welding	QW-262
12	Resistance Welding	QW-263
13	Laser Beam Welding (LBW)	QW-264 & QW-264.1
14	Low-Power Density Laser Beam Welding (LLBW)	QW-264.2
15	Flash Welding	QW-265
16	Diffusion Welding (DFW)	QW-266
17	Friction Stir Welding (FSW)	QW-267

Steps to be followed for preparation of WPS:

First of all we need to identify the welding process which is to be used for example weather it's a SMAW or GMAW or GTAW or any other welding process or it's a combination of two or more welding processes. Once the welding process is decided then we need to see the corresponding table (QW-252 to QW-257) for the complete list of variables. With the help of the table we can list out all the necessary variables to be used in our WPS.
Once the minimum variables (essential, nonessential and supplementary variable, if any) are decided a preliminary WPS (or proposed WPS also known as pWPS) is prepared.

Based on the proposed WPS, Test coupon (or coupons) is prepared, and the coupon is welded as per the values (or range) provided in the pWPS. All the real time data (observed during the welding of test coupon) are recorded.
After successful welding, test coupon (or coupons) is subjected to destructive test, and if the test coupon (or coupons) meets the minimum code requirement then the same pWPS is finalized and approved for further job. In case of any change same procedure is repeated till the test coupon doesn't meet the minimum code requirement.
All the real time data during welding of test coupon and destructive test report data is compiled into one document known as Procedure qualification record (PQR).
After successful preparation of PQR, final WPS is prepared and produced to the authorized welding inspector for final approval.

Important Articles in ASME Section IX:

Article I Welding General Requirements

QW-150 Tension Tests

QW-153 Acceptance Criteria-Tension Tests

QW-160 Guided-Bend Tests

QW-163 Acceptance Criteria-Guided Bend Tests

QW-171 Toughness Tests

QW-172 Toughness Tests-Drop Weight

QW-180 Fillet-Weld Tests

QW-182 Fracture Tests

QW-183 Macro Examination-Procedure Specimens

Article II Welding Procedure Qualifications

QW-200 General

QW-210 Preparation of Test Coupon

QW-250 Welding Variables

ARTICLE III WELDING PERFORMANCE QUALIFICATIONS

QW-300 GENERAL

QW-302 TYPE OF TEST REQUIRED

QW-302.2 Volumetric NDE.

QW-302.3 Test Coupons in Pipe

QW-302.4 Visual Examination

QW-303 LIMITS OF QUALIFIED POSITIONS AND DIAMETERS

QW-303.3 Special Positions.

QW-350 WELDING VARIABLES FOR WELDERS

Article IV **Welding Data**

QW-400 Variables

QW-401.1 Supplementary Essential Variable (Procedure)

QW-402 Joints

QW-403 Base Metal

QW-404 Filler Metal

QW-405 Position

QW-406 Preheat

QW-407 Post Weld Heat Treatment

QW-408 Gas

QW-409 Electrical Characteristics

QW-410 Technique

QW-420 Base Metal Groupings

Table QW/QB-422 Grouping of Base Metals for Qualification

QW-430 F-Numbers

Table QW-432 Grouping of Electrodes and Welding Rods for Qualification

QW-440 Weld Metal Chemical Composition

Table QW-442 A-Numbers Classification of Ferrous Weld Metal Analysis for Procedure Qualification

QW-450 Specimens

Table QW-451.1 Groove-Weld Tension Tests and Transverse-Bend Tests

Table QW-451.2 Groove-Weld Tension Tests and Longitudinal-Bend Tests

Table QW-451.3 Fillet-Weld Tests

Table QW-451.4 Fillet Welds Qualified by Groove-Weld Tests

QW-461 Positions

QW-461.3 Groove Welds in Plate-Test Positions

QW-461.4 Groove Welds in Pipe-Test Positions

QW-461.5 Fillet Welds in Plate-Test Positions

QW-461.6 Fillet Welds in Pipe-Test Positions

QW-462 Test Specimen Table QW-462.1(a) to QW-462.5(e) Fig QW-463.1(a) to QW-469.2

QW-470 Etching — Processes and Reagents

7. GENRERAL INFORMATION

Company name and address

Enter the complete company name and address in this section. If the data sheets are to be used by two or more certified plants within the same company the applicable plants need to be identified in the documentation submitted.

WPS No.
Each company should have its own method of numbering welding procedure data sheets. This can range from a relatively simple consecutive number system to one that identifies the process, position, groove type and electrode. Each welding procedure data sheet number should be unique so that the WPDS can be easily referenced on production schedules, work orders, shop drawings etc.

Date and Revision
Enter the date the welding procedure data sheet was prepared and the revision number.

Reference Standards
Some welding standards that may be referenced are:

- API 1104 Welding of Pipeline and Related Facilities
- ASME BPVC Sec. IX Welding, Brazing, and Fusing Qualifications

Reference WPS
Record the welding procedure specification number that applies to this data sheet.

8. PROCESS INFORMATION

Welding Processes
The welding process to be used should be specified in this section. If two welding processes are used to weld the joint they can be each be entered in the areas identified “1” and “2”. Some of the common processes used are listed below with their corresponding letter designations:

Process	Letter Designation
Shielded Metal Arc Welding	SMAW
Gas Metal Arc Welding	GMAW
Flux Cored Arc Welding	FCAW
Metal Cored Arc Welding	MCAW
Gas Tungsten Arc Welding	GTAW
Submerged Arc Welding	SAW
Plasma Arc Welding	PAW
Electroslag Welding	ESW
Electrogas Welding	EGW
Stud Welding	SW

The letter designation may be used to identify the process.

Pulsed
If pulsed current is used check box.

Shielding Gas type
Record the complete generic composition or gas trade name as shown on the label on the gas cylinder.
Use of the generic composition is advantageous as it allows the user to change brands of shielding gas with the same composition with no required changes to the WPS.
Note: If the trade name is used, a change to another brand name, even if it is of identical composition, will require revised data sheets.

The gas manufacturer/supplier may be able to provide you with the generic composition. For gas metal arc welding, the wire is classified using 100% CO2 ; however, argon-oxygen-carbon dioxide combinations may be used based on the oxygen equivalent.

9. JOINT INFORMATION

Positions
Positions shown on the data sheet should be the production position classified as Flat (F), Horizontal (H), Vertical-Up (V-U), Vertical Down (V-D) or Overhead.

Number and letter combinations are also used to designate each welding position for quick reference. The letter G stands for groove weld, letter F for fillet weld. The numbers 1, 2, 3 and 4 correspond to flat, horizontal, vertical and overhead positions respectively. For the vertical position indicate if the progression is vertical up or vertical down.

In actual shop fabrication welding can be in any intermediate position. For detailed information on the definition of the various welding positions please consult AWS A3.0, Standard Welding Terms and Definitions.

Process mode (manual, semi-automatic, machine and auto)
One of the four process modes should be checked in this section based on the following definitions. Do not enter more than one process mode unless multiple processes are used.

Manual welding. Welding with the torch, gun or electrode holder held and manipulated by hand. Accessory equipment, such as part motion devices and manually controlled filler material feeders may be used. An example is SMAW or GTAW.

Semi-automatic welding. Manual welding with equipment that automatically controls one or more of the welding conditions. Examples are FCAW, GMAW

Machine welding (mechanized welding). Welding with equipment that requires manual adjustment of the equipment controls in response to visual observation of the welding, with the torch, gun or electrode holder held by a mechanized device. SAW is an example.

Automatic welding. Welding with equipment that requires only occasional or no observation of the welding and with no manual adjustment of the equipment controls. An example is a robotic application.

Joint type
Check the box(s) to indicate the joint type. The five basic types are butt, tee, corner, lap and edge. For definitions and details of joint type, please consult AWS A3.0, Standard Welding Terms and Definitions & AWS D1.6, Basic Joints and Preparation for Welding.

Penetration (complete, partial, ETT)
The depth of penetration of a groove weld needs to be identified.

A complete joint penetration groove weld is defined as one in which the weld metal extends through the joint thickness. This can be achieved with or without backing. If complete joint penetration is achieved the box marked “Complete” should be checked.

A partial joint penetration groove weld is one in which incomplete joint penetration exists. If this is the case the box marked “Partial” should be checked and the effective throat thickness (ETT) should be dimensioned in the space provided. The ETT may be specified as a percentage of T, eg. ETT = 0.75T.

Fillet
The box marked “fillet” should be checked if the weld is a weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap-joint, T-joint or corner joint. Joints with a groove angle greater than 135 degrees or less than 30 degrees require greater detail in the sketch (defined as skewed joints).

Backing (material and thickness)
Backing is a material or device placed against the back side of the joint adjacent to the joint root to support and shield molten weld metal.

Permanent backing is designed to remain in place as part of the finished weld.

Backings used for the welding of steels up to and including 480 MPa (70 ksi) minimum specified tensile.

QW – 402.4 requires that backings used for the welding (SMEW) of steels of over 480 MPa (70 ksi) minimum specified tensile strength and shall be of the same material as the base material.

If steel backing is used enter the material and thickness of backing in the space provided.

Non-permanent backings can be made from materials such as ceramic, copper or flux. If they are used enter the material, type and form of the backing in the space provided.

Back gouging (Yes/ No, Method, Depth)
Back gouging is 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. Methods include grinding to sound metal (GTSM), air carbon arc and plasma.

If back gouging is used, the back gouging box should be checked. The method used and the depth identified.

Back weld
A weld made at the back side of a groove weld as part of the original weld.

10. TECHNICAL DATA

Electrode extension
The electrode extension for the gas metal arc welding, flux cored arc welding, submerged arc welding processes is the length of electrode extending beyond the end of the contact tip.

The electrode extension for the gas tungsten arc welding and plasma arc welding processes is the length of electrode extending beyond the end of the collett.

Enter the electrode extension in this section. Do not leave it blank. If the information requested does not pertain to the welding process used insert N/A (Not Applicable) e.g. SMAW.

Tungsten electrodes (type, dia.)

The tungsten type and diameter used should be specified for the GTAW process. For other processes enter N/A. The choice of the type and size of tungsten electrode for a particular application depends on the operating current and current type.

Common tungsten types are listed below.

AWS CLASSIFICATION	COMMON NAME	COLOUR CODE
EWCe-2	2% Ceriated Tungsten	Orange
EWLa-1	1% Lanthanated Tungsten	Black
EWTh-1	1% Thoriated Tungsten	Yellow
EWTh-2	2% Thoriated Tungsten	Red
EWZr-1	1% Zirconiated Tungsten	Brown
EWG	Other - Needs to be Specified	Gray

Cleaning procedures

Enter the cleaning procedures used. This is particularly important for the welding of aluminum alloys because a change in cleaning method is considered an essential variable. Full details of the cleaning procedure used should be included in the corresponding welding procedure specification.

11. JOINT PREPARATION

Joint Configuration and Pass/Layer sequence

A sketch of the joint configuration with the welding symbol and a typical sequence of the layers and passes should be included in this section of the form. It is recommended that the sketch be drawn in the correct welding postion.

The joint configuration should include the following information:

- thickness of parts
- root opening
- root face
- bevel angle
- groove angle
- depth of preparation
- radius (for HSS)
- diameter (for solid bars/tubing/pipe)
- effective throat thickness (ETT)

Filler material

All filler metals and fluxes shall conform to one of the following, except as provided below:

a) AWS A5.1;

b) AWS A5.2;
c) AWS A5.5;
d) AWS A5.17;
e) AWS A5.18;
f) AWS A5.20;
g) AWS A5.23;
h) AWS A5.28;
i) AWS A5.29;
j) AWS A5.36.

Filler metals and fluxes that do not conform to the specifications listed may be used, provided they have been utilized during welding procedure qualification.

Storage and Handling Filler metals and fluxes shall be stored and handled to avoid damage to them and to the containers in which they are shipped. Filler metals and fluxes in opened containers shall be protected from deterioration, and filler metals that are coated shall be protected from excessive changes in moisture. Filler metals and fluxes that show signs of damage or deterioration shall not be used.

The following filler material groups may be used for shielded metal arc welding (SMAW):

Group	Electrode Classifications
F1	EXX22, EXX24, EXX27, EXX28
F2	EXX12, EXX13, EXX14
F3	EXX10, EXX11
F4	EXX15, EXX16, EXX18, EXX48

Filler material treatment shall be in accordance with manufacturer's recommendations and the requirements of the applicable standard.

Base material

A change from a base metal listed under one P-Number in Table QW -422 to a metal listed under another P-Number or to any other base metal. When joints are made between two base metals that have different P-Numbers, a procedure qualification shall be made for the applicable combination of P-Numbers, even though qualification tests have been made for each of the two base metals welded to itself.

12. WELDING DETAILS

Thickness

Record the thickness of material to be welded in the space provided.

Weld size/ ETT
The weld size for a fillet weld or effective throat for a groove weld should be entered in this section.

Layer and pass number
Enter the number of passes and sequence of welding.There are several ways available to determine the number of layers and passes for a WPDS including:

- The Nomograph Method
- The Mathematical Equation Method
- The Weld Calculator Program Method

These methods require you to calculate the area of weld and to select a deposition rate. Deposition rates can be found in some welding textbooks, online or from your electrode supplier.

13. WELDING PROCESSES

Process	Letter Designation
Shielded Metal Arc Welding	SMAW
Gas Metal Arc Welding	GMAW
Flux Cored Arc Welding	FCAW
Metal Cored Arc Welding	MCAW
Gas Tungsten Arc Welding	GTAW
Submerged Arc Welding	SAW
Plasma Arc Welding	PAW
Electroslag Welding	ESW
Electrogas Welding	EGW
Stud Welding	SW

Diameter

The standard units of measurement for electrode diameter are mm in SI (metric) and inch (imperial). The following shows common electrode sizes in SI (metric) and Imperial units.

INCH	MM
0.030	0.8
0.035	0.9
0.040	1.0
0.045	1.2
1/16	1.6
5/64	2.0
3/32	2.4
1/8	3.2
5/32	4.0
3/16	5.0
1/4	6.0

Be consistent with the selection of the choice of units.

Wire feed speed:
The standard units of measurement for wire feed speed are m/min in S.I. (metric) and inches/ min (imperial). A calibrated wire feed meter is preferred for measuring wire feed speed when the actual welding is in progress. If a verification of the recorded number is necessary or a wire feed meter is not available, measure the length of wire discharged from the gun for a period of 20 seconds. Multiply the length of discharged wire by 3 to give the wire feed speed in inches/minute or meters/minute. Take care to ensure that these are the real wire feed speeds and not the run in values.

Current
Current values can be found in welding textbooks, online or by contacting your electrode supplier for one of their product catalogs. The current to be used depends on many factors including electrode type, size, welding position, joint design.

Measure the amperage using a calibrated clamp type amp meter. Follow the meter manufacturer's directions and measure the amperage as close to the gun/holder as possible without interfering with the operator. This usually is about 3 or 4 feet from the gun/holder.

Voltage
When measuring voltage, different techniques can be used depending on the welding process being used. For the SMAW and GMAW processes the voltage can be taken between the cable terminals on the welding machine.

For the GMAW and FCAW processes, the voltage can be taken between the work lead at the work connection clamp and the electrode lead at the the contractor in the wire feed unit. If not practical, the voltage can also be taken between terminal or between the cable terminals on the welding machine.

For the SAW process, the voltage can be taken between the electrode lead connection at the torch and the work lead clamp.

Warning-Welding parameters should only be measured by properly trained personnel following safe work practices. Follow manufacturer's recommendations.

Current Polarity

Enter the current and polarity for the electrode, electrode-gas or electrode- flux combination being used. This information can be found in welding textbooks (CWB Learning Centre Module 4), electrode standards, online or from electrode catalogues or from your supplier.

Direct current electrode positive (DCEP) is the arrangement of direct current welding leads in which the electrode is the positive pole and the work piece is the negative pole of the welding arc. A non standard term for this is direct current reverse polarity.

Direct current electrode negative (DCEN) is the arrangement of direct current welding leads in which the electrode is the negative pole and the work piece is the positive pole of the welding arc. A non standard term for this is direct current straight polarity.

Alternating current is the current flow in an electrical circuit, usually at a pre-determined frequency.

Arc Travel Speed/ Welding Speed

The arc travel speed can be measured by recording the time taken to weld a specific length of weld, then convert the measured time and length to inches/minute or millimeters/minute. Record the calculated arc travel speed (ATS) value and not just the measured length and time. This can be done using one of the following formulas:

$$\text{ATS (ins/min)} = \frac{\text{Measured Weld Length in inches} \times 60}{\text{Measured Time in Seconds}}$$

or

$$\text{ATS (mm/min)} = \frac{\text{Measured Weld Length in millimeters} \times 60}{\text{Measured Time in Seconds}}$$

Gas flow rate

The shielding gas flow rate should be high enough to maintain adequate shielding for the arc but not so high that it causes turbulence in the weld pool. The gas flow rate to be used depends on a number of factors such as the process, welding position, shielding gas, electrode extension and operating parameters. With GTAW, flow rates are typically in the range of 15 to 20 cubic feet per hour (CFH). With GMAW and FCAW flow rates typically vary between 25 and 45 CFH depending on the factors noted above. Manufacturer's literature should be consulted for more details.

The standard units of measurement for gas flow rate are l/min in S.I. (metric) and cubic feet/ hr CFH (imperial). To convert from CFH to L/min multiply by 0.472. To convert from L/min multiply by 2.119

CFH	15	20	25	30	35	40	45
L/min.	7	9.5	12	14	16.5	19	21

Check the gas flow rate with a meter and record the rate and the unit of measurement (in brackets).

Heat input

Enter the heat input and the unit of measurement when the heat input needs to be controlled. Examples are when welding quenched and tempered steels and when specific impact properties need to be achieved. Heat input is the energy supplied by the welding arc to the work piece. The heat input is calculated using the following formula:

$$H = \frac{V \times A \times 60}{1000 \times T}$$

where:

H = heat input (kJ/in or kJ/mm)

V = arc voltage (volts)

A = current (amps)

T = travel speed (in/min or mm/min)

14. HEAT TREATMENT

For preheat or interpass temperatures refer to the applicable table in the handbooks welding & API 1104 Rev.2021. Alternatively enter the values in Centigrade or Fahrenheit. This box cannot be left empty or marked as ambient or not applicable (N/A).

If a post weld heat treatment is used the temperature and time should be recorded.

Preheat temperatures:
The minimum temperature of the base material in the volume surrounding the point of welding immediately before welding is started. In a multipass weld, it is also the minimum temperature immediately before the second and subsequent passes are started.

Interpass temperatures:
The temperature at a location near the start position of the welding arc(s) recorded immediately before initiating the next pass or passes (multi-arc processes).

The method of heating and minimum preheat temperature immediately before welding is started shall be specified. The maximum interpass temperature shall be specified.

The methods, width to be heated, minimum preheat temperature, minimum ambient temperature below which preheat is required (if applicable), and maximum interpass temperature shall be specified in the WPS.

Post Heat:
Heating a completed weld to temperatures intended to accelerate hydrogen diffusion.
Note: Post heat is not PWHT (see 3.1.38) Standard API 1104 Rev.2021.

When used during qualification, the minimum temperature and time at temperature range of any postheating for hydrogen diffusion shall be specified.

Post Weld Heat Treatment (PWHT):
Heating a completed weld to temperatures intended to result in stress relief tempering, normalizing, or other metallurgical changes.

The details of the PWHT procedure shall be specified in the WPS. PWHT procedures shall include method of application, heating rate, temperature range, Time at temperature, and cooling rate.

15. ADDITIONAL REMARKS

Any additional remarks or requirements should be added in this section. It can also be used for notes if there is insufficient space in other sections of the welding procedure data sheet form. Examples are details of pulsed welding or welding techniques such as stringer or weave beads.

16. SUBMISSION OF WELDING PROCEDURES

A WPS can be accepted based on the following:

• The joint geometry and parameters are specified by the governing standard to be prequalified
• The company has previous procedure qualification test data recorded on a PQR (procedure qualification record)
• By successfully passing procedure qualification tests conducted in accordance with the requirements of the applicable standard
• By successfully passing procedure qualification tests conducted in accordance with other recognized specifications or standards
• By successfully passing a special procedure qualification test recorded on a PQR (an alternative type test)

The requirements for procedure qualification testing will be identified by the Procedure Engineer in a letter sent to the client.

17. REVIEW AND APPROVAL OF WELDING PROCEDURES

General

Each submission is reviewed by a Procedure Engineer based on the requirements of the applicable standards and/or codes. The applicable standard and/ or code must be referenced on the document submitted.

The Procedure Engineers use their professional discretion when reviewing all documents to ensure that they are feasible and meet the requirements as set out in the certi cation standards.

When a Welding Procedure Data Sheet meets all prequalied requirements but does not seem feasible, soundness tests are required.

In cases not directly covered by the certi cation standards, the Procedure Engineers apply the general concepts of the standard combined with the requirements of other relevant standards and codes to complete the review and approval process

18. WELDING PROCEDURE SPECIFICATIONS QUALIFIED

Welding procedure specifications that satisfy the requirements specified in the applicable standard are stamped accepted.

Welding procedure specifications submitted for approval shall include, as a minimum, the applicable essential variables of the governing design or manufacturing standard.

Prequalified Joints: Welding procedure data sheets, using joints designated as prequalified in the governing standard, can be accepted by the Client as prequalified without further testing by the company, provided all other requirements of the governing standard have been met. Examples of governing standards that designate joints as prequalified are AWS Code D1.1.

Approval using the Client database:
Welding procedure data sheets that are not prequalified in the governing standard can be accepted by the Client if sufficient relevant testing information has been accumulated by the Client. The Client reviews all submitted Welding Procedure Specification that are not prequalified against the information in our database. This database contains procedure qualification tests completed by companies, and if sufficient information is found, acceptance can be granted without procedure testing. Welding Procedure Specification that satisfy these requirements are stamped accepted on the basis of previous tests accumulated by the Client.

Non Prequalified Joints - Procedure Testing:
Welding procedure data sheets that are not prequalified in the governing standard can be accepted by the Bureau if relevant procedure qualification testing is completed by the company and witnessed by the Client. The requirements for procedure qualification testing are identified by the Procedure Engineer in a letter sent to the client. Welding procedure Specification.

That are successfully tested are stamped accepted to the applicable standard on the basis of procedure qualification.

More than one qualification standard/code specified on the Welding Procedure Data Sheet:
If there is more than one standard/code, the requirements of all specified standards/codes must be met. For example: A fillet weld Welding Procedure Specification with both ASME BPVC Sec. IX and AWS D1.1 , will required 3 macro-etch tests.

The following checklist can be used for completing welding procedure data sheets.

WELDING PROCEDURE DATA SHEET ITEM	SMAW	GMAW	FCAW	MCAW	GTAW	SAW
General Information						
Company name and address	X	X	X	X	X	X
WPDS No.	X	X	X	X	X	X
Date and Rev	X	X	X	X	X	X
Process Information						
Reference Standards	X	X	X	X	X	X
Welding Process	X	X	X	X	X	X
Pulsed current		X	X	X	X	
Shielding gas type		X	X	X	X	
Joint Information						
Positions	X	X	X	X	X	X
Process mode	X	X	X	X	X	X
Joint type	X	X	X	X	X	X
Penetration	X	X	X	X	X	X
Fillet	X	X	X	X	X	X
Backing material and thickness	X	X	X	X	X	X
Back gouging	X	X	X	X	X	X
Technical information						
Electrode extension		X	X	X		X
Flux classificatio						X
Tungsten electrode					X	
Cleaning	X	X	X	X	X	X
Joint preparation						
Joint configuration joint type	X	X	X	X	X	X
Base and ller material						
Identificatio to standard or group	X	X	X	X	X	X
Identificatio of fille material	X	X	X	X	X	X
Welding details						
Thickness	X	X	X	X	X	X
Weld size	X	X	X	X	X	X
Layers	X	X	X	X	X	X
Pass No.	X	X	X	X	X	X

WELDING PROCEDURE DATA SHEET ITEM	SMAW	GMAW	FCAW	MCAW	GTAW	SAW
Welding Process	X	X	X	X	X	X
Diameter	X	X	X	X	X	X
Wire feed speed		X	X	X		X
Voltage	-	X	X	X	-	X
Current, Current Type/ polarity	X	X	X	X	X	X
Arc travel speed	-	X	X	X	-	X
Gas flo rate		X	X	X	X	X
Additional items						
Heat treatment/ preheat/ interpass	X	X	X	X	X	X
Additional remarks						
Company authorization	X	X	X	X	X	X
Charpy V-notch						
Reference standard	X	X	X	X	X	X
Heat input	X	X	X	X	X	X
Stringer or weave bead	X	X	X	X	X	X
Arc Spot welds						
Visible diameter	X				X	
Coating thickness	X				X	

Welding Procedure Specification According to API 1104 Rev. 2021

WELDING PROCEDURE SPECIFICATION

WPS Number _____

Process(es)/Method of Application _____

Material grade(s) _____

Outside diameter _____ Wall thickness _____

Joint type _____ Bevel angle _____

Backing type (if applicable) _____ Roll or fixed position _____

Direction of welding _____ Number of welders _____

Preheat temperature _____ Interpass Temperature _____

Method of Heating _____

Filler metal(s) and Flux _____

Flame characteristics _____ Cleaning and/or grinding tools _____

Type and removal of lineup clamp _____ Minimum number of passes _____

Maximum time between root pass and start of the second pass _____ Maximum time between second pass and start of third pass _____

Method of cooling _____ PWHT procedure _____

JOINT DESIGN

SEQUENCE OF BEADS

WELDING PARAMETERS

Pass	Process / Electrical Characteristics	Filler Metal Group or Classification	Electrode Size	Shielding Gas Type and Flow Rate or Shielding Flux	Voltage Range	Amperage Range	Travel Speed Range	Heat Input Range
Root Bead								
Second Bead								

Note: Number of weld beads are not intended to be limited by this table and the table should be adjusted to present all required passes.

Supporting qualification weld report No(s). _____

Approved by: _____

Welding Procedure Specification According to ASME Sec.IX Rev. 2021

FORM QW-482 SUGGESTED FORMAT FOR WELDING PROCEDURE SPECIFICATIONS (WPS)
(See QW-200.1, Section IX, ASME Boiler and Pressure Vessel Code)

Organization Name _____ By _____

Welding Procedure Specification No. _____ Date _____ Supporting PQR No.(s) _____

Revision No. _____ Date _____

Welding Process(es) _____ Type(s) _____
(Automatic, Manual, Machine, or Semi-Automatic)

JOINTS (QW-402) Details

Joint Design _____

Root Spacing _____

Backing: Yes _____ No _____

Backing Material (Type) _____
(Refer to both backing and retainers)

☐ Metal ☐ Nonfusing Metal

☐ Nonmetallic ☐ Other

Sketches, Production Drawings, Weld Symbols, or Written Description should show the general arrangement of the parts to be welded. Where applicable, the details of weld groove may be specified.

Sketches may be attached to illustrate joint design, weld layers, and bead sequence (e.g., for toughness procedures, for multiple process procedures, etc.)

*BASE METALS (QW-403)

P-No. _____ Group No. _____ to P-No. _____ Group No. _____

OR

Specification and type, grade, or UNS Number _____

to Specification and type, grade, or UNS Number _____

OR

Chem. Analysis and Mech. Prop. _____

to Chem. Analysis and Mech. Prop. _____

Thickness Range:

Base Metal: Groove _____ Fillet _____

Maximum Pass Thickness ≤ 1/2 in. (13 mm) (Yes) _____ (No) _____

Other _____

*FILLER METALS (QW-404)	1	2
Spec. No. (SFA)		
AWS No. (Class)		
F-No.		
A-No.		
Size of Filler Metals		
Filler Metal Product Form		
Supplemental Filler Metal		
Weld Metal Deposited Thickness: Groove Fillet		
Electrode-Flux (Class)		
Flux Type		
Flux Trade Name		
Consumable Insert		
Other		

*Each base metal-filler metal combination should be specified individually.

(07/17)

POSITIONS (QW-405)
Position(s) of Groove _____
Welding Progression: Up _____ Down _____
Position(s) of Fillet _____
Other _____

PREHEAT (QW-406)
Preheat Temperature, Minimum _____
Interpass Temperature, Maximum _____
Preheat Maintenance _____
Other _____
(Continuous or special heating, where applicable, should be specified)

POSTWELD HEAT TREATMENT (QW-407)
Temperature Range _____
Time Range _____
Other _____

GAS (QW-408)

	Gas(es)	Percent Composition (Mixture)	Flow Rate
Shielding			
Trailing			
Backing			
Other			

ELECTRICAL CHARACTERISTICS (QW-409)

Weld Pass(es)	Process	Filler Metal		Current Type and Polarity	Amps (Range)	Wire Feed Speed (Range)	Energy or Power (Range)	Volts (Range)	Travel Speed (Range)	Other (e.g., Remarks, Comments, Hot Wire Addition, Technique, Torch Angle, etc.)
		Classification	Diameter							

Amps and volts, or power or energy range, should be specified for each electrode size, position, and thickness, etc.

Pulsing Current _____ Heat Input (max.) _____
Tungsten Electrode Size and Type _____
(Pure Tungsten, 2% Thoriated, etc.)
Mode of Metal Transfer for GMAW (FCAW) _____
(Spray Arc, Short-Circuiting Arc, etc.)
Other _____

TECHNIQUE (QW-410)
String or Weave Bead _____
Orifice, Nozzle, or Gas Cup Size _____
Initial and Interpass Cleaning (Brushing, Grinding, etc.) _____
Method of Back Gouging _____
Oscillation _____
Contact Tube to Work Distance _____
Multiple or Single Pass (Per Side) _____
Multiple or Single Electrodes _____
Electrode Spacing _____
Peening _____
Other _____