

Evaluation of Welding Requirements as Applicable to API Product Specifications

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Contents

	Page	
1 Scope	1	
2 Normative References	1	
3 Terms, Definitions, and Abbreviations	2	
3.1 Terms and Definitions	2	
3.2 Abbreviated Terms	2	
4 Application	2	
5 Approach	3	
5.1 General	3	
5.2 Welding Requirements Identified in API Product Specifications	3	
5.3 API Specification Q1 Requirements	3	
5.4 API Monogram Program Advisories	4	
5.5 Oil and Gas Industry-Related Welding Activities	4	
5.6 Welding Performed After Manufacturing	4	
5.7 The Use of National Welding Codes & Standards	5	
6 Development of Benchmark Criteria	5	
7 Performance of Gap Analyses	6	
8 Results of Analyses, Including Recommendations	6	
9 Information Applicable to all API Product Specifications Reviewed	7	
10 Summary	9	
Tables		
1 API Product Specifications Evaluated	10	
2 Welding Benchmark Criteria	11	
3 API Q1 Requirements for Processes Requiring Validation (e.g. welding)	11	
4 Types of Welding Processes Included	12	
Annex A (informative) Welding Requirement Spreadsheets		13
Specification 2C—Specification for Offshore Pedestal-mounted Cranes	14	
Specification 4F—Specification for Drilling and Well Servicing Structures	15	
Specification 5CT—Specification for Casing and Tubing	16	
Specification 5DP—Specification for Drill Pipe	17	
Specification 5L—Specification for Line Pipe	18	
Specification 5LC—CRA Line Pipe	19	
Specification 6A—Specification for Wellhead and Christmas Tree Equipment	20	
Specification 6D—Specification for Pipeline Valves	21	
Specification 6DSS—Specification for Subsea Pipeline Valves	22	
Specification 7-1—Specification for Rotary Drill Stem Elements	23	
Specification 7K—Drilling and Well Servicing Equipment	24	
Specification 8C—Specification for Drilling and Production Hoisting Equipment (PSL 1 and PSL 2)	25	
Specification 14A—Specification for Subsurface Safety Valve Equipment	26	
Specification 14L—Specification for Lock Mandrels and Landing Nipples	27	
Specification 16A—Specification for Drill-through Equipment	28	
Specification 16C—Choke and Kill Systems	29	
Specification 16D—Specification for Control Systems for Drilling Well Control Equipment	30	

Contents

	Page
Specification 17D—Specification for Subsea Wellhead and Christmas Tree Equipment	31
Specification 19G1—Side-pocket Mandrels	32
Bibliography	33

Introduction

This Task Group reviewed specific API Specifications to identify consistency of referenced welding requirements. It was determined that some requirements were more consistently referenced, while others were inconsistently referenced. The requirements were grouped into those consistently noted or not, to allow the API Specification Chairs to identify and address these gaps as appropriate.

The API Product Specifications selected for use in this document are a result of agreement between the API staff and Subcommittee 18, Task Group for Welding TG 6 (hereafter known as TG 6). There is no attempt made to evaluate all product specifications. The specifications are selected based upon:

- a) criticality of the products identified within the specifications;
- b) welding processes already identified within the specifications;
- c) different types of welding processes identified between the specifications.

The members of TG 6 were experienced professionals, with welding, materials, and/or engineering experience, background, and knowledge.

The following is the charge provided by Subcommittee 18 to TG 6:

“To review all API Product Specifications and Recommended Practices and to cross-functionally identify requirements for welding, brazing, and soldering; the purpose is to identify criteria to be recommended for use in where these processes are required.”

Additionally, further clarification was provided to TG 6:

To identify for the API Monogram Program Product Specification Subcommittee chairpersons the following for their use in the future revision of API Product Specifications that address welding:

- rationale and methodology used to illustrate the differences in welding requirements between sample product specifications;
- information that would assist in the creation of robust welding requirements across the API Monogram Program product specifications and recommended practices.

NOTE While the API Recommended Practices were included the charge, direction was provided by Subcommittee 18 to address them at a later date.

By nature, Technical Reports are not auditable documents; therefore, there is no intention for this Technical Report to be used to perform audits.

Evaluation of Welding Requirements as Applicable to API Product Specifications

1 Scope

This Technical Report is a result of an evaluation of the consistency of welding requirements between API Product Specifications that are primarily used in exploration and production. The intent of the evaluation was to identify a means to standardize welding requirements across API Product Specifications.

The product specifications selected are identified in Table 1.

2 Normative References

The following documents contain provisions that, through reference in this text, constitute provisions of this Technical Report. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

API Advisory 8¹, *Implementation and Maintenance of Quality Management System*

API Product Specifications—see Table 1, *API Product Specifications Evaluated*

API Specification Q1, 8th Edition, *Specification for Quality Programs for the Petroleum, Petrochemical and Natural Gas Industry*

API Specification Q1, 9th Edition, *Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry*

ASME Section IX², *ASME Boiler and Pressure Vessel Code (BPVC), Section IX: Welding, Brazing, and Fusing Qualifications: Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing and Fusing Operators*

ASNT-TC 1A³, *Personnel Qualification and Certification in Nondestructive Testing*

AWS D1.1⁴, *Structural Welding Code - Steel*

AWS B2.3, *Specification for Soldering Procedure and Performance Qualification*

AWS A3.0, *Standard Welding Terms and Definitions—Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*

IPC-A-610, Cl. 2⁵, *Acceptability of Electrical Assemblies*

IPC-A-620, *Requirements and Acceptance for Cable and Wire Harness Assemblies*

ISO 9001:2008⁶, *Quality management systems—Requirements*

¹ American Petroleum Institute, 1220 L Street NW, Washington, DC 20005.

² ASME International, 345 East 47th Street, New York, New York 10017-2392.

³ American Society for Nondestructive Testing, 4153 Arlingate Plaza, Columbus, Ohio 43228-0518.

⁴ American Welding Society, 550 Northwest LeJeune Road, Box 351040, Miami, Florida 33135.

⁵ Association Connection Electronics Industries, 3000 Lakeside Drive, 105 N, Bannockburn, IL 60015.

⁶ International Organization for Standardization (ISO), 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland.

3 Terms, Definitions, and Abbreviations

3.1 Terms and Definitions

For the purposes of this Technical Report, the following terms and definitions apply:

3.1.1

brazing and soldering

Processes used to join metals by thermal input, with filler materials, as defined by AWS A3.0.

3.1.2

welding

Process used to join metals by thermal input, with or without filler materials, as defined by ASME Section IX and/or AWS D1.1.

NOTE Processes and applications may also include ERW seam welding, hard surfacing, and hard banding.

3.1.3

welding benchmark criteria

Criteria developed by TG 6 that was subsequently used to perform gap analyses against the selected API Product Specifications (see Table 1).

3.2 Abbreviated Terms

API	American Petroleum Institute
ASME	American Society of Mechanical Engineering
AWS	American Welding Society
ERW	Electric Resistance Welding
ISO	International Organization for Standardization
PQR	Procedure Qualification Record
TG	Task Group
TR	Technical Report
WPS	Weld Procedure Specification

4 Application

4.1 This Technical Report is intended to be used as a guideline for:

- the incorporation of technical welding requirements into API Product Specifications;
- the creation or modification of welding controls by manufacturers and/or fabricators;
- the identification of welding methodologies that are not currently addressed in API Product Specifications;
- organizations working to the quality management system requirements of [API Specification Q1](#) in conjunction with or independent of the API Monogram Program;

- e) organizations that primarily focus on national welding codes and standards other than ASME Section IX and/or AWS D1.1, even though these requirements (ASME/AWS) may be specified in API Product Specifications;
- f) providing a better understanding of welding to auditors who audit API specified requirements, such as:
 - API Product Specification requirements;
 - [API Specification Q1](#), *Specification for Quality Programs for the Petroleum, Petrochemical and Natural Gas Industry*;
 - API Advisory 8 requirements;
 - conformity to ASME Section IX and/or AWS D1.1 through the use of national or regional welding criteria.

4.2 This Technical Report could be used to harmonize welding requirements across all API Product Specifications and/or Recommended Practices, with the mitigation of risk associated with welding processes in mind.

4.3 The consideration and implementation of the comprehensive requirements of this Technical Report could assist user organizations to achieve a robust welding program.

5 Approach

5.1 General

The approach used to develop the Welding Benchmark Criteria (Table 2) included the following considerations and activities (clauses 5.2 through 5.7):

5.2 Welding Requirements Identified in API Product Specifications

A cursory analysis of the selected API Product Specifications (Table 1) concluded that there would be minimal value in creating a matrix of the welding requirements currently specified in existing documents.

Purpose: Existing specification requirements were perceived as being inconsistently deployed between API Product Specifications. Specifications such as [API 6A](#) included robust, detailed requirements, whereas specifications such as [API 2C](#) contained lesser, high-level requirements.

5.3 [API Specification Q1](#) Requirements

The requirements of [API Specification Q1](#), 8th Edition and 9th Edition, were considered during the development of the output shown in this Technical Report. Table 3 identifies the Q1 requirements for the validation of welding processes.

Purpose: There is a direct interaction of the Q1 quality management system requirements and the welding processes identified in API Product Specifications and/or the requirements for the organizations that perform welding, whether licensed under the API Monogram Program or that have a quality management system certification to Q1 and/or ISO 9001.

5.4 API Monogram Program Advisories

The requirements of the API Monogram Program Requirements, Advisory 8, *Implementation and Maintenance of Quality Management System Requirements*, were considered since this advisory requires licensees to apply their quality management system requirements to non-monogrammmable products if said products are to be used in the oil and gas industries. Shown below is a partial excerpt of Advisory 8's wording:

"It is a program requirement that all licensees must maintain a quality program in conformance with the requirements of [API Specification Q1](#) for all products at all times. All API product specification requirements are applicable to the specific products manufactured and/or services provided in conformance with those specifications, including API-monogrammed equipment. However, a quality management system in conformance with the [API Spec Q1](#) is to be applied to all products and services of the petroleum, petrochemical and natural gas industries, at all times, whether or not these products or services carry the API Monogram. This policy is in accordance with the API's objective of supporting a high standard of quality, environmental, and health performance expectations for the petroleum, petrochemical and natural gas industry."

Purpose: To provide structure to the auditing of non-API monogrammmable product (i.e. not under an API Product Specification license) where welding is performed.

5.5 Oil and Gas Industry-Related Welding Activities

The emphasis on this evaluation considered the welding activities, as defined by the API Product Specifications reviewed in Table 1, for API Monogram Program licensees and those organizations that have a Quality Management System Certification through API Quality Registrars for [API Q1](#) and/or ISO 9001.

Table 4 identifies the types of welding processes included as part of this Technical Report. Welding activities such as hard banding, hard surfacing, and other processes are being used on product (e.g. drill stem subs, stabilizers) which is typically performed by [API Specification 7-1](#) licensees as part of their offering to a customer.

Purpose: Welding activities, whether or not addressed in an API Product Specification, have the potential to have an impact upon product use.

5.6 Welding Performed After Manufacturing

The following welding activities were not considered as part of the TG 6 assignment, since there is no direct API overview through the API Monogram Program or API Quality Registrars.

- a) Welding and/or repair welding on products manufactured under API Product Specifications after initial manufacturing and/or monogramming as directed by customers; for example:
 - at the manufacturer's facilities;
 - at a supplier's facility;
 - at a third-party facility.
- b) field welding on a manufactured product that contains an API Monogram;
- c) welding occurring independent from the manufacturer as a "service" to the end-user during or related to the (re) installation process;

- d) Welding being performed by the manufacturer as a “service” to the end-user during or related to the (re) installation process as part of their contract.

5.7 The Use of National Welding Codes & Standards

The evaluation of welding criteria also included the identification of international codes and standards identified in API Product Specifications other than ASME Section IX and/or AWS D1.1.

Purpose: Since a large percentage of the API Monogram Program licensees and quality management system certificate holders are located outside of the United States, manufacturers and fabricators routinely defer to their national welding criteria. While there are no high-level requirements identified for use of alternate codes or standards, the licensees remain responsible for demonstrating compatibility of national standards with those specified in API Product Specifications.

This Technical Report, including its attachments, provides the reader and API auditors product specification gap analyses from which to determine the level of conformity of a licensee’s welding program, particularly where international welding codes or standards are used in lieu of ASME Section IX and/or AWS D1.1.

6 Development of Benchmark Criteria

Development of criteria for the evaluation of API Product Specifications included the following activities:

- a) Since the identified API Product Specifications (Table 1) did not consistently address welding requirements, the TG brainstormed and identified high-level criteria that, if implemented, would result in a robust welding program.
- b) The TG’s efforts resulted in the identification of Welding Benchmark Criteria (see Table 2).
- c) The intent of the Welding Benchmark Criteria was to address the requirements of:
 - API Product Specifications;
 - ASME Section IX or AWS D1.1;
 - Customers.
- d) The Welding Benchmark Criteria considered widely used welding codes/standards and determined that ASME Section IX and AWS D1.1 should be used, since these requirements are identified in the majority of API Product Specifications where welding is identified.
- e) Thereafter, the TG created a matrix for aligning the requirements of the benchmark criteria to the specified requirements of ASME Section IX and AWS D1.1 where such requirements existed.
- f) This information was illustrated on a spreadsheet; the “X” (horizontal axis) identified the benchmark criteria, whereas the “Y” axis (vertical axis) identified the ASME and AWS requirements in their own set of rows.
- g) This effort resulted in a template that was subsequently used to perform gap analyses of the API Product Specifications shown in Table 2.

7 Performance of Gap Analyses

The gap analyses were performed by TG 6 members and included the following activities:

- a) Once the Welding Benchmark Criteria and gap analysis template were developed, gap analyses were performed.
- b) The API Product Specifications identified in Table 1 were assigned to TG members with experience in those specifications to perform a gap analysis on each of the specifications assigned to them.
- c) Upon completion of the gap analyses, the results were subsequently reviewed by a TG peer group to ensure that the recorded information was accurate.
- d) The gap analyses results are illustrated in Attachments 1 through 19.

8 Results of Analyses, Including Recommendations

8.1 The TG suggests that the information identified in this Technical Report and in its attachments be used by API Subcommittee chairpersons to improve API Product Specifications that contain requirements for welding.

8.2 In order to standardize welding performance of API Monogram Program licensees and API Quality Registrar certified organizations, the TG also recommends that auditors who audit welding requirements receive specific training in the requirements and output identified within this Technical Report and its attachments, including any API Product Specifications revised as a result of the TG's activities.

8.3 The gap analysis results identified gaps between the Welding Benchmark Criteria (Table 2) and the API Product Specifications (Table 1) reviewed.

Subsequently, the following activities were performed:

- The comprehensive results were evaluated. Upon evaluation, the gap analysis results were broken out into three (3) specific groups.
 - **Group 1:** Information that had a direct relationship to welding requirements identified in API Product Specifications reviewed; this information was found to be the most commonly referenced information amongst the product specifications reviewed, and is included in the first and/or second section of each of the attachments to this report.

NOTE Where ASME and AWS were applicable, there will be two (2) tabs identifying each of the code names. However, if one or the other is applicable to a specific API Product Specifications, then either ASME or AWS will be identified as applicable.

The relevant criteria from Table 2, Welding Benchmark Criteria, are as follows:

- i) PQR
- ii) WPS
- iii) Welder Qualification
- iv) Welder Continuity

- **Group 2:** Information that was found to be inconsistently referenced amongst the product specifications reviewed and is included in a tab entitled “Comparative References” in the attachments to this report.

The relevant criteria from Table 2, Welding Benchmark Criteria, are as follows:

- i) Welding Equipment Approval
 - ii) Calibration of Monitoring and Measuring Equipment
 - iii) Control and Issuance of Consumables
 - iv) Weld Repair
 - v) Post-Weld Heat Treatment
 - vi) Weld Acceptance Criteria
- **Group 3:** Information that was applicable to the quality aspects of the API Product Specifications reviewed (see Table 1). This information is further addressed in the content of this Technical Report.

The relevant criteria from Table 2, Welding Benchmark Criteria, are as follows:

- i) Linkage to Q1
- ii) Traceability
- iii) NDT Personnel Certification
- iv) Welding Program Revalidation
- v) Records

8.4 The Group 1 and Group 2 output have been included in the attachments to this Technical Report. Color coding of the attachments indicates:

- a) Separation of Benchmark Criteria columns are shown in light-blue highlighting.
- b) Blue text identifies the information contained in the applicable API Product Specification where the said information aligned with Benchmark Criteria.
- c) Where there is a missing requirement, “Requirement Not Specified” is shown in red text, which includes a dashed “X” over the wording.
- d) Where Benchmark Criteria does not exist, the cell was highlighted gray.

9 Information Applicable to all API Product Specifications Reviewed

The following topics are applicable to all API Product Specifications reviewed (see Table 1). Users of this Technical Report should consider the following:

- a) Linkage to Q1, 9th Edition—While arguably the majority of Q1 criteria could apply to welding activities, the following Q1 criteria may provide risk-mitigation considerations and have a direct impact upon the implementation and the welding program:
- 4.4.3, Control of Documents
 - 4.4.4, Use of External Documents in Product Realization
 - 4.4.5, Control of Records
 - 5.6.1, Purchasing Control, Qualified Mechanical Test Laboratory, NDT Companies, Calibration Companies, Electrode Suppliers, Third-Party Welding Services and/or Consulting Companies
 - 5.8, Control of Testing, Measuring, and Monitoring Equipment
 - 6.3, Analysis of Data
 - 6.5, Management Review
- b) Traceability
- Welds should be traceable to the welder as required by the API Product Specification.
- c) NDT Personnel Certification
- Evaluation for acceptance or rejection should be performed by an NDT Level II at a minimum.
 - Visual inspection personnel should have an AWS CWI or CAWI; ASNT-TC 1A Level II; or equivalent qualification.
- d) Welding Program Revalidation
- Change of code issuance/requirement; for example, review of WPSs and welder qualifications for compliance to most current issuance or as defined by the applicable API Product Specification.
 - WPS evaluation (i.e. need for change); for example:
 - analysis of performance data;
 - equipment changes;
 - personnel qualification;
- e) Records
- The following records should be maintained:
 - results of PQR testing;
 - welder qualification;
 - welder continuity;

- calibration;
- post-weld heat treatment;
- NDT results;
- NDT personnel certification.

NOTE The applicable API Product Specification should be consulted, since they typically identify record-retention requirements.

10 Summary

TG 6 has identified that gaps do exist for welding requirements between the API Product Specifications reviewed, listed in Table 1. Through the gap analyses (attachments), TG 6 has been able to determine, define, and group the processes as shown in Section 8.3, Groups 1, 2, and 3, and in Table 2. The most consistently mentioned welding requirements are in Group 1, and the least consistent are in Group 2. Also noted is that quality management system requirements are seldom identified in API Product Specifications, as shown in Group 3.

Table 1—API Product Specifications Evaluated

Item #	API product specification	Title	Edition	Addendum/Errata
1	2C	<i>Specification for Offshore Pedestal-mounted Cranes</i>	6 th	
2	4F	<i>Specification for Drilling and Well Servicing Structures</i>	3 rd	
3	5CT	<i>Specification for Casing and Tubing</i>	9 th	
4	5DP	<i>Specification for Drill Pipe</i>	1 st	
5	5L	<i>Specification for Line Pipe</i>	44 th	Addendum 3/Errata 1
6	5LC	<i>CRA Line Pipe</i>	3 rd	
7	6A	<i>Specification for Wellhead and Christmas Tree Equipment</i>	20 th	Addendum 1/Errata 2
8	6D	<i>Specification for Pipeline Valves</i>	22 nd	Addendum 1 and 2
9	6DSS	<i>Specification for Subsea Pipeline Valves</i>	2 nd	Errata 1 and 2
10	7-1	<i>Specification for Rotary Drill Stem Elements</i>	1 st	Addendum 3
11	7K	<i>Drilling and Well Servicing Equipment</i>	5 th	
12	8C	<i>Specification for Drilling and Production Hoisting Equipment (PSL 1 and PSL 2)</i>	4 th	Addendum 2
13	14A	<i>Specification for Subsurface Safety Valve Equipment</i>	11 th	
14	14L	<i>Specification for Lock Mandrels and Landing Nipples</i>	2 nd	
15	16A	<i>Specification for Drill-through Equipment</i>	3 rd	
16	16C	<i>Choke and Kill Systems</i>	1 st	
17	16D	<i>Specification for Control Systems for Drilling Well Control Equipment</i>	2 nd	
18	17D	<i>Design and Operation of Subsea Production Systems—Subsea Wellhead and Tree Equipment</i>	2 nd	Errata, September 2011
19	19G1	<i>Side-pocket Mandrels</i>	1 st	

NOTE Soldering was also included in the evaluation of welding requirements; see Table 4 for further information.

Table 2—Welding Benchmark Criteria

Item #	Criteria	Group
1	PQR	1
2	WPS	
3	Welder Qualification	
4	Welder Continuity	
5	Welding Equipment Approval	2
6	Calibration of Monitoring and Measuring Equipment	
7	Control and Issuance of Consumables	
8	Weld Repair	
9	Post-Weld Heat Treatment	
10	Weld Acceptance Criteria	
11	Linkage to Q1	3
12	Traceability	
13	NDT Personnel Certification	
14	Welding Program Revalidation	
15	Records	

Table 3—API Q1 Requirements for Processes Requiring Validation (e.g. welding)

Item #	Q1, 8 th Edition Validation of Processes for Production and Service Provision (Clause 7.5.2)	Q1, 9 th Edition Validation of Processes for Production and Servicing (Clause 5.7.1.5)
1	Defined criteria for review and approval of the processes	Identification of acceptance criteria
2	Approval of equipment and qualification of personnel	Required equipment; qualification of personnel
3	Use of specific methods and procedures	Use of specific methods, including identified operating parameters
4	Requirements for records	Requirements for records
5	Revalidation	Revalidation

Table 4— Types of Welding Processes Included

1.	Welding processes covered by ASME Section IX and AWS D1.1
2.	Brazing
3.	Hard-Facing Overlay
4.	Corrosion-Resistant Overlay
5.	Rotary Friction Welding (direct drive or inertia)
6.	Electric Resistance Welding
7.	Soldering*
8.	Hard Surfacing
9.	Hard Banding

* Guidance on soldering may be found in the following codes/standards:.

- AWS B2.3, Specification for Soldering, Procedure & Performance Qualification
- IPC-A-610, Cl. 2 Acceptability of Electrical Assemblies
- IPC-A-620, Requirements & Acceptance for Cable & Wire Harness Assemblies

Annex A
(informative)

Welding Requirement Spreadsheets

Specification 2C
Specification for Offshore Pedestal-mounted Cranes

No Requirements Specified for ASME

SPEC.	API Spec. 2C	EDITION	6TH	ADDENDUM / ERRATA	N/A	WELDING CODE	ASME Section IX
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Key:
 Black Text: Reference Document Language
 Red Text: Missing Requirement
 Blue Text: API Product Language

Line Item #	PQR		WPS		Welder Qualification		Welder Continuity	
1	Documented PQR QW 483 minimum	Requirement Not Specified	Documented WPS QW 482 minimum	Requirement Not Specified	Documented Welder Process Qualification with all required essential variables: Article III, QW 300	Requirement Not Specified	QW322 Maintain Welder Continuity	Requirement Not Specified
2	QW 250 Essential & Supplemental Essential Variables	Requirement Not Specified	QW 250 Essential & Supplemental Essential Variables	Requirement Not Specified	Welder Qualification shall be performed in accordance with a qualified WPS with all essential variables satisfied: QW 350	Requirement Not Specified		
3	Testing Requirements QW 450	Requirement Not Specified	Additional Customer Requirements	Requirement Not Specified	Additional Customer Requirements	Requirement Not Specified		
4	Additional Customer Requirements	Requirement Not Specified	Verify correct WPS is available at point of use	Requirement Not Specified	Documented Welder Qualification Program	Requirement Not Specified		
5			Continual monitoring required	Requirement Not Specified				

SPEC.	API Spec. 2C	EDITION	6TH	ADDENDUM / ERRATA	NA	WELDING CODE	AWS D1.1
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Key:
 Black Text: Reference Document Language
 Red Text: Missing Requirement
 Blue Text: API Product Language

Line Item #	PQR		WPS		Welder Qualification		Welder Continuity	
1	Documented PQR Annex N minimum	Requirement Not Specified	Documented WPS Annex N minimum	Requirement Not Specified	Documented Welder Process Qualification with all required essential variables: Clause 4, Part C	15.3 Welder Performance The performance of welders shall be verified by destructive testing or by radiographic examination. Radiographic examination shall be limited to groove welds using the shielded metal-arc, submerged-arc, gas tungsten-arc, gas metal-arc (globular arc, spray arc or pulsating arc only) and flux cored arc processes. The performance of welders employing shortcircuiting (short-arc) gas metal arc welding processing shall be qualified by destructive testing only.	Maintain Welder Continuity, Clause 6, 6.4, 6.4.3	Requirement Not Specified
2	Essential & Supplemental Essential Variables: Table 4.5 & 4.6	Requirement Not Specified	Essential & Supplemental Essential Variables: Table 4.5 & 4.6	15.2 WELDING PROCEDURES A written procedure specification shall be prepared for all welding. Pre-qualified procedures as defined in AWS D1.1 are acceptable only for joining the materials using the consumables, joint configurations, and procedure limits specified therein. The welding of materials or use of procedures other than those defined by the AWS specifications shall be qualified by testing a sample weld produced in accordance with a written procedure and tested in accordance with the standard used in Section 15.1.	Welder Qualification shall be performed in accordance with a qualified WPS with all essential variables satisfied: Table 4.10 & 4.11	Requirement Not Specified		
3	Testing Requirements: Table 4.2	Requirement Not Specified	Verify correct WPS is available at point of use	9.2.2.4 Welding All welding on races for the attachment of the bearings to the pedestal or upper frame shall be performed in accordance with the bearing manufacturer's recommended procedures and shall exhibit fracture toughness equivalent to the race base metal.	Additional Customer Requirements	Requirement Not Specified		
4	Additional Customer Requirements	Requirement Not Specified	Continual monitoring required	15.1 STANDARDS All welding procedures for joining of structural load bearing or load transfer members of the crane and the performance of welders employing these procedures shall be qualified in accordance with a recognized standard such as the American Welding Society AWS D1.1 (latest edition).	Documented Welder Qualification Program	Requirement Not Specified		

2C COMPARATIVE REFERENCES

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Line Item #	Requirement	Welding Equipment Approval	Calibration of Monitoring & Measuring Equipment	Control & Issuance of Consumables	Weld Repair	Post Weld Heat Treatment	Weld Acceptance Criteria						
1	ASME Section IX	Equipment capable of meeting WPS essential variables as a system	Requirement Not Specified	Calibration Program ensures that equipment used for welding and welding verification meets intended requirements	Requirement Not Specified	Documented procedure for the purchase, storage and issuance of welding consumables	Requirement Not Specified	Documented weld repair process which includes: >Identification of defect type >Excavation method >Excavation depth	Requirement Not Specified	Documented procedure for post weld heat treatment: Clause 5, 5.8	Requirement Not Specified	As required by the applicable API Product Specification	Requirement Not Specified
2	ASME Section IX	Verification of WPS parameters	Requirement Not Specified	Equipment used to produce welds shall be calibrated in accordance with manufacturer's recommendations; minimally equipment includes:	Requirement Not Specified	The documented procedure shall address as applicable: >Containers: open, unopened, hermitically sealed >Non low hydrogen electrodes >Low hydrogen electrodes >Solid wire/electrodes >Cored wire/electrodes >Flux >Powdered/granular materials >Gas	Requirement Not Specified	>Excavation dimensional requirements (i.e., groove design) >NDT of excavation >WPS to be used for the repair >NDT procedure used for repair acceptance	Requirement Not Specified	>Post weld heat treatment equipment specified >Furnace survey: minimally in accordance with API Spec. 6A, 20th Edition, Annex M Qualification of heat-treating equipment	Requirement Not Specified	If the API Product Specification does not address acceptance criteria: >100% Visual Inspection is required in accordance with AWS D1.1, Table 6.1	Requirement Not Specified
3	ASME Section IX	Continual monitoring required	Requirement Not Specified	>Welding power supplies >Arc monitoring devices >Weld measuring tools	Requirement Not Specified	Welding consumables shall be stored in a clean dry environment in accordance with AWS specification A5.xx and Consumable Manufacturer's Recommendations	Requirement Not Specified	>WPS qualification required for change from original welding procedure	Requirement Not Specified	Method for: >Thermocouple attachment >Thermocouple location >Number of thermocouples >Thermocouple removal and NDT criteria	Requirement Not Specified	>Magnetic particle examination or liquid penetrant examination as determined by the designer	Requirement Not Specified
4	ASME Section IX			>Consumable storage devices >Heat treating equipment (i.e., temperature monitoring equipment)	Requirement Not Specified								

5	ASME Section IX				>Other equipment that could effect essential variables	Requirement Not Specified							
1	AWS	Equipment capable of meeting WPS essential variables as a system	Requirement Not Specified	Calibration Program ensures that equipment used for welding and welding verification meets intended requirements	Requirement Not Specified	Documented procedure for the purchase, storage and issuance of welding consumables	Requirement Not Specified	Documented weld repair process which includes: >Identification of defect type >Excavation method >Excavation depth	Requirement Not Specified	Documented procedure for post weld heat treatment: Clause 5, 5.8	Requirement Not Specified	As required by the applicable API Product Specification	16.4 EXAMPLES OF WORKMANSHIP STANDARDS Table 11 shows examples of components that may be considered critical in some crane designs; some recognized procedures for conducting nondestructive examinations, and acceptance criteria representing workmanship standards. The manufacturer shall be responsible for developing a similar scheme (with appropriate acceptance criteria) from consideration of the specific crane design, criticality of the component, and applicable nondestructive examination methods. Acceptance criteria based on fitness for-purpose evaluations shall consider applied and residual stresses, material properties, environmental exposure, and the limitations of the selected nondestructive examination method for detection and evaluation of imperfections.
2	AWS	Verification of WPS parameters	Requirement Not Specified	Equipment used to produce welds shall be calibrated in accordance with manufacturer's recommendations; minimally equipment includes:	Requirement Not Specified	The documented procedure shall address as applicable: >Containers: open, unopened, hermetically sealed >Non low hydrogen electrodes >Low hydrogen electrodes >Solid wire/electrodes >Cored wire/electrodes >Flux >Powdered/granular materials >Gas	Requirement Not Specified	>Excavation dimensional requirements (i.e., groove design) >NDT of excavation >WPS to be used for the repair >NDT procedure used for repair acceptance	Requirement Not Specified	>Post weld heat treatment equipment specified >Furnace survey: minimally in accordance with API Spec. 6A, 20th Edition, Annex M Qualification of heat-treating equipment	Requirement Not Specified	If the API Product Specification does not address acceptance criteria: >100% Visual Inspection is required in accordance with AWS D1.1, Table 6.1	15.3 WELDER PERFORMANCE The performance of welders shall be verified by destructive testing or by radiographic examination. Radiographic examination shall be limited to groove welds using the shielded metal-arc, submerged-arc, gas tungsten-arc, gas metal-arc (globular arc, spray arc or pulsating arc only) and flux cored arc processes. The performance of welders employing shortcircuiting (short-arc) gas metal arc welding processing shall be qualified by destructive testing only.
3	AWS	Continual monitoring required	Requirement Not Specified	>Welding power supplies >Arc monitoring devices >Weld measuring tools	Requirement Not Specified	Welding consumables shall be stored in a clean dry environment in accordance with AWS specification A5.xx and Consumable Manufacturer's Recommendations	Requirement Not Specified	>WPS qualification required for change from original welding procedure	Requirement Not Specified	Method for: >Thermocouple attachment >Thermocouple location >Number of thermocouples >Thermocouple removal and NDT criteria	All bearings to be attached to the structure by welding shall be provided with a transition piece of weldable steel. The weld between the hardenable steel and the transition piece shall be subjected to stress relief heat treatment at a temperature not to exceed the tempering temperature employed in the heat treatment of the race.	>Magnetic particle examination or liquid penetrant examination as determined by the designer	16.3 MINIMUM EXTENT OF NONDESTRUCTIVE EXAMINATION The manufacturer shall identify all critical components of the crane. These components shall be subjected to nondestructive examinations in accordance with a recognized workmanship standard or, at the option of the manufacturer, by a written examination procedure and acceptance criteria developed in a fitness-for-purpose fracture control plan. The extent of nondestructive examination of non-critical components is also the responsibility of the manufacturer 15.4 WELDING PROPERTIES The strength and fracture toughness of welds and heataffected zones in critical components shall meet the minimum specified design requirements of the materials being joined. Mechanical testing shall be conducted during procedure qualification to verify that the required properties of the weld and heat-affected zones are attained by the controls outlined in the welding procedure specification. 16 Nondestructive Examination of Critical Components 16.1 NONDESTRUCTIVE EXAMINATION PROCEDURES The manufacturer shall establish written nondestructive examination procedures for the examination of critical components of the crane. The procedures shall consider the stage of manufacture in which the examination is to be performed, the accessibility to examination methods, and the configuration of the component to be examined. These procedures shall be employed by the manufacturer's personnel and/or any contract nondestructive examination personnel utilized by the manufacturer.

4	AWS			>Consumable storage devices >Heat treating equipment (i.e., temperature monitoring equipment)	Requirement Not Specified									
5	AWS			>Other equipment that could effect essential variables	Requirement Not Specified									

Specification 4F

Specification for Drilling and Well Servicing Structures

No Requirements Specified for ASME

SPEC.	4F	EDITION	3rd	ADDENDUM / ERRATA	N/A	WELDING CODE	ASME Section IX
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Line Item #	PQR		WPS		Welder Qualification		Welder Continuity	
1	Documented PQR QW 483 minimum	~~Requirement Not Specified~~	Documented WPS QW 482 minimum	~~Requirement Not Specified~~	Documented Welder Process Qualification with all required essential variables: Article III, QW 300	~~Requirement Not Specified~~	QW322 Maintain Welder Continuity	~~Requirement Not Specified~~
2	QW 250 Essential & Supplemental Essential Variables	~~Requirement Not Specified~~	QW 250 Essential & Supplemental Essential Variables	~~Requirement Not Specified~~	Welder Qualification shall be performed in accordance with a qualified WPS with all essential variables satisfied: QW 350	~~Requirement Not Specified~~		
3	Testing Requirements QW 450	~~Requirement Not Specified~~	Additional Customer Requirements	~~Requirement Not Specified~~	Additional Customer Requirements	~~Requirement Not Specified~~		
4	Additional Customer Requirements	~~Requirement Not Specified~~	Verify correct WPS is available at point of use	~~Requirement Not Specified~~	Documented Welder Qualification Program	~~Requirement Not Specified~~		
5			Continual monitoring required	~~Requirement Not Specified~~				

SPEC.	4F	EDITION	3rd	ADDENDUM / ERRATA	N/A	WELDING CODE	AWS D1.1
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Line Item #	PQR	WPS	Welder Qualification	Welder Continuity
1	Documented PQR: Annex N minimum 10.3 Written Documentation Weld joints and/or process not meeting AWS D1.1 requirements for prequalification shall be qualified in with the applicable standard. The procedure qualification record (PQR) shall record all essential and supplementary essential (when required) variables of the weld procedure and the PQR shall be maintained as records in accordance with the requirements of Section 12 of this standard.	Documented WPS: Annex N minimum 10.3 Written Documentation Welding shall be performed in accordance with welding with the applicable standard. The WPS shall describe all the essential variables as listed in the applicable standard.	Documented Welder Process Qualification with all required essential variables: Clause 4, Part C 10.2 Welding Qualifications All welding undertaken on components shall be performed using welding procedures which are recognized industry standard. This welding shall only be carried out by welders or welding operators who are qualified in accordance with abovementioned standards. Workmanship and technique shall be in accordance with the same standard.	Maintain Welder Continuity: Clause 6.6.4, 6.4.3 Requirements Not Specified
2	Essential & Supplemental Essential Variables: Table 4.5 & 4.6 10.3 Written Documentation The procedure qualification record (PQR) shall record all essential and supplementary essential (when required) variables of the weld procedure used for the qualification tests.	Essential & Supplemental Essential Variables: Table 4.5 & 4.6 10.3 Written Documentation Weld joints in filler processes not meeting AWS D1.1 requirements for prequalification shall be qualified in accordance with the applicable standard. The procedure qualification record (PQR) shall record all essential and supplementary essential (when required) variables of the weld procedure used for the qualification tests. Both the PQR and the WPS shall be maintained as records in accordance with the requirements of Section 12 of this standard.	Welder Qualification shall be performed in accordance with the applicable standard. The procedure qualification record (PQR) shall record all essential variables satisfied: Table 4.10 & 4.11 10.2 Welding Qualifications This welding shall only be carried out by welders or welding operators who are qualified in accordance with abovementioned standards. Workmanship and technique shall be in accordance with the same standard.	
3	Testing Requirements: Table 4.2 Section 11.3 addresses	Verify correct WPS is available at point of use	Additional Customer Requirements Requirements Not Specified	
4	Additional Customer Requirements	Continual monitoring required	Documented Welder Qualification Program 10.2 Welding Qualifications This welding shall only be carried out by welders or welding operators who are qualified in accordance with abovementioned standards. Workmanship and technique shall be in accordance with the same standard.	

API COMPARATIVE REFERENCES												
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Line Item #	Requirement	Welding Equipment Approval	Calibration of Monitoring & Measuring Equipment		Control & Issuance of Consumables		Weld Repair		Post Weld Heat Treatment		Weld Acceptance Criteria	
1	ASME Section IX	Equipment capable of meeting WPS essential variables as a system	Requirement Not Specified	Calibration Program ensures that equipment used for welding and welding verification meets required requirements	Requirement Not Specified	Documented procedure for the purchase, storage and issuance of welding consumables	Requirement Not Specified	Documented weld repair process which includes identification of defect type Excavation method Excavation depth	Requirement Not Specified	Documented procedure for post weld heat treatment: Clause 5, 5.8	Requirement Not Specified	As required by the applicable API Product Specification
2	ASME Section IX	Verification of WPS parameters	Requirement Not Specified	Equipment used to produce welds shall be calibrated in accordance with manufacturer's recommendations, intervals, equipment includes:	Requirement Not Specified	The documented procedure shall address as applicable: Consumables (gas, electrode, tungsten) used Flow for hydrogen electrodes Flow for hydrogen electrodes Shield metal electrodes Shield metal electrodes Other Shielded/granular materials Gases	Requirement Not Specified	Excavation dimensional requirements (i.e., groove design) WPS to be used for the repair NDE to be used for the repair NDE to be used for repair acceptance	Requirement Not Specified	Post weld heat treatment equipment specified Duration of heat treatment in accordance with API Spec. QA, 200 Addendum, Annex M Verification of heat-treating equipment	Requirement Not Specified	If the API Product Specification does not address acceptance criteria: 100% Visual Inspection is required in accordance with AWS D1.1, Table 6.1
3	ASME Section IX	Continual monitoring required	Requirement Not Specified	Welding power supplies After monitoring devices Weld measuring tools	Requirement Not Specified	Welding consumables shall be stored in a clean dry environment in accordance with AWS Specification A5.1 and Consumable Manufacturer's Recommendations	Requirement Not Specified	WPS qualification required for change from original welding procedure	Requirement Not Specified	Method for: Thermocouple attachment Thermocouple location Number of thermocouples Thermocouple removal and NDT criteria	Requirement Not Specified	Magnetic particle examination or liquid penetrant examination as determined by the designer
4	ASME Section IX			Consumable storage devices Heat treating equipment (i.e., temperature monitoring equipment)	Requirement Not Specified							
5	ASME Section IX			Other equipment that could affect essential variables	Requirement Not Specified							
1	AWS D1.1	Equipment capable of meeting WPS essential variables as a system	Requirement Not Specified	Calibration Program ensures that equipment used for welding and welding verification meets intended requirements	11.2 Measurement and Test Equipment Equipment used to inspect, test or examine material or other equipment shall be identified, controlled, calibrated and adjusted at specific intervals in accordance with the manufacturer's documented procedures, and consistent with a recognized industry standard to maintain the required level of accuracy. 12.2 Documentation to be kept by the manufacturer, of measuring and test equipment calibration records.	Documented procedure for the purchase, storage and issuance of welding consumables	10.6 Control of Consumables Welding consumables shall conform to American Welding Society (AWS) or consumable manufacturer's specifications. The manufacturer shall have a written procedure for storage and control of weld consumables. Materials of the hydrogen type shall be stored and used as recommended by the consumable manufacturer to retain their original low hydrogen properties.	Documented weld repair process which includes: Identification of defect type Excavation method Excavation depth	10.8.2 Heat Treatment The welding procedure specification used for qualifying a repair shall reflect the actual sequence of weld repair and heat treatment imposed to the repaired item.	Documented procedure for post weld heat treatment: Clause 5, 5.8	11.8 Acceptance Criteria The acceptance criteria of AWS D1.1 for visually tested structures shall be used for the visual, before and after repair NDE examination. NDE, 2. — The acceptance criteria of AWS D1.1 for typically tested structures shall be applied to critical welds of made and service.	As required by the applicable API Product Specification
2	AWS D1.1	Verification of WPS parameters	Requirement Not Specified	Equipment used to produce welds shall be calibrated in accordance with manufacturer's recommendations, intervally equipment includes:	11.2 Equipment used to inspect, test or examine material or other equipment shall be identified, controlled, calibrated and adjusted at specific intervals in accordance with the manufacturer's documented procedures, and consistent with a recognized industry standard to maintain the required level of accuracy.	The documented procedure shall address as applicable: Consumables (gas, electrode, tungsten) used Flow for hydrogen electrodes Flow for hydrogen electrodes Shield metal electrodes Shield metal electrodes Other Shielded/granular materials Gases	Requirement Not Specified	Excavation dimensional requirements (i.e., groove design) WPS to be used for the repair NDE to be used for the repair NDE to be used for repair acceptance	Requirement Not Specified	Post weld heat treatment equipment specified Duration of heat treatment in accordance with API Spec. QA, 200 Addendum, Annex M Verification of heat-treating equipment	Requirement Not Specified	If the API Product Specification does not address acceptance criteria: 100% Visual Inspection is required in accordance with AWS D1.1, Table 6.1
3	AWS D1.1	Continual monitoring required	Requirement Not Specified	Welding power supplies After monitoring devices Weld measuring tools	Requirement Not Specified	Welding consumables shall be stored in a clean dry environment in accordance with AWS specification A5.1 and Consumable Manufacturer's Recommendations	10.6 Control of Consumables Welding consumables shall conform to American Welding Society (AWS) or consumable manufacturer's specifications. The manufacturer shall have a written procedure for storage and control of weld consumables. Materials of the hydrogen type shall be stored and used as recommended by the consumable manufacturer to retain their original low hydrogen properties.	WPS qualification required for change from original welding procedure	Requirement Not Specified	Method for: Thermocouple attachment Thermocouple location Number of thermocouples Thermocouple removal and NDE criteria	Requirement Not Specified	Magnetic particle examination or liquid penetrant examination as determined by the designer
4	AWS D1.1			Consumable storage devices Heat treating equipment (i.e., temperature monitoring equipment)	Requirement Not Specified							11.3 Surface NDE
5	AWS D1.1			Other equipment that could affect essential variables	Requirement Not Specified							

Specification 5CT
Specification for Casing and Tubing

No Requirements Specified for ASME

SPEC.	API 5CT	EDITION	9th	ADDENDUM / ERRATA	N/A	WELDING CODE	ASME Section IX
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Line Item #	PQR		WPS		Welder Qualification		Welder Continuity	
1	Documented PQR QW 483 minimum	Requirement Not Specified	Documented WPS QW 482 minimum	Requirement Not Specified	Documented Welder Process Qualification with all required essential variables: Article III, QW 300	Requirement Not Specified	QW322 Maintain Welder Continuity	Requirement Not Specified
2	QW 250 Essential & Supplemental Essential Variables	Requirement Not Specified	QW 250 Essential & Supplemental Essential Variables	Requirement Not Specified	Welder Qualification shall be performed in accordance with a qualified WPS with all essential variables satisfied: QW 350	Requirement Not Specified		
3	Testing Requirements QW 450	Requirement Not Specified	Additional Customer Requirements	Requirement Not Specified	Additional Customer Requirements	Requirement Not Specified		
4	Additional Customer Requirements	Requirement Not Specified	Verify correct WPS is available at point of use	Requirement Not Specified	Documented Welder Qualification Program	Requirement Not Specified		
5			Continual monitoring required	Requirement Not Specified				

No Requirements Specified for AWS

SPEC.	API 5CT	EDITION	NINTH	ADDENDUM / ERRATA	N/A	WELDING CODE	AWS D1.1
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Line Item #	PQR		WPS		Welder Qualification		Welder Continuity	
1	Documented PQR Annex N minimum	Requirement Not Specified	Documented WPS Annex N minimum	Requirement Not Specified	Documented Welder Process Qualification with all required essential variables: Clause 4, Part C	Requirement Not Specified	Maintain Welder Continuity, Clause 6, 6.4, 6.4.3	Requirement Not Specified
2	Essential & Supplemental Essential Variables: Table 4.5 & 4.6	Requirement Not Specified	Essential & Supplemental Essential Variables: Table 4.5 & 4.6	Requirement Not Specified	Welder Qualification shall be performed in accordance with a qualified WPS with all essential variables satisfied: Table 4.10 & 4.11	Requirement Not Specified		
3	Testing Requirements: Table 4.2	Requirement Not Specified	Verify correct WPS is available at point of use	Requirement Not Specified	Additional Customer Requirements	Requirement Not Specified		
4	Additional Customer Requirements	Requirement Not Specified	Continual monitoring required	Requirement Not Specified	Documented Welder Qualification Program	Requirement Not Specified		
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5CT COMPARATIVE REFERENCES

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Line Item #	Requirement	Welding Equipment Approval		Calibration of Monitoring & Measuring Equipment		Control & Issuance of Consumables		Weld Repair		Post Weld Heat Treatment		Weld Acceptance Criteria	
1	ASME Section IX and AWS D1.1	Equipment capable of meeting WPS essential variables as a system	Requirement Not Specified	Calibration Program ensures that equipment used for welding and welding verification meets intended requirements	Requirement Not Specified	Documented procedure for the purchase, storage and issuance of welding consumables.	Requirement Not Specified	Documented weld repair process which includes: >Identification of defect type >Excavation method >Excavation depth	9.14: Not allowed	Documented procedure for post weld heat treatment as required by the WPS as specified in QW 482	6.2.1 6.5	As required by the applicable API Product Specification	7.13 Table C22/E22 8.8? 8.13.1e 10.3.2 10.4.2 10.4.5 10.5 10.5.4 -Definitions needed 10.11 10.12 10.15 (10.15.10 Weld Seam) SR11
2	ASME Section IX and AWS D1.1	Verification of WPS parameters	Requirement Not Specified	Equipment used to produce welds shall be calibrated in accordance with manufacturer's recommendations; minimally equipment includes:	Requirement Not Specified	The documented procedure shall address as applicable: >Containers: open, unopened, hermitically sealed >Non low hydrogen electrodes >Low hydrogen electrodes >Solid wire/electrodes >Cored wire/electrodes >Flux >Powdered/granular materials >Gas	Requirement Not Specified	>Excavation dimensional requirements (i.e., groove design) >NDT of excavation >WPS to be used for the repair >NDT procedure used for repair acceptance	9.14: Not allowed	>Post weld heat treatment equipment specified >Furnace survey; minimally in accordance with API Spec. 6A, 20th Edition, Annex M Qualification of heat-treating equipment	Requirement Not Specified	If the API Product Specification does not address acceptance criteria: >100% Visual Inspection is required in accordance with AWS D1.1, Table 6.1	Requirement Not Specified
3	ASME Section IX and AWS D1.1	Continual monitoring required	Requirement Not Specified	>Welding power supplies >Arc monitoring devices >Weld measuring tools	Requirement Not Specified	Welding consumables shall be stored in a clean dry environment in accordance with AWS specification A5.xx and Consumable Manufacturer's Recommendations	Requirement Not Specified	>WPS qualification required for change from original welding process	9.14: Not allowed	Method for: >Thermocouple attachment >Thermocouple location >Number of thermocouples >Thermocouple removal and NDT criteria	Requirement Not Specified	>NDT as determined by the designer and/or customer requirements	10.15 (10.15.10 Weld Seam) Table C42/E42
4	ASME Section IX and AWS D1.1			>Consumable storage devices >Heat treating equipment (i.e., temperature monitoring equipment)	Requirement Not Specified								
5	ASME Section IX and AWS D1.1			>Other equipment that could effect essential variables	Requirement Not Specified								

Specification 5DP
Specification for Drill Pipe

SPEC.	5DP	EDITION	1st	ADDENDUM / ERRATA	N/A	WELDING CODE	ASME Section IX
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Line Item #	PQR		WPS		Welder Qualification		Welder Continuity	
1	Documented PQR QW 483 minimum	Addressed in para 6.4.2: "The manufacturer shall develop, qualify and use a welding procedure, including post-weld heat treatment (WPS and PQR), in accordance with the ASME Boiler and Pressure Vessel Code, Section IX.	Documented WPS QW 482 minimum	Addressed in para 6.4.2: "The manufacturer shall develop, qualify and use a welding procedure, including post-weld heat treatment (WPS and PQR), in accordance with the ASME Boiler and Pressure Vessel Code, Section IX.	Documented Welder Process Qualification with all required essential variables: Article III, QW 300	6.4.2: Establishes the requirement "The manufacturer shall qualify the welding machines and welding operators to a specific WPQ for each WPS utilized by the operators."	QW322 Maintain Welder Continuity	Requirement Not Specified
2	QW 250 Essential & Supplemental Essential Variables	Addressed in para 6.4.2	QW 250 Essential & Supplemental Essential Variables	Addressed in para 6.4.2	Welder Qualification shall be performed in accordance with a qualified WPS with all essential variables satisfied: QW 350	Requirement Not Specified		
3	Testing Requirements QW 450	Addressed in para 6.4.2: Macrostructural examination; also para 6.3: Material Requirements; also para 6.7: Testing of Welds; also para 6.9 Hardness Testing	Additional Customer Requirements	Requirement Not Specified	Additional Customer Requirements	Requirement Not Specified		
4	Additional Customer Requirements	Requirement Not Specified	Verify correct WPS is available at point of use	Requirement Not Specified	Documented Welder Qualification Program	Requirement Not Specified		
5			Continual monitoring required	Requirement Not Specified				