ASME STANDARDS TECHNOLOGY, LLC

STP-NU-078

COMPARISON REPORT ON WELDING QUALIFICATION AND WELDING QUALITY ASSURANCE

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ASME STANDARDS TECHNOLOGY, LLC

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FOREWORD

In 2012, ASME Standards Technology LLC (ASME ST-LLC) published the results of the Code Comparison Report for Class 1 Nuclear Power Plant Components (STP-NU-051-1), which was carried out by various Standard Development Organizations (SDOs) responsible for the development of major nuclear components construction codes and standards, in response to a request from the Multinational Design Evaluation Programme (MDEP) Codes and Standards Working Group (MDEP-CSWG). The objective of this Code Comparison Report was to compare the requirements of major nuclear codes and standard for the Class 1 Nuclear Power Plant components with regards to design, materials, fabrication-welding, examination and testing.

The Code Comparison Report was part of a larger effort towards harmonization of nuclear pressure-boundary codes and standards, promoted by MDEP-CSWG. Within the same framework, a request was initiated by the SDO Convergence Board to develop a comparison document regarding the requirements for welding qualifications in major international codes and standards. This was coordinated by the World Nuclear Association (WNA), the report various comparison sections were drafted by TWI Ltd (TWI), Doosan Heavy Industries & Construction, JGC Corporation, CWB institute, and VÖ Safety. Westinghouse France, Sperko Engineering, Claypine Technologies Inc. and AREVA NP provided reviews of the report. The outcome of the comparison is presented in this report.

ASME ST-LLC appreciates the collaborative effort put forth by all those involved in the development of this report. We also acknowledge the nuclear regulatory authorities and the SDOs who supported this work, which was initiated with a global vision of codes and standards consistency.

Established in 1880, the American Society of Mechanical Engineers (ASME) is a professional not-for-profit organization with more than 135,000 members and volunteers promoting the art, science and practice of mechanical and multidisciplinary engineering and allied sciences. ASME develops codes and standards that enhance public safety, and provides lifelong learning and technical exchange opportunities benefiting the engineering and technology community. Visit www.asme.org for more information.

ASME ST-LLC is a not-for-profit Limited Liability Company, with ASME as the sole member, formed in 2004 to carry out work related to new and developing technology. The ASME ST-LLC mission includes meeting the needs of industry and government by providing new standards-related products and services, which advance the application of emerging and newly commercialized science and technology, and providing the research and technology development needed to establish and maintain the technical relevance of codes and standards. Visit www.stllc.asme.org for more information.

ABBREVIATIONS AND ACRONYMS

AFCEN	Association Française pour les règles de Conception, de construction et de surveillance en exploitation des matériels des Chaudières Electro Nucléaires (French Association for Design, Construction and In-service Inspection Rules for Nuclear Island Components)
AFNOR	Association Française de Normalisation (French Association of Standardization)
AIA	Authorized Inspection Agency
ANI	Authorized Nuclear Inspector
ASME	American Society of Mechanical Engineers
ASN	Autorité de Sûreté Nucléaire française (French Safety Authority)
ASTM	American Society for Testing and Materials
BPVC	Boiler and Pressure Vessel Code
CEA	Commissariat à l'Energie Atomique (Atomic Energy Authority)
CEN	European Committee for Standardization
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
CSWG	MDEP Codes and Standards Working Group (formerly WGCMO)
EBW	Electron Beam Welding
EN	European Norms
ESPN	Equipement Sous Pression Nucléaire (French regulation for Pressurized Equipment for Nuclear applications)
ESRs	Essential Safety Requirements, in the context of the PED
EU	European Union
FCAW	Flux Cored Arc Welding
GMAW	Gas Metal Arc Welding
GTAW	Gas Tungsten Arc Welding
HAZ	Heat-Affected Zone
IIW	International Institute of Welding
ISO	International Organization for Standardization
ISO/TR	ISO Technical Report
IWS	International Welding Specialist
IWT	International Welding Technologist
IWE	International Welding Engineer
JIS	Japanese Industrial Standards
JSME	Japanese Society of Mechanical Engineers
LBW	Laser Beam Welding
MDEP	Multinational Design Evaluation Programme
MAG	Metal Active Gas (welding)
MIG	Metal Inert Gas (welding)
MMA	Manual Metal Arc
NA	Not Applicable
NB-	Indicates clauses in ASME BPVC Section III, Subsection NB
NCA-	Indicates clauses in ASME BPVC Section III, Subsection NCA
NDE	Non-Destructive Examination
NRC	US Nuclear Regulatory Commission
PAW	Plasma Arc Welding
PED	(European) Pressure Equipment Directive
PQR	Procedure Qualification Record
PWHT	Post Weld Heat Treatment
QG-	Indicates general clauses in ASME BPVC Section IX

QW-	Indicates fusion welding-related clauses in ASME BPVC Section IX
RCC	Règles de Conception et de Construction (Design and Construction Rules) Règles de Conception et de Construction des Matériels Mécaniques des Ilots
RCC-M	Nucléaires REP (Design and Construction Rules for Mechanical Components of PWR Nuclear islands)
PD	Published Document
Rostechnadzor	Russian Regulatory Body
SMAW	Shielded Metal Arc Welding
SWPS	Standard Welding Procedure Specification
TC	Technical Committee (ISO)
TIG	Tungsten Inert Gas
TR	Technical report
PNAE G-7	Set of Rostechnadzor's normative documents on integrity of NPP mechanical components
QA	Quality Assurance
RWC	Responsible Welding Coordinator
SAW	Submerged Arc Welding
SDOs	Standards Development Organizations
SI	Système International (International System)
TC	Technical Committee
WGCMO	MDEP Working Group on Component Manufacturing Oversight
WPQ	Record of welder/welding operator qualification (ASME BPVC Section IX)
WPQR	Welding Procedure Qualification Record
WPS	Welding Procedure Specification

1 COMPARISON METHODOLOGY

1.1 General

As observed in the Code Comparison Report, CSA, JSME and AFCEN codes were originally developed based on ASME BPVC Section III, therefore, the ASME BPVC was used as the baseline and the requirements of the codes and standards included in the scope of work were compared with the corresponding ones from the ASME BPVC.

A direct comparison between the structure of the ISO standards included in the scope of this project and the ASME BPVC would be inappropriate, as explained in Section 3. However, the scope of the ISO standards for welding qualification considered in this project (ISO 15609, ISO 15613, the ISO 15614 series, ISO 9606-1 and ISO 14732) broadly matches that of Section IX of the ASME BPVC, hence a comparison was possible.

Based on these, a high-level comparison structure was developed, as shown in Figure 1-1 through Figure 1-3. For each standard listed in these tables (right-hand side column), a line-by-line comparison with the requirements of the corresponding sections of the ASME BPVC was carried out, where possible. When specific requirements in the codes and standards included in the scope of work referenced other codes or standards (e.g. ASTM or ISO standards for material specification or mechanical testing methods), the comparison did not extend to the detailed requirements of the reference standards, unless these could be readily compared (e.g. geometry and size of test specimens, destructive or non-destructive testing acceptance criteria). With reference to material grades, types of components and welding processes, the comparison considered those applied for nuclear power plant components. With regards to welding variables: for welder and welding operators, the comparison was limited to the essential variables, as defined in ASME BPVC Section IX; for welding procedures, supplementary essential variables were considered as well.

The corresponding requirements were then evaluated according to the comparison scale described in Section 1.2.

Figure 1-1: Schematic Representation of Code Comparison for Welder and Welding Operator Qualifications

Baseline code (ASME BPVC)	Codes to be compared				
Section IX	ISO 9606-1 [Note(1)] and ISO 14732				
Section IX +III	RCC-M	PNAE G-7	CSA	JSME	KEPIC

Note

(1) At the time of preparing this report, two standards for welder qualification for fusion welding of steels were current: EN 287-1 and ISO 9606-1. The latter was intended to replace EN 287-1. However, EN 287-1 remained current due to its citation in Pressure Equipment Directive 97/23/EC. In September 2015 the European Commission advised CEN that ISO 9606-1, Annex ZA, should have been modified to ensure it was fully compliant with the essential safety requirements of the Pressure Equipment Directive (PED) 97/23/EC. Therefore, until Annex ZA would be updated, EN 287-1 remained cited in the Official Journal of the EU and continued to provide presumption of conformity with the PED. According to information available to the authors, changes to Annex ZA of ISO 9606-1 were being discussed at the time of issuing this report. Therefore, EN 287-1 was expected to be withdrawn shortly after publication of the report and was not considered.

Figure 1-2: Schematic Representation of Code Comparison for the Technical Content of Welding Procedure Specifications and the Qualification Thereof

Baseline code (ASME BPVC)	Codes to be compared				
Section IX	ISO 15609, ISO 15614 series [Note(1)] and ISO 15613				
Section IX +III	RCC-M	PNAE G-7	CSA	JSME	KEPIC

Note
(1) Limited to ISO 15614-1, ISO 15614-8 and ISO 15614-11.

Figure 1-3: Schematic Representation of Code Comparison for a System for Technical Management and Supervision of Welding as a Manufacturing / Construction Tool

Baseline code (ASME BPVC)	Codes to be compared					
Section IX +III	RCC-M	PNAE G-7	CSA	JSME	ISO 3834	KEPIC

1.2 Comparison Scale

The comparison scale used in this report and in the appendices is described below. This is based on the scale used for the Code Comparison Report, which was modified to address more specifically the cases in which significant differences between codes or standards requirements were identified.

A1 = Same
Requirements classified as category A1 are considered to be technically identical. Requirements are classified as category A1 and considered to be the same even if there are inconsequential differences in wording, such as might result due to translation from one language to another, as long as the wording does not change the meaning or interpretation of the requirement. Likewise, differences in paragraph numbering are not considered when classifying requirements as long as the same requirement exists in both codes being compared.

A2 = Equivalent
Requirements are considered to be equivalent when applying either code or standard, if compliance with the applied code or standard will also meet the requirements of the other code or standard. Equivalence is not affected by differences in level of precision of unit conversions

B1 = Different – Not specified
Requirements are considered to be different –not specified, if one code or standard includes requirements that the compared code or standard does not specify. This classification may result because of differences in the scope of equipment covered by a respective code, the scope of industrial practices applied in context of the respective code, differences in regulatory requirements applicable in conjunction with application of a particular code or simply as a result of differences in requirements addressed in one code versus those of another.

B2 = Technically Different
Requirements are considered to be technically different if either code requires something more or less than, or otherwise technically different from, the requirements imposed by the other. These differences might be due to different technical approaches applied by a code or imposition of regulatory requirements within the country from which a code originates.

2 BACKGROUND INFORMATION ON ISO AND EUROPEAN STANDARDS

2.1 General Description of ISO

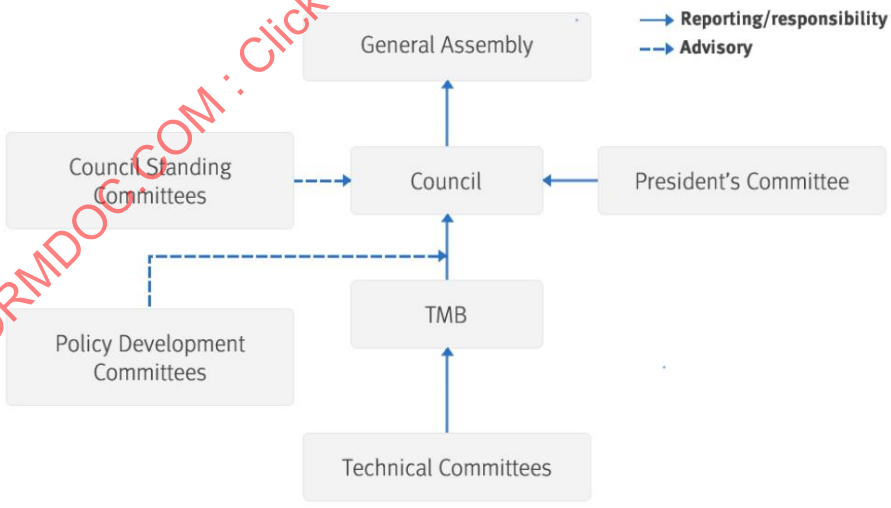
The International Organization for Standardization (ISO) [1] is an independent, non-governmental membership organization and the world's largest developer of voluntary International Standards.

ISO was founded in 1946 when delegates from 25 countries met at the Institute of Civil Engineers in London and decided to create a new international organization 'to facilitate the international coordination and unification of industrial standards'. In February 1947 the new organization, ISO, officially began operations. Since then, ISO has published over 19,500 International Standards covering almost technology and manufacturing, food safety, to agriculture and healthcare. ISO is currently made of 163 member countries who are the national SDOs worldwide, with a central secretariat based in Geneva, Switzerland.

The General Assembly is the ultimate authority for ISO work. This annual meeting is attended by ISO's members and Principal Officers, including the President, the Vice-President (policy), the Vice President (technical management), the Vice-President (finance), the Treasurer and the Secretary General. The ISO Council takes care of most governance issues. It meets twice a year and is made up of 20 member bodies, the ISO Officers and the Chairs of Policy Development Committees (CASCO, COPOLCO, DEVCO). Membership to the Council is open to all member bodies and rotates to make sure it is representative of the member community.

The management of the technical work is taken care of by the Technical Management Board. This body is also responsible for the technical committees that lead standard development and any strategic advisory boards created on technical matters. The General Assembly and the Council map out ISO's strategic direction. However, day to day operations are run by the Central Secretariat in Geneva, Switzerland. The Central Secretariat is under the direction of the Secretary General, who is also one of ISO's Principal Officers. ISO's governance structure is shown in Figure 2-1.

Figure 2-1: ISO Governance Structure



The Secretary General is a member of the President's Committee, reports to the President and to Council and receives advice from the policy and advisory groups (who also advise Council). The Central Secretariat is responsible for supporting the governance and policy and advisory structure and the operations of ISO.

2.2 ISO Standards and Relation with European (EN) and National Standards

ISO standards are developed by a panel of experts, within a technical committee (TC). Once the need for a standard has been established, these experts meet to discuss and negotiate a draft standard. As soon as a draft has been developed it is shared with ISO's members who are asked to comment and vote on it. As part of the voting process, a proposed draft standard may be discussed by the designated national experts with their country's mirror committee, which reviews it and develops a position on the proposal. If a consensus is reached the draft becomes an ISO standard, if not it goes back to the technical committee for further edits (Figure 2-2). The ISO technical committee responsible for welding-related standards is ISO/TC 44 'Welding and allied processes'. The scope of this technical committee includes standardization of welding, by all processes, as well as allied processes; these standards include terminology, definitions and the symbolic representation of welds on drawings, apparatus and equipment for welding, raw materials (gas, parent and filler metals) welding processes and rules, methods of test and control, calculations and design of welded assemblies, welders' qualifications, as well as safety and health. Electrical safety matters related to welding are excluded and are the responsibility of ISO technical committee IEC/TC 26. Participation to ISO/TC 44 currently extends to 32 countries, with the addition of 33 observing countries. In addition to the main TC, various subcommittees have been formed (Figure 2-3). The TC and its subcommittees have published a total number of 303 standards, including those included in this comparison (see references).

With regards to Europe, European standards ('EN standards') are issued by one of the European standardization organizations (depending on the topic), such as the European Committee for Standardization (CEN). CEN may decide to adopt/approve ISO standards without modifications, in which case they are then given the status of European standards and published as 'EN ISO' (for example ISO 15614-1 has been approved by CEN and published as EN ISO 15614-1).

European countries that are members of CEN are obliged to publish EN standards as national standards; so an EN standard automatically becomes a national standard in European countries. For example: once EN ISO 15614-1 was published, this was adopted by European countries and it was published as a national standard (e.g. as BS ISO 15614-1 in the UK, NF EN ISO 15614-1 in France).

Figure 2-2: ISO Standard Development Route

Figure 2-3: Structure of ISO/TC 44

Subcommittee / Working Group	Title
ISO/TC 44/JAG	IIW - ISO/TC 44 - CEN/TC 121 Coordination Committee
ISO/TC 44/WG 3	Brazing materials and processes
ISO/TC 44/WG 4	Welding and brazing in aerospace
ISO/TC 44/WG 5	Welding simulation
ISO/TC 44/SC 3	Welding consumables
ISO/TC 44/SC 5	Testing and inspection of welds
ISO/TC 44/SC 6	Resistance welding and allied mechanical joining
ISO/TC 44/SC 7	Representation and terms
ISO/TC 44/SC 8	Equipment for gas welding, cutting and allied processes
ISO/TC 44/SC 9	Health and safety
ISO/TC 44/SC 10	Unification of requirements in the field of metal welding
ISO/TC 44/SC 11	Qualification requirements for welding and allied processes personnel
ISO/TC 44/SC 12	Soldering materials

3 ISO STANDARDS FOR PRESSURE-RETAINING EQUIPMENT

As an international organization, ISO encompasses a number of countries, industry sectors and types of products and activities (Section 2), and no self-contained ISO standard, or collection of standards, exists that covers the design, fabrication and testing of nuclear power plant components or 'non-nuclear' pressure-retaining equipment. These are addressed by the SDOs and nuclear and pressure component regulatory bodies, as well as by legal requirements of each individual member country. Various collections of standards or individual publications applicable to pressure-retaining equipment, which are broadly comparable to sections of the ASME BPVC, are published by national or international bodies and were not included in the scope of work of this project, such as:

- EN 12952 series 'Water-tube boiler and auxiliary installations', broadly corresponding to ASME BPVC Section I.
- EN 13445 series 'Unfired pressure vessel', broadly corresponding to ASME BPVC Section VIII.
- National standards such as the British Standard PD 5500 'Specification for unfired fusion welded pressure vessels', broadly corresponding to ASME BPVC Section VIII.

With regards to welding qualifications and welding coordination, the above standards refer to the ISO standards listed in Figure 1-1 through Figure 1-3.

4 ROLE OF THE PRESSURE EQUIPMENT DIRECTIVE

4.1 General

The Pressure Equipment Directive (PED, 97/23/EC) was adopted by the European Parliament and the European Council in May 1997. It has initially come into force on 29 November 1999. From that date until 29 May 2002, manufacturers had a choice between applying the pressure equipment directive and continuing with the application of the existing national legislation. From 30 May 2002 the pressure equipment directive is obligatory throughout the EU. The directive provides, together with the directives related to simple pressure vessels (2009/105/EC), transportable pressure equipment (99/36/EC) and Aerosol Dispensers (75/324/EEC), for an adequate legislative framework on European level for equipment subject to a pressure hazard.

The PED arises from the European Community's Programme for the elimination of technical barriers to trade and is formulated under the "New Approach to Technical Harmonization and Standards". Its purpose is to harmonize national laws of Member States regarding the design, manufacture, testing and conformity assessment of pressure equipment and assemblies of pressure equipment. It therefore aims to ensure the free placing on the market and putting into service of the equipment within the European Union and the European Economic Area. Under the Community regime of the Directive, pressure equipment and assemblies above specified pressure and/or volume thresholds must meet essential safety requirements (ESRs) covering design, manufacture and testing; satisfy appropriate conformity assessment procedures; and carry the so-called 'CE marking' and other information (by placing the CE marking on a product a manufacturer is declaring, on his sole responsibility, conformity with all of the legal requirements to achieve CE marking). Less stringent requirements apply to pressure equipment and assemblies below the specified pressure / volume thresholds, for instance, specific marking is required. However, this does not need to be a CE marking. It should be noted that the purpose of CE marking is to prove that a product has been assessed before being put on the EU market; hence it may be applied to pressure-retaining equipment manufactured outside the EU, provided the ESRs of the PED are met.

The implications of the PED with regards to 'non-nuclear' and nuclear pressure equipment are discussed in Sections 4.2 and 4.3 below, respectively.

4.2 Application of the PED to Pressure Equipment ('conventional')

The scope of the PED is defined in its Article 1 of the directive and it includes "piping, safety accessories and pressure accessories", as defined in the directive itself. As discussed above, pressure equipment to be put on the EU market shall meet the ESRs established by the PED.

If a manufacturer uses a so-called 'harmonized standard', he has presumption of conformity with the corresponding ESRs. A harmonized standard can be a harmonized product standard for an item of pressure equipment or an assembly which may be CE marked. Examples of harmonized standards are the EN 13445 and EN 12952 series (Section 3).

The use of harmonized standards is not mandatory. Guidance on the application of the PED is provided in a collection of guidelines published by the European Commission [2], from which the following has been extracted: "The use of harmonized standards is not mandatory. However, the directive does not include provisions to give presumption of conformity to documents other than harmonized standards. A manufacturer using another document [authors' note: (e.g. ASME BPVC Section VIII)], shall describe in its technical documentation the solutions adopted to meet the essential requirements of the directive. The notified body (or the user inspectorate) shall validate these solutions, if required (further details are not considered relevant to this project).

In addition, different parts (design, manufacture, inspection, etc.) of a harmonized standard, a code or a specification for pressure equipment form a consistent set of documents which should be followed. Nevertheless, the partial use of a harmonized standard, a code or a specification is not forbidden.

In these conditions, the essential requirements covered by the part(s) of harmonized standards, codes or specifications used shall be identified. The essential requirements not covered by the part(s) of harmonized standards, codes or specifications shall be subject to an analysis to judge the validity of the adopted solutions. Then, if several different parts of harmonized standards, codes or specifications are used, it shall be verified that there are no incompatibility or inconsistency between these parts, particularly for the application data (permissible stress, safety coefficient, extent of the inspection, etc.)." (Guidelines 9/5 and 9/6)

4.3 Application of the PED to Pressure Equipment for Nuclear Use

According to Article 1 of the PED, clause 3.8 "items specifically designed for nuclear use, failure of which may cause an emission of radioactivity;" are excluded from the directive. The reason for this exclusion is that the directive does not take into account the risk of emission of radioactivity and the subsequent safety implications.

The national nuclear regulators of EU member countries define how to regulate pressure equipment for nuclear use, according to requirements specifically intended for nuclear use, which are over and above the ESRs of the PED. However, in some cases (e.g. France) the national regulation for pressurized equipment for nuclear applications (ESPN) includes a requirement for compliance with the ESRs of the PED (except CE marking). In fact, Annex ZZ to the RCC-M code includes specific provisions (with regards to the application of the RCC-M code when the equipment shall comply with the ESRs of the PED.

4.4 Implications of the PED to Welding Qualifications [2]

4.4.1 Welding Qualification

With regards to the welding qualifications, the following is required by Annex 1 'Essential safety requirements' of the PED:

"For pressure equipment, permanent joining of components which contribute to the pressure resistance of equipment and components which are directly attached to them must be carried out by suitably qualified personnel according to suitable operating procedures." (Clause 3.1.2)

In addition to permanent pressure-retaining joints, qualification is required when the joint may cause failure of pressure retaining equipment, for example:

- Welding of a lifting lug on a pressure bearing chamber
- Welding of an attachment to a valve body;
- Welding of reinforcing pads for nozzles;
- Repair by welding on a chamber before placing on the market;
- Major welding on a casting during production.

Examples of joints that do not require qualification, provided an analysis demonstrates that there is no 'pressure hazard', are:

- Minor welding on a casting during production;
- Overlay welding on a pressure chamber (anticorrosive, wear coating…).

Compliance with the above requirements is ensured through the application of a harmonized standard, however, as discussed in Section 4.2, the application of a harmonized standard is not mandatory and it is apparent that the above requirement is also broadly in line with the requirements of the construction codes in the ASME BPVC.

With regards to the qualification of welders and welding operators, the abovementioned PED guidance document explains that:

"In the absence of harmonized standards, the manufacturer shall refer to an existing document (draft standard candidate for harmonization, professional document, guide, recognized third party/notified body document, company document, etc.) or shall establish a specific document.

Such a document shall define at least:

- *equipment to be used by the personnel;*
- *degree of automatization of the process and the operations to be carried out by the personnel;*
- *conditions to apply when making the test piece to be used for the test*
- *approval and results to be achieved;*
- *range of validity and conditions for the duration of the validity." (Guideline 6/6)*

Similar guidance applies to the qualification of welding procedures:

"In the absence of harmonized standards, the manufacturer shall refer to an existing document (draft standard candidate for harmonization, professional document, guide, recognized third party/notified body document, company document) or shall establish a specific document.

- *Such a document shall define at least:*
- *essential variables for the procedure that may affect the properties of the permanent joining;*
- *inspection and testing to be carried out for the qualification of the procedure;*
- *acceptance criteria;*
- *range of validity." (Guidance 6/11)*

Guidance is also provided with regards to the approval certificates, when a standard other than a harmonized one is applied:

"The approval certificate should also indicate the tests performed in addition to those in the document used for approval. If certificates do not include a reference to the PED, the application of the last paragraph of Annex I section 3.1.2 shall be checked through the detailed examination of the WPQR (Welding Procedure Qualification Record)." (Guideline 6/15)

4.4.2 Approval by a Third Party

With regards to approval by a third party, the following is required by Annex 1 'Essential safety requirements' of the PED, Clause 3.1.2:

"For pressure equipment in categories II, III and IV, operating procedures and personnel must be approved by a competent third party which, at the manufacturer's discretion, may be:

- *A notified body,*
- *A third-party organization recognized by a Member State as provided for in Article 13.*

To carry out these approvals the third party must perform examinations and tests as set out in the appropriate harmonized standards or equivalent examinations and tests or must have them performed."

This requirement constitutes one of the major differences between the requirements of the ASME BPVC and those of the PED; in particular the abovementioned PED guideline document [2] states that:

"The current version of ASME Boiler & Pressure Vessel code Section IX is an example of where properties are not sufficiently dealt with for some applications in order to comply by itself with the PED (for example: impact property in the HAZ; hardness test etc.). Furthermore, it does not require that the tests and examinations shall be performed under the responsibility of a third party" (Guideline 6/12)

5 COMPARISON OF THE REQUIREMENTS FOR WELDER AND WELDING OPERATOR QUALIFICATIONS

5.1 Introduction

The qualification of welders and welding operators is covered by Section IX of the ASME BPVC and is collectively referred to as 'welding performance qualification'. Section IX is the reference specification for all ASME Construction Codes that require welding performance qualification. Section 5.2 below presents a comparison between the requirements for welder and welding operator qualification provided by Section IX alone and by the corresponding ISO standards.

When nuclear power plant components are considered, Section III of the ASME BPVC (hereafter referred to as Section III) is the applicable Construction Code. This provides additional requirements that affect the welding performance qualification. As discussed in Section 3, no self-contained ISO standard, or collection of standards, exists that covers the design, fabrication and testing of nuclear power plant components. These are addressed by the SDOs and nuclear and pressure component regulatory bodies, as well as by legal requirements of each individual ISO member country. Therefore, the requirements for welding performance qualification of Section III were compared with those of other codes with a similar scope, namely RCC-M (Section 5.3), JSME (Section 5.4), PNAE G-7 (Section 5.5), CSA (Section 5.6) and KEPIC (Section 5.7). The comparisons were limited to Class 1 nuclear components (as defined by Section III, NCA-2000 for classification) and to the corresponding component classes according to the abovementioned standards. With regards to the ASME BPVC, Class 1 components are addressed by Section III, Division 1, Subsection NB. Within Section III-NB, welding qualifications are covered by NB-4300. The corresponding Clause in the RCC-M code is section IV S4000. NB-4300 requires the application of Section IX (NB-4321), with additional requirements discussed in Section 5.3 below. The ISO standards corresponding to Section IX for performance qualifications are ISO 9606-1 (welders) and ISO 14732 (welding operators).

5.2 ASME BPVC Section IX versus ISO Standards

5.2.1 General

Highlights:

- Under ISO 9606-1 and ISO 14732, an organization that welds products where these standards are being followed may employ welders or welding operators qualified by another organization. This is not permitted by ASME BPVC IX.
- The renewal and confirmation/revalidation of welder qualifications to ASME BPVC IX and ISO standards are 'process based' and 'certificate based', respectively. For the first, if a welder or welding operator uses a process, all of his/her qualifications for that process are renewed; for the latter, a welder or welding operator's qualification is confirmed/revalidated only if that person has worked within the range of approval of that qualification within a specified period of time.
- The systems for renewal (ASME)/revalidation (ISO) of qualifications are significantly different. However, the ISO standards permits 'unlimited' six monthly extensions of welder qualifications, in line with the requirements of ASME BPVC IX, provided specific conditions are met. NOTE: at the time of issuing this report, the application of the six-monthly extension rule with regard to compliance with the PED (and as a consequence RCC-M) was under review, see Note 1 to Figure 1-1 and 5.2.2 (c) below.
- Although essential variables are broadly in common, qualification ranges may be significantly different. For example, when qualifying welders to ISO 9606-1, unlike ASME BPVC IX, a butt weld test does not cover a welder for production fillet welds. ISO 9606-1 does not consider the parent material as an essential variable.

- ISO 9606-1 and ISO 14732 are comparable to ASME BPVC IX or exceed it in all but the acceptance criteria for volumetric non-destructive examination (NDE). Therefore, qualifications to ISO 9606-1 and ISO 14732 may also satisfy the requirements of ASME BPVC IX, provided specific administrative, technical and testing conditions are met. These will be addressed by an annex to the 2015 edition of ASME BPVC IX (see Section 8).
- ASME publishes official interpretations of Section IX. Interpretations of ISO 9606 or ISO 14732 are not published by ISO; however, they are voluntarily published by the relevant ISO committee.

With regards to welding performance, the purpose of standardized qualifications is to determine if a welder or welding operator have the required skills to produce sound welds in a consistent and repeatable fashion. The welder's ability to achieve such results is not affected by the final application of the product being welded, or by the standard/code to which the product is being manufactured. To paraphrase a statement included in a document by the Section IX committee: when a welder is preparing a test piece for performance qualification or makes a production weld, that person does not know whether the applicable code/standard is ASME, ISO or other. Therefore, recent revisions of the ISO standards for welder (ISO 9606-1) and welder operator (ISO 14732) qualification as well as the 2015 edition of ASME BPVC IX (referred to as 'Section IX' from this section onwards), as discussed in Section 8, have resulted in a significant step towards convergence between these codes/standards.

ASME issues written replies to inquiries concerning interpretation of technical aspects of the Code. Section IX interpretations are issued by the relevant ASME committee and published twice yearly. The ISO committee 'TC44/SC11', which has direct responsibility for ISO 9606 and ISO 14732, deals with requests for interpretations. When approved by the TC44/SC11 committee, interpretations are published by the committee on the Linkedin.com website; however, they are not officially published by ISO. In some cases, national 'mirror committees' provide interpretations, however, these are under the sole responsibility of the national committees, and they are not issued as official interpretations by ISO. Individual national standardization bodies may publish these as official interpretations under their responsibility.

A line-by-line comparison between the requirements in Section IX that are common to welder and welding operators could be compared directly with both ISO standards (I.1 ASME BPVC Section IX versus ISO Standards), whilst requirements specific for welders and welding operators, these were compared with ISO 9606-1 (table) and ISO 14732, respectively.

5.2.2 ASME BPVC IX versus ISO 9606-1 and ISO 14732

This section presents a comparison between the requirements for the qualification of welders according to Section IX for welder and welding operators, against ISO 9606-1 and ISO 14732, respectively. Both Section IX and the ISO standards require qualification of welders and welding operators by mechanical testing or non-destructive examination and define ranges of qualifications for welding variables referred to as 'essential variables' (NOTE: welder qualification for semi-automatic processes may require both mechanical testing and non-destructive, see ISO 9606-1:2013, table 13 note b). Changes beyond the qualification ranges for essential variables require requalification. Both documents provide a system for base materials grouping Section IX assigns 'P-Numbers' and Group numbers' (QW-422), whereas ISO standards refer to 'groups' and 'subgroups' as defined in ISO/TR 15608. A summary of material grouping according to the two systems is provided in Figure I-4. The parent material group is not considered as an essential variable for qualifications to ISO 9606-1, hence "any suitable material from ISO/TR 15608, material groups 1 to 11" is permitted.

With regards to welder qualifications, Section IX lists essential variables and their respective qualification ranges in individual tables for each welding process, whereas ISO 9606-1 addresses each essential variable in a separate clause, some of which apply to all processes, whilst others include requirements specific to

individual welding processes. With regards to welding operator qualifications, both Section IX and ISO 14732 provide lists of essential variables for automatic welding and mechanized welding, which overlap for their major part.

Significant differences are observed when considering administrative requirements and organizational responsibility: Section IX requires that welder and welding operator qualifications shall be under the supervision and control of the organization that will employ that welder or welding operator. The expression 'supervision and control' broadly encompasses activities such as issuing consumables, issuing the welding procedure specification (WPS) or standard welding procedure specification (SWPS) to be used, as well as identifying, verifying and recording the information that will be entered in the record of welder/welding operator qualification (WPQ). Therefore, each organization shall have full responsibility for the production of test piece(s), the subsequent testing or examination, the termination of a test, and the issue of the WPQ. The intent of this requirement is to ensure that organizations that apply the ASME BPVC code employ individual(s) with the appropriate competence to be able to supervise and control the welding qualification process, hence any welding-related manufacturing activities. On the other hand, ISO 9606-1 and ISO 14732 assign the responsibility of supervising welding of test pieces, testing and to an examiner/examining body, which could be an employee of the organization (e.g. welding coordinator, welding inspector, welding engineer) or external. When the ISO standards are applied, it is common practice for project contracts and/or technical specifications to prescribe that an examining body is employed and that this is an independent third party organization.

One further major difference is the basis for extension of welding performance qualifications. According to Section IX, performance qualifications are valid for six months, and can be 'extended' by six months' periods or 'renewed', when they expired. A qualification for a process expires if a welder or welding operator has not welded with that process during a period of six months or more. On the other hand, the ISO standards give provisions for both 'confirmation' and 'revalidation' of a qualification. According to the ISO standards, a welder or welding operator qualification begins from the date of welding; it shall be confirmed every six months and revalidated according to three possible routes, one of which must be stated on the qualification certificate at the time of issue:

a) Retesting every three years for welders or six for welding operators
b) Revalidation by the examiner or examining body every two years for welders or three years for welding operators, based on volumetric NDE or destructive testing evidence from the previous six months.
c) Revalidation is not required if the qualification is confirmed every six months, and specific conditions are met:
    - The welder or welding operator is working for the same manufacturer for whom he or she qualified, and who is responsible for the manufacture of the product
    - The manufacturer's quality program has been verified in accordance with ISO 3834-2 or ISO 3834-3;
    - The manufacturer has documented that the welder has produced welds of acceptable quality based on application standards; the welds examined shall confirm the following conditions: welding position(s), weld type (FW, BW), material backing (mb) or no material backing (nb).

Option (c) effectively allows 'unlimited' six-monthly extension of welder qualifications and it is essentially in line with Section IX. It should be noted that such option is not recommended by the UK standardization body (BSI), which added a statement to the national foreword in the UK issue of the standard (BS EN ISO 9606-1) that "options a) and b) more fully confirm a welder's ability/skill to reproduce and meet the acceptance levels of the original test conditions". In addition, at the time of preparing this report, the application of option (c) to the fabrication of pressurized components in compliance with the PED is being discussed by construction code committees and yet to be approved (see Note 1 to Figure 1-1). Based on information available to the authors, it is expected that option (c) will be approved for PED-compliant

components, provided that the revalidation is carried out by an examiner/examining body and that this is a competent third party (a notified body or a recognized third party organization).

With regards to the scope of the documents, ISO 9606-1 is limited to steels (e.g. it does not cover nickel and nickel alloys, which fall under other parts of ISO 9606), whilst ISO 14732 and Section IX covers any grades of metallic materials. In particular, Section IX includes a list of 'approved' material specifications and grades ('assigned materials') and also permits the use of 'unassigned'.

5.3 ASME BPVC Section III&IX versus RCC-M

Highlights:

- ASME III refers to Section IX and no additional technical requirements are given for welding performance qualification, whereas RCC-M refers to EN 287-1 and EN 1418 with additional requirements.
- EN 287-1 is expected to be replaced by ISO 9606-1, see Note 1 to Figure 1-1 and 5.2.2 (c). EN 1418 will be replaced by ISO 14732.
- Significant administrative and QA-related differences prevent harmonization between the requirements for welding performance qualification in the two codes.

This section presents a comparison between the requirements for welder and welding operator qualification provided by the ASME BPVC section for nuclear power plant Class 1 components and those provided by the RCC-M code. The comparison was limited to Class 1 components are addressed by ASME BPVC Section III, Division 1, Subsection NB (hereafter referred to as Section III-NB). Within Section III-NB, welding qualifications are covered by NB-4300. The corresponding Clause in the RCC-M code is section IV S4000.

NB-4300 requires the application of Section IX (NB-4321), and adds provisions for maintenance and certification of qualification records (NB-4322). The edition of RCC-M valid at the time of writing this report refers to the EN 287-1 (welders) and EN 1418 (welding operators), see below, and provides a number of additional requirements, which integrate those provided by the reference

- For welders: EN 287-1 (for steels) and ISO 9606-4 (for nickel and nickel alloys, not included in the scope of this project), with additional requirements described in clause S4220 (technical requirements), S4230 (range of approval) and S4240 (additional test pieces). As explained in Figure 1-1, Note 1, at the time of preparing this report both EN 287-1 and ISO 9606-1 were current, however, only EN 287-1 allowed presumption of compliance with the PED, pending changes to ISO 9606-1. It is the authors' understanding from the relevant AFCEN sub-commission that a decision regarding referencing ISO 9606-1 in the RCC-M code was pending, however, the author considers this likely for future editions. Therefore, ISO 9606-1 was considered for this comparison.
- For welding operators: EN 1418, which at the time of writing this report has been superseded by ISO 14732. It is the authors' understanding from communication with the relevant AFCEN sub-commission that reference to ISO 14732 will be made in future editions of the RCC-M code, therefore, ISO 14732 was considered for this comparison.

A comparison between the requirements of Section IX, ISO 9606-1 and ISO 14732 is given in Section 5.2 above. Therefore, this section only considers the additional requirements provided by ASME III-NB over and above those included in Section IX. As the comparison is based on Section IX, the additional requirements of RCC-M that do not have a corresponding requirement in Section IX are not discussed. It should be noted that qualifications to ISO 9606-1 and ISO 14732 may satisfy the requirements of Section IX (see Section 8.1 below), whereas qualification to the RCC-M code will not satisfy the requirements of Section IX. This is due to the difference in the required quality assurance (QA) system (e.g. the ASME Stamp system has no equivalent in RCC-M), as well as minor administrative differences (e.g., the base

materials required for performance qualification to RCC-M are not assigned a P-No, but they are grouped according to ISO/TR 15608, as required by EN 287-1 and ISO 9606-1, see Figure I-2).

Neither Section III nor the RCC-M code requires witnessing of procedure qualifications by an independent third party. However, this is applied for RCC-M qualifications, if required by national regulations. For instance, for equipment to be installed in France depending on the Class/Category level, third party witnessing is required by the PED and ESPN.

Section III-NB provides special qualification requirements for performance qualification for welding of instrument tubing (NB-4337), tube-to-tubesheet welds (NB-4350) and for specially designed welded seals (NB-4368). Similarly, RCC-M addresses 'special cases' in Clause S4300, namely: cladding and buttering (S4310), welding of heat exchangers or steam generators tube to tube plate (S4320), specific seal welds (S4330), pipe socket welds (S4340) and friction welding (S4350); it also requires additional test pieces for specific components (e.g. nozzles), see S4240. The scope of this comparison was limited to the requirements for tube-to-tubesheet welding (see details in Figure I-6).

The performance qualification requirements for tube-to-tubesheet welds are almost identical between the two codes, with the exception of the leak test (not required by ASME) and the required throat thickness which is average 0.8 (min 0.66) times the nominal wall thickness of the tubes for RCC-M and minimum 0.66 for ASME (no requirements on average).

With regards to repair by welding, both codes allow weld repairs and require qualification of welders and welding operators and welding procedures, see ASME III NB-4453.2 and RCC-M S7600.

5.4 ASME BPVC Section III&IX versus JSME

Highlights:

- The structure of the JSME standard for performance qualification is broadly similar to that of Section IX, with some significant differences listed in Figure I-7.
- With regards to the expiration and renewal of welding performance qualifications, JSME only specifies that the validation of welders and welding operator's qualification shall be carried out every 2 years and 10 years, respectively.
- In Japan, renewal of welders and welding operators assigned to nuclear power plant are subject to government approval, where welders and welding operators may be renewed based on their experience for welding of nuclear power equipment.

The requirements for welder performance qualification for Nuclear Components are specified in Part 3 of JSME S NB1. Figure I-7 shows the main difference between Section IX and JSME S NB1 Part 3.

5.5 ASME BPVC Section III&IX versus PNAE G-7

Highlights:

There are the following in accordance with PNAE G-7-003-87 in contrast to the ASME BPVC IX:

- In addition to the weld performance, the theoretical examination shall be passed during the qualification procedure.
- Mechanical test is not required by qualification procedure, only NDE shall be done.
- The maximum period of validity of welder/welding operator qualification is 48 months. After this period, the qualification shall be renewed.
- The welded joint category is the "essential variable". The grade and product form of the filler material is not the "essential variable".
- The list of welding methods is limited.

This section presents a comparison between the requirements for welder and welding operator qualification provided by the ASME BPVC section IX and those provided by the PNAE G-7 set of documents.

The main PNAE G-7 document included the requirements for welder and welding operator qualification is the PNAE G-7-003-87 “Rules for Qualification of Welders of Components and Pipelines of Nuclear Power Facilities”. The general requirements on integrity of NPP components (included some requirements on welding) are in PNAE G-7-008-89 “Rules for Design and Safe Operation of Components and Pipelines of Nuclear Power Facilities”. The requirements on welding and examination of welds are in PNAE G-7-009-89 “Components and Pipelines of Nuclear Power Facilities. Welding and Cladding. General rules” and PNAE G-7-010-89 “Components and Pipelines of Nuclear Power Facilities. Welding and Cladding. Examination rules”.

Similar to the requirements of ASME BPVC IX, welder qualification according to PNAE G-7-003-87 shall be held by the Manufacturer. At the same time, it is possible for one Manufacturer to perform the qualification of the personal of another Manufacturer.

In accordance with PNAE G-7-003-87, only the welders, who finished specific theoretical and practical training, and have a certain level of welding experience, are allowed to pass the qualification test. The higher the category of the welded joint, the stricter the experience requirements are. Such requirements are absent in ASME BPVC IX.

A significant difference of the qualification procedures in according with PNAE G-7-003-87 is the requirement to conduct a theoretical examination before the practical implementation of the welded joint. Another distinctive feature of PNAE G-7-003-87 is a quality examination procedure for the performed welded joints, according to which mechanical testing of welded joints is not required, and only 100% NDE is performed. At the same time, it should be noted that for the qualification of welding procedures mechanical testing is required.

PNAE G-7-003-87 defines the following four types of qualification: initial, additional, periodical and extraordinary. Additional qualification, similar to the requirements of ASME BPVC IX, is conducted after the 6-month break in the implementation of the relevant welding or in the case of extending the scope of the welding qualification. However, in distinction from the ASME BPVC IX, PNAE G-7-003-87 qualification is valid for 24 months. This period may be extended twice for 12 months without a re-qualification, after which it is necessary to carry out the periodical qualification. Thus, according to PNAE G-7-003-87 the maximum period of qualification validity is 48 months.

PNAE G-7-003-87 does not use the «essential variables» term. Instead, it uses the concept of "characteristics of welded joints." Three sets of characteristics are defined: for welded joints, tube-to-tubesheet welding and corrosion-resistant cladding. PNAE G-7-003-87, unlike ASME BPVC IX, does not have separate chapters for the qualification requirements for manual, semi-automatic, automatic, machine welding, in PNAE G-7-003-87 requirements are mixed in the text.

The characteristics of the welded joints of PNAE G-7-003-87 are little less detailed, compared to the “essential variables” of ASME BPVC IX. For the welded joints the following characteristics are defined:

- welded joint category (defined in accordance with PNAE G-7-010-89);
- welding method;
- base material group (steels and alloys);
- type and dimensions of welded components (pipe/plate, diameter, thickness);
- welding position.

The PNAE G-7-003-87 list of welding methods is limited to manual arc welding, manual/semi-automatic/automatic argon-arc welding, automatic submerged arc welding, electroslag welding and electron beam welding. This list does not include, for example, plasma welding, friction welding, welding in carbon dioxide and nitrogen sphere, stud welding.

The base materials are distributed in groups according to the metallurgical characteristics, for example one group contains all kinds of carbon steel with yield strength of more than 315 MPa. The list of specific grades of materials, which belong to a particular group, in the PNAE G-7-003-87 is absent. Generally, both ASME Code IX and PNAE G-7-003-87 deal with the same base material groups (steels, nickel, aluminum, copper, zirconium and titanium alloys).

The grade and the product form of filler material is not a characteristic according to PNAE G-7-003-87. This is due to the fact that PNAE G-7-009-89 explicitly connects filler materials with base ones.

Determination of welding position in PNAE G-7-003-87 to a large extent corresponds to ASME BPVC IX. The extension of welding qualification in accordance with PNAE G-7-003-87 uses an approach similar to ASME BPVC IX: more complex welding positions qualify simpler ones, the groove welds qualify the fillet welds, and welds of certain thickness and diameter qualify others. Also there are some technical differences between PNAE G-7-003-87 and ASME BPVC IX in welding qualification extension parameters.

The results of the qualification are issued in the form of a protocol in accordance with the PNAE G-7-003-87 and ASME BPVC IX (the recommended form is included in both documents, as well as a form for certificates). Also in accordance with PNAE G-7-003-87 welder receives a stamp, as opposed to numbers, letters or symbols in accordance with the ASME BPVC IX.

5.6 ASME BPVC Section III&IX versus CSA

5.6.1 Introduction

CSA Standard N285.0 “General requirements for pressure-retaining systems and components in CANDU nuclear power plants” and its accompanying series provide specific requirements for nuclear plants in Canada. CSA N285.0 establishes rules for classification of various components referencing requirements for construction of the applicable ASME Boiler and Pressure Vessel Code (BPVC) classes. The establishment of the requirements for each class of system, component or support is consistent with the Nuclear Safety and Control Act.

The technical requirements for fabrication and installation of Class 1 components are specified in Clause 9.2.1 of CSA N285.0, and make direct reference to ASME BPVC, Section III, Division 1, NB-4000.

Figure 5-1: Section III and CSA for Fabrication and Installation

ASME Equivalent Section	CSA N285.0 “Fabrication and Installation”	Section Title	Description
NB-4000	Clause 9.2 Specific Requirements	Clause 9.2.1 Class 1 components and non-standard fittings	The licensee shall have Class 1 components and non-standard fittings fabricated and installed to comply with the requirements of the ASME BPVC, Section III, Division 1, NB-4000.

In addition to this requirement, CSA N285.0 requires that fabrication and installation shall be carried out under a quality assurance program as outlined in Clause 10, including preparation of the following documents:

- Fabrication and installation documents, instruction, and procedures including verification;
- Records demonstrating completion of all required tests, examination and treatments, including qualification of personnel and procedures used;
- Records demonstrating the acceptance of inspection and testing plan by authorized inspector;
- Permanent and non-permanent records for the applicable period of time; and
- Records showing the actual stamping on the nameplate.

5.6.2 Comparison of the Requirements for Welder and Welding Operator Qualifications

The qualification of welders, brazers and welding operators is specified in Section 9.3 of CSA Standard N285.0. Except for the in-service plugging fusion welding of Class 1 heat-exchanger tube or tube sheet holes with a one-inch maximum diameter, all welding personnel are required to be qualified in accordance to ASME BPVC Section IX. In addition, the licensee is required to retain records of welding personnel qualification accepted or issued by the authorized inspection agency. In Canada, the authorized inspection agencies are established by the Canadian jurisdiction of each Province or Territory that regulates the technical requirements of the ASME BPVC Section IX for qualification of welding personnel.

Figure 5-2: Section III and CSA for the Welder and Welding Operator Qualification

ASME Equivalent Section	CSA N285.0 "Fabrication and Installation"	Section Title	Description
ASME BPVC Section III	Clause 9.3 "Welding and Brazing"	Clause 9.3.3	The licensee shall retain records in accordance with Clause 12 to demonstrate that, for welding or brazing performed in accordance to class 1 component, the welders, brazers, or welding operators are qualified for the process as required by the ASME BPVC Section IX, and they possess current, valid qualification documentation accepted or issued by the authorized inspection agency.

In addition to the above requirements, CSA N285.0 specifies in Annex J provisions for in-service plugging fusion welding of Class 1 heat-exchanger tube or tube sheet holes with a one-inch maximum diameter. Annex J is an informative (non-mandatory) annex written in normative (mandatory) language to facilitate adoption where users of the Standard or regulatory authorities wish to adopt it formally.

According to Annex J, all welding personnel are required to be qualified in accordance to ASME BPVC Section IX and the following additional requirements:

- Performance qualification shall be conducted in accordance with a WPS qualified in accordance with specific requirements of this Annex;
- The initial performance qualification requires welding personnel to conduct five consecutive acceptable welds examined in accordance to this Annex;

- The P-number, SFA number, diameter, and welding position are considered non-essential variables for welding operators performing automatic welding;
- Welders are required to be tested under conditions and in position simulating the weld area access, including radiation protection gear and record on the performance qualification record accordingly;
- Renewal of qualification is required when the welding operator was not involved in plugging for more than 6 months or when there is a specific reason to questions his/her ability to make quality welds.
- Renewal of qualification for welders is required to be identical to the initial qualification, except that only one shall be required.

5.7 ASME BPVC Section III&IX versus KEPIC

Highlights:

- ASME Code inserted many variables for the new welding process such as LBW in QW-200, 300 & 400. However, KEPIC code's most variables were not reflected or treated as non-essential variables. In previous QW-300 there was only NDE RT to check weld soundness for welder's performance qualification but newly replaced into volume NDE to have alternative.
- KEPIC is considered that it is necessary to reflect it to follow the newly reflected ASME Code contents.

There is little that changed on the contents of the ASME code and KEPIC. The requirements for tamper bead weld repair that were subdivided in the existing ASME code, however, it was integrated in the new ASME. In addition, detailed information about welding procedure qualification has been reflected in ASME IX, KEPIC code follows the old version of ASME. It needs to reflect that in KEPIC code.

6 COMPARISON OF THE REQUIREMENTS FOR THE TECHNICAL CONTENT OF WELDING PROCEDURE SPECIFICATIONS AND THE QUALIFICATION THEREOF

6.1 Introduction

The qualification of welding procedure is covered by Section IX of the ASME BPVC and is collectively referred to as 'welding procedure qualification'. Section IX is the reference specification for all ASME Construction Codes that require welding procedure qualification. Section 6.2 below presents a comparison between the requirements for welding procedure qualification provided by Section IX alone and by the corresponding ISO standards.

When nuclear power plant components are considered, Section III of the ASME BPVC is the applicable Construction Code. For Class 1 components (see Section III, NCA-2000 for classification), the requirements of ASME BPVC Section III, Division 1, Subsection NB (hereafter referred to as Section III-NB) shall be applied. Within Section III-NB, welding qualifications are covered by NB-4300. This requires the application of Section IX (NB-4321), and adds provisions for maintenance and certification of qualification records (NB-4322), as well as requirements additional to Section IX for welding procedure qualification tests (NB-4331 to 4335) and special qualification requirements for instrument tubing (NB-4337), tube-to-tubesheet welds (NB-4350), and specially designed welded seals (NB-4360).

As discussed in Section 3, no self-contained ISO standard, or collection of standards, exists that covers the design, fabrication and testing of nuclear power plant components. These are addressed by the SDOs and nuclear and pressure component regulatory bodies, as well as by legal requirements of each individual ISO member country. Therefore, the requirements for welding procedure qualification of Section III were compared with those of other codes with a similar scope, namely RCC-M (Section 6.3), JSME (Section 6.4), PNEA-G7 (Section 6.5), CSA (Section 6.6) and KEPIC (Section 6.7). The comparisons were limited to Class 1 nuclear components (as defined by ASME BPVC Section III, NCA-2000 for classification) and to the corresponding component classes according to the abovementioned standards.

6.2 ASME BPVC Section IX versus ISO standards

Highlights:

- Section IX does not require NDE for procedure qualification. ISO standards require NDE, as well as mechanical tests not required by Section IX, e.g. hardness testing, impact testing. With regards to the latter, Section IX makes reference to the applicable Construction Code.
- Both Section IX and ISO standards assign responsibility for procedure qualification to the 'organization' (Section IX) or 'manufacturer' (ISO). However, ISO standards require that an examiner/examining body witnesses welding, testing and the issue of the procedure qualification record. This is often an independent third party, as required by application codes/standards, national regulations or contractual requirements.
- Heat input according to ISO standards is calculated considering a thermal efficiency factor, which varies according to the welding process. This thermal efficiency factor is not used by Section IX.
- Section IX gives specific provisions for the calculation of heat input when waveform controlled processes are used. These are not addressed by ISO standards.
- Different qualification ranges are provided for various welding variables.
- ASME publishes official interpretations of Section IX. Interpretations of ISO 15614 are provided to individual enquirers, but not published by the relevant ISO committee.
- This section provides a comparison between Section IX and the ISO standards for procedure qualification, focusing in particular on the comparison with ISO 15614-1, which covers the majority of welding processes and materials used for the construction of nuclear power plants. A

line-by-line comparison between Section IX and ISO 15614-1 is tabulated in Figure II-1, this also includes references to other standards in the ISO 15614 series (see below), and whose scope is entirely or partly covered by Section IX.

Section IX covers the specification qualification of welding procedures, brazing operatives and brazing procedures for the complete range of ferrous and non-ferrous engineering metals (steels, copper, nickel, aluminum, titanium and zirconium alloys) and oxy-gas, arc, power beam, resistance and solid phase welding processes. With regards to ISO standards, the specification of welding procedures is covered by the ISO 15609 series, whereas their qualification is covered by the ISO 15614 series and by ISO 15613, which require procedure qualification based on standardized test pieces and on a pre-production welding test, respectively.

Within the ISO 15614 series, ISO 15614-1 covers the welding procedure qualification of arc and gas welds in steel and nickel alloys. Other alloys and joining processes are covered by additional specifications within the ISO 15614 series, e.g. ISO 15614-7 for weld-overlay and hard facing, ISO 15614-8 for tube-to-tubesheet welding and ISO 15614-11 for beam processes (EBW and LBW). On the other hand, ISO 15613 is applied when the production/joint geometry requirements do not represent the standardized test pieces as shown in ISO 15614.

Both Section IX and ISO 15614-1 include 'essential variables' (although ISO 15614-1 does not define them as such) to each of which is assigned a range of approval. A change to an essential variable outside of its range of approval requires the welding procedure to be re-qualified. Section IX in addition identifies supplementary essential and nonessential variables. Supplementary variables are only invoked when toughness requirements are specified by the construction code, e.g. ASME III-NB or ASME B31.3. Non-essential variables, as the name suggests, are variables that are not regarded as affecting the quality or mechanical properties of the welded joint and comprise such variables as the weld preparation, shield gas flow rate, method of back gouging, shield gas nozzle size etc. Although these variables are non-essential it is a requirement that they should be referenced on the welding procedure. ISO 15614-1 does not identify any variables as non-essential; where a variable is not regarded as significant it is simply not referenced in the standard. However, a list of all variables that shall be addressed in a WPS is provided in ISO 15609. Therefore, variables that are listed in ISO 15609 and not listed in ISO 15614 have the same significance as Section IX's nonessential variables. A detailed comparison between the welding variables required by the two specifications is provided in Figure II-1.

In order to reduce the amount of qualification testing, both specifications group alloys of similar characteristics together. Qualifying the welding of one alloy within the group allows the other alloys within the group to be welded. Section IX assigns the groups numbers with steels being numbered P-No 1 to P-No 15F. Any alloy that does not have a P-number is regarded as 'unassigned'; a procedure qualification carried out using an unassigned alloy qualifies only that specific designation of alloy. Until recently only alloys that complied with the ASME and/or ASTM material specifications and/or had a UNS number were assigned P numbers. However, a limited number of European, Canadian, Chinese and Japanese alloys have recently been introduced into the list of assigned alloys. In addition, a P-number may be requested for any 'unassigned' weldable material, provided data are submitted according to the guidelines in Section IX, in Appendix J. ISO 15614-1 also groups steel and nickel alloys into families with similar properties but is somewhat less prescriptive than Section IX code, in that provided alloys have similar chemical compositions and mechanical properties, the material specification is not relevant – for example a plain carbon steel with less than 0.25%C and a minimum specified yield strength less than 460MPa falls into Group 1 irrespective of whether or not it is a pressure vessel or structural steel or supplied in accordance with EN or ASTM material specifications. ISO/TR 15608 specifies which group a specific alloy falls under, whether it is ferrous or non-ferrous, and assigns it a group number.

Material grouping to ISO/TR 15608 is provided for in Section IX for material grades listed QW/QB-422, as well as in various ISO standards, for European material grades (ISO/TR 20172), US grades and others (ISO/TR 20173) Japanese grades (ISO/TR 20174). A summary of material grouping according to the two systems is provided in Figure I-4.

Other significant differences between the two specifications with respect to the arc welding processes are:

- Section IX requires only tensile and bend tests to qualify a butt weld. ISO 15614-1 requires a far more extensive test program of visual inspection, radiography or ultrasonic examination, surface crack detection, tensile and bend tests and macro-examination. In certain circumstances Charpy-V impact tests and hardness surveys are also required.
- Section IX (QW-153) specifies that the tensile strength of the cross joint tensile specimen shall be:
  - At least that of the minimum specified for the base metal, or
  - The weakest of the two for dissimilar metal welds, or
  - The minimum specified tensile strength of the weld metal, when the applicable construction code allows weld metal with tensile strength under matching the base metal, or
  - It allows tensile strength no more than 5% below the minimum specified for the base metal if the specimen breaks outside the weld or weld interface.

ISO 15614-1 (Clause 7.4.2) specifies identical acceptance criteria to the first two listed above, and addresses the third and fourth criteria by permitting tensile strength lower than that of the base metal if "specified prior to testing".

- Section IX (QW-163) specifies that bend test coupons should have no discontinuity greater than 3mm. An identical criterion is specified by ISO 15614-1.
- ISO 15614-1 requires non-destructive testing of qualification test coupons and provides acceptance criteria. These are not addressed by Section IX.
- ISO 15614-1 requires Charpy-V impact testing for steels over 12mm thick when the material specification requires it. Section IX requires impact testing only when specified in the Construction Code. This requirement makes heat input a supplementary essential variable in Section IX but an essential variable in ISO 15614-1.
- The definition of heat input is different in the two specifications. 'Heat input' according to Section IX corresponds to 'arc energy' according to ISO 15614-1. Heat input according to ISO 15614-1 is calculated considering a thermal efficiency factor, which varies according to the welding process.
- Hardness testing is required by ISO 15614-1 for all ferritic steels with a specified minimum yield strength greater than 275MPa. A maximum hardness for joints in either the as-welded or Post Weld Heat Treated condition is specified. Section IX does not require hardness testing.
- Section IX allows a reduction in preheat of 55°C before requalification is required. ISO 15614-1 does not permit any reduction in preheat from that used in the qualification test.
- Section IX allows the maximum interpass temperature to be 55°C above that measured in the qualification test. ISO 15614-1 permits no such increase.
- Section IX requires pressure containing fillet welds to be qualified by a butt weld procedure qualification test. Non-pressure retaining fillet welds may be qualified by a fillet weld test only. ISO 15614-1 requires a fillet weld to be qualified by a butt weld when mechanical properties ".... are relevant to the application..." i.e. when it is a load carrying fillet weld. In addition, whilst a butt weld will qualify a fillet weld "....fillet weld tests shall be required where this is the predominant form of production welding..." i.e. an ISO compliant welding procedure where the majority of the welding is of load carrying fillet welds must reference both a butt weld and a fillet weld procedure qualification.
- Weld metal transfer mode, where relevant, is an essential variable in both ISO 15614-1 and Section IX but the current type is an essential variable in ISO 15614-1 and a supplementary essential variable in Section IX.

- A change from manual to automatic welding is an essential variable in ISO 15614-1 but a non-essential variable in Section IX.
- Weld backing is an essential variable in ISO 15614-1 but a non-essential variable in Section IX.
- For ISO 15614-1, the filler metal manufacturer and trade name are an essential variable for processes employing a flux or flux-coating (MMA, FCAW, SAW) when impact testing is required, and it is a supplementary essential variable in Section IX only for filler metals not covered by an SFA specification or with a "G" suffix within an SFA specification.
- Other variables affecting procedure qualifications according to ISO 15614-1 and not addressed or defined as nonessential variables by Section IX are:
  - Fillet weld size
  - Pipe diameter
  - Angle of branch connections
  - Weld backing
  - Preheat maintenance (in Section IX, addressed only for the PAW Hard-Facing Spray Fuse process and for the Hybrid Laser-GMAW process)
  - Initial heat treatment of precipitation hardening materials

With regards to LBW (see bottom of Figure II-1), a few variables are identical or equivalent, with the main difference being that whilst Section IX addresses specific essential welding variables, according to ISO 15614-11 the qualification of a WPS obtained is valid only insofar as the specified range of the welding parameters defined in the WPS (see section 4.13 in ISO 15609-4) and the tolerances specified are met.

A significant difference concerns how ASME and ISO deal with enquiries concerning interpretation of technical aspects of the Code/Standards. Section IX interpretations are issued by the relevant ASME committee and published twice yearly. Whilst the ISO committee 'TC44/SC10' deals with requests for interpretations, these are provided to the individual enquirer and are not formally published. In some cases, national 'mirror committees' provide interpretations, however, these are under the sole responsibility of the national committees, and they are not issued as official interpretations by ISO. Individual national standardization bodies may publish these as official interpretations under their responsibility.

6.3 ASME BPVC Section III&IX versus RCC-M

Highlights:

- The requirements of Section III-NB additional to those of Section IX are in most instances less stringent than the corresponding ones in RCC-M.
- The requirements of Section III&IX for the qualification of repair without post weld heat treatment (temper bead) are more stringent than those provided by RCC-M.
- Section IX PQRs do not expire. RCC-M states that, limited to specific joints listed in S6232 and B4231 (eg steam generator tube-to-tubesheet welds), when welding procedures have not been applied for a period longer than three years, they need to be requalified or supplemented by a production test (prior to production commencing).

This section presents a comparison between the requirements for welding procedure qualification provided by the ASME BPVC section for nuclear power plant Class 1 components and those provided by the RCC-M code. The comparison was limited to Class 1 components are addressed by ASME BPVC Section III, Division 1, Subsection NB (hereafter referred to as Section III-NB). Within Section III-NB, welding qualifications are covered by NB-4300. The corresponding Clause in the RCC-M code is section IV S3000. A line-by-line comparison, based on Section III-NB is provided in Figure II-3.

Class 1 components for nuclear power plants are required to be 'ASME stamped', hence welding procedure qualification can only be carried out by an organization who has a quality system accredited by ASME (i.e.

a 'Certificate Holder') and who holds an appropriate stamp (N-stamp for manufacturers of nuclear components). For Class 1 components (see Section III, NCA-2000 for classification), the requirements of ASME BPVC Section III, Division 1, Subsection NB (hereafter referred to as Section III-NB) shall be applied. Within Section III-NB, welding qualifications are covered by NB-4300. This requires the application of Section IX (NB-4321), and adds provisions for maintenance and certification of qualification records (NB-4322), as well as requirements additional to Section IX for welding procedure qualification tests (NB-4331 to 4335) and special qualification requirements for instrument tubing (NB-4337), tube-to-tubesheet welds (NB-4350) and specially designed welded seals (NB-4360). On the other hand, RCC-M (S3110) makes reference to ISO 15609-1 for welding procedure specifications and to ISO 15614-1 for arc welding of steels and to a number of additional requirements defined in clauses S 3200 and B4231. Other parts of the ISO 15614 series are referred to, e.g. ISO 15614-8 for tube-to-tubesheet welds and ISO 15614-11 for EBW.

A comparison between the requirements of Section IX and ISO 15614 series is given in Section 6.2 above. Therefore, this section only considers the additional requirements provided by ASME III-NB over and above those included in Section IX. As the comparison was based on Section IX, requirements provided by RCC-M in addition to ISO 15614-1, which do not have a corresponding requirement in Section IX, are mentioned, although not discussed in detail.

With regards to administrative aspects, Section IX (QG-108) states that PQRs made in accordance with Section IX 1962 or any later edition may be used in any ASME construction. It also states that PQRs made to earlier editions may be used, provided they meet all the requirements of the 1962 edition or later editions. RCC-M allows use of existing PQRs qualified according to previous editions of RCC-M, provided the conditions of RCC-M S1900 of the applicable edition are met. In cases where heat input and interpass were not recorded during the qualification, the RCC-M requires that the existing PQRs are integrated by preparing a test coupon under the same condition as the original welding procedure qualification. This would be used to establish the range of qualification for heat input and interpass. Similarly, QW-401.3 allows WPSs qualified without impact testing to be upgraded simply by welding an additional test coupon and documenting the supplementary essential variables

A significant difference is found in the 'expiry date' of welding procedure qualification: whilst Section IX PQRs do not expire, RCC-M S6320 states that, limited to specific joints listed in S6232 and B4231 (e.g. steam generator tube-to-tubesheet welds), when welding procedures have not been applied for a period longer than three years, they need to be requalified or supplemented by a production test (prior to production commencing).

RCC-M (S6500) allows a welding procedure qualification test conducted at a workshop or site to be applied by another workshop or site belonging to the same manufacturer, provided this other workshop is qualified as required by S6200. The manufacturer shall indicate in a report the arrangements made (technical precautions and supervision) to ensure the continuity of the skill and experience following the transfer. It is not permitted to transfer procedure qualifications to other manufacturers. These requirements are equivalent to those of Section IX QW-201 and QG-106.1, see Figure II-1.

Neither Section III nor the RCC-M code requires witnessing of for procedure qualifications by an independent third party. However, this is applied for RCC-M qualifications, if required by national regulations. For instance, for equipment to be installed in France depending on the Class/Category level, third party witnessing is required by the PED and ESPN.

- Both codes allow weld repairs and require qualification of welding procedures as per production welds (see ASME III NB-4453.2 and RCC-M, S3300, S3400 and S7600). RCC-M welding procedure qualification for repair welds in castings must be performed using cast material (S3400), whereas Section III permits use of other product forms, such as plate. With regards to repair without

post weld heat treatment (temper bead), both codes permit weld repair without post weld heat treatment, provided the temper bead technique is applied. Whilst RCC-M only allows temper bead repairs by MMA welding, ASME III-NB, allows the following welding processes: SMAW, GMAW and FCAW (GTAW is allowed for repair welds to cladding). As summarized in Figure 6-1, the ASME code provides more specific and stringent requirements for the performance and qualification of temper bead welding.

Figure 6-1: Comparison between Section III and RCC-M Requirements for the Qualification of Weld Repairs without Post Weld Heat Treatment

ASME Sect III NB-4622.9 and Sect IX QW-290	RCC-M Clause S7620
Permitted if: • Temper bead process is applied *General requirements:* • Specific requirements for qualification (QW-290) with specific essential variables • Limited to SMAW, GMAW, FCAW, GTAW	*Permitted if:* • Temper bead process is applied • Approved by Contractor • Contractor may require stress analysis *General requirements:* • Qualified as production welds • Limited to MMA

The procedure qualification requirements for tube to tubesheet welds are addressed by NB-4350 and RCC-M S3800. These can be considered equivalent, with the exception of the leak test (not required by ASME) and the required throat thickness which is average 0.8 (min 0.66) times the nominal wall thickness of the tubes for RCC-M and minimum 0.66 for ASME (no requirements on average). A detailed comparison is shown in Figure 6-2. NOTE: according to S3800, weld assemblies of tubes on the tube plate with gap (meaning without tube expansion after welding) shall be qualified according to the requirements of standard NF EN ISO 15614-8. Weld assemblies of tubes on the tube plate without gap shall be qualified according to S3810 to S3830.

Figure 6-2: RCC-M and ASME III-NB Requirements for Welding Procedure Qualification of Tube to Tubesheet Welds

Test piece	ASME		RCC-M	
	Required	Reference	Required	Reference
Procedure qualification	Section III NB-4350 Section IX QW-202.6, QW-193		EN ISO 15614-8	
Number of tubes	10	QW-193.1	10	S3823
Visual test	Yes	QW-193.1.1	Yes	S3834a
Liquid penetrant test	Yes	QW-193.1.2	Yes	S3834b
Leak test	Not required	-	Yes, as in production	S3834c
Macro-examination	Yes, on 10 tubes Minimum leakage path (weld throat) 2/3 specified tube wall thickness	QW-193.1.3 NB-4350	Yes, on 10 tubes Mean weld throat thickness 0.8e and no individual value below 0.66e (e=nominal tube wall thickness). Root discontinuities <0.24e (max 0.30mm)	S3834d

With regards to weld overlay by austenitic-ferritic stainless steel (note: this terminology refers to austenitic steel with a certain ferrite content, rather than duplex stainless steels), Section III does not provide additional requirements to Section IX, whilst the qualification practice of RCC-M includes the same destructive and non-destructive tests required by ASME (Section IX), as well as additional tests. The major differences between the two codes are listed here and tabulated in Figure 6-3, which also includes reference to the relevant ASME clauses:

- RCC-M limits the base metal qualification to the grade used during testing, with the exception given in S 3612, whereas Section IX qualifications are limited to base metals with the same P-No.
- RCC-M requires that the range of qualification for the weld overlay is based on the number of layers and the chemical analysis is performed at a depth of 2mm, after grinding 0.5mm from the surface of the as-welded overlay (S 3633b). On the other hand, Section IX qualifications are based on the overlay thickness at which the required chemical analysis has been obtained.

RCC-M provides specific requirements for Ni-alloy weld overlay, these are largely identical to those for austenitic-ferritic weld overlay, with some exceptions; for instance, corrosion testing is not required for Ni-alloy weld overlay.

Figure 6-3: ASME III-NB and RCC-M Requirements for Weld Overlay Procedure Qualification for Austenitic-Ferritic Stainless Steel on Carbon and Low-Alloy Steels

Type of test	RCC-M		ASME	
	Requirement	Reference	Requirement	Reference
NDE	Same NDE required in qualification as in production (see S7700)	S 3632	Liquid penetrant	QW-453
Bend test	Four side bends (two parallel and two normal to welding direction)	S 3633a	Four side bends (two parallel and two normal to welding direction)	QW-453
Chemical analysis	2+0.5mm below as-welded surface of cladding(1)	S 3633b	Any distance from weld interface [Note (2)]	QW-453
Determination of δ-ferrite content	Delong diagram	S 3633c	Not required [Note (3)]	-
Metallographic examination	Two macrographic sections (one parallel and one normal to welding direction)	S 3633d	Not required [Note (3)]	-
Hardness measurement	One traverse	S I 500	Not required(3)	-
Corrosion test	See reference	S I 600	Not required(3)	-

Notes

(1) Qualification range based on number of layers (S 3616).
(2) The distance from the approximate weld interface is the minimum qualified overlay thickness.
(3) May be required by the relevant equipment specifications.

A number of requirements for procedure qualification are provided in RCC-M, which are not addressed by Section III-NB and IX or considered nonessential variable by Section IX, as follows:

- The qualification is limited to the amperage range specified in the qualification test or in the qualification data sheet as described in S5000. This is a nonessential variable in Section IX.
- The qualification is limited to filler materials with exactly the same geometrical characteristics as the filler metal used for the qualification test piece. In this case, 'geometrical characteristics' is interpreted as referring to electrode or wire diameter. This is a nonessential variable in Section IX.
- Destructive testing for procedure qualification of groove welds include the following, which are not required by Section IX: chemical analysis, hardness testing, metallographic examination, determination of δ-ferrite content for group 8 steels (austenitic stainless steels) and intergranular corrosion test for austenitic or austenitic-ferritic weld deposits.
- RCC-M requires the welding procedure qualification test coupon to be examined in accordance with the production weld joint NDE requirements and to meet the applicable acceptance criteria (S3200, para 7.1a). Section III-NB does not require this examination.
- RCC-M provides specific requirements for the qualification of 'special welds', which are not addressed separately by Section III-NB, as generally covered by Section IX:
  - Dissimilar metal welds
  - Pipe socket welds
  - Friction welding
  - Electron beam welding
  - Clad plates

6.4 ASME BPVC Section III&IX versus JSME

Highlights:

- The structure of the JSME standard for procedure qualification is broadly similar to that of Section IX, with some significant differences listed in Figure II-4.
- The essential variables not listed in Figure II-4 can be considered equivalent to those in Section IX.

The requirements for welding procedure qualification for Nuclear Components are specified in Part 2 of JSME S NB1. The main differences between Section IX and JSME S NB1 Part 2 are shown in Figure II-4.

6.5 ASME BPVC Section III&IX versus PNAE G-7

Highlights:

- PNAE G-7-010-89 and ASME BPVC IX are very similar in the case of principles of welding procedure qualification, but PNAE G-7-010-89 is more general; it does not include the technical details, which ASME BPVC IX does.

There are the following in accordance with PNAE G-7-010-89 in contrast to the ASME BPVC IX:

- Both mechanical and non-destructive tests are required by procedure qualification.
- The maximum period of validity of procedure qualification is determined (it differs depended on joint category). After this period, the qualification shall be renewed.
- The welded joint category is the "essential variable". The position, electrical characteristics and heat input are not the "essential variables".
- The list of welding methods is limited.

This section provides a comparison between ASME BPVC Section IX and the PNAE G-7 set of documents for procedure qualification, focusing in particular on the comparison with PNAE G-7-009-89 "Components and Pipelines of Nuclear Power Facilities. Welding and Cladding. General rules" and PNAE G-7-010-89 "Components and Pipelines of Nuclear Power Facilities. Welding and Cladding. Examination rules", which cover the welding processes. A line-by-line comparison between ASME BPVC Section IX and PNAE G-7-009/010-89 is tabulated in Figure II-7; this also includes references to other PNAE G-7 documents, whose scope is entirely or partly covered by ASME BPVC Section IX.

The requirements on procedure qualification are included in chapters 3, 10.3, appendix 1 and 2 of PNAE G-7-010-89.

Similar to the requirements of ASME BPVC IX, procedure qualification according to PNAE G-7-010-89 shall be held by the Manufacturer. It is not allowed to use welding procedure for components manufacturing, which have not been qualified.

The consequence of procedure qualification in accordance with PNAE G-7-010-89 and ASME BPVC IX is similar. Both documents require the production of welded joint (similar to one which will be used during production), the preparing of test coupon, the examination of test coupon, and evaluation of results on their compliance with the requirements for the production of welded joint.

Figure 6-4 lists the documentation used for procedure qualification in accordance with PNAE G-7 and ASME BPVC.

Figure 6-4: Documentation used for Procedure Qualification

PNAE G-7	ASME BPVC
Process and Technological Documentation (Standard Technological Instruction, etc.) *prepared by Material Organization*	Standard Welding Procedure Specification *prepared by AWS*
Process and Technological Documentation (Procedure Qualification Program, Technological Instruction, etc.) *prepared by Manufacturer*	Welding Procedure Specification *prepared by Manufacturer*
↓ Welding Procedure Qualification ↓	
Procedure Qualification Record *prepared by Manufacturer*	Procedure Qualification Record *prepared by Manufacturer*

PNAE G-7-010-89 defines the following three types of qualification: initial, periodical and extraordinary. In distinction from the ASME BPVC IX, PNAE G-7-010-89 procedure qualification is valid for 18, 24 and 36 months (in relation with the welded joint category). These periods may be extended twice or up to the finish of component producing (in the case if the component producing is longer the extended period).

PNAE G-7-010-89 does not use the «essential variables» term. Instead, it uses the concept of "group of single-type welded joints" (it means that this group includes the welded joints with the same essential variables). Three types of group are defined: for welded joints, tube-to-tubesheet welding and corrosion-resistant cladding.

For the group of single-type welded joints the following characteristics are defined in PNAE G-7-010-89:

- welded joint category;
- welding method;
- base material grade (may be grouped);
- filler material grade (may be grouped);
- thickness of welded parts;
- curvature radius of welded parts;
- joint type (groove weld, fillet weld, etc.);
- groove geometry;
- groove cladding (if it is necessary);
- preheat;
- PWHT.

The characteristics of the single-type welded joints of PNAE G-7-010-89 are little less detailed, compared to the essential variables of ASME BPVC IX. There are no tables included lists of essential/nonessential variables for any welding method in PNAE G-7-010-89. Also as it could be seen, position, electrical characteristics and heat input are not the essential variables in accordance with PNAE G-7-010-89. The groups of base and filler material grade are also not listed, there are only recommendations on how to group the materials.

The PNAE G-7-009/010-89 list of welding methods is limited to automatic submerged arc welding, manual metal-arc welding, manual/semi-automatic/automatic argon-arc welding, electroslag welding, electron beam welding in vacuum, plasma-arc welding. This list does not include, for example, oxyfuel gas welding, electrogas welding, friction welding and stud welding. But there is the procedure for including the other welding methods in the PNAE G-7-009/010-89 list.

The one major difference is the list of examinations of test coupons required. In accordance with PNAE G-7-010-89 in addition to the mechanical tests, the suitable NDE (visual, surface and volumetric) shall be done. Also, mechanical tests may include tensile tests at high temperatures, if it is required by Process and Technological Documentation. If the drop weight test is out of PNAE G-7 scope at all, the Charpy test is used.

6.6 ASME BPVC Section III&IX versus CSA

Highlights:
CSA Standard N285.0 "General requirements for pressure-retaining systems and components in CANDU nuclear power plants" and its accompanying series provide specific requirements for nuclear plants in Canada. CSA N285.0 establishes rules for classification of various components referencing requirements for construction of the applicable ASME Boiler and Pressure Vessel Code (BPVC) classes. The establishment of the requirements for each class of system, component or support is consistent with the Nuclear Safety and Control Act.

The technical requirements for fabrication and installation of Class 1 components are specified in Clause 9.2.1 of CSA N285.0, and make direct reference to ASME BPVC, Section III, Division 1, NB-4000.

Figure 6-5: Section III and CSA Requirements for Fabrication and Installation

ASME Equivalent Section	CSA N285.0 "Fabrication and Installation"	Section Title	Description
NB-4000	Clause 9.2 Specific Requirements	Clause 9.2.1 Class 1 components and non-standard fittings	The licensee shall have Class 1 components and non-standard fittings fabricated and installed to comply with the requirements of the ASME BPVC, Section III, Division 1, NB-4000.

In addition to this requirement, CSA N285.0 requires that fabrication and installation shall be carried out under a quality assurance program as outlined in Clause 10, including preparation of the following documents:

- Fabrication and installation documents, instruction, and procedures including verification;
- Records demonstrating completion of all required tests, examination and treatments, including qualification of personnel and procedures used;
- Records demonstrating the acceptance of inspection and testing plan by authorized inspector;
- Permanent and non-permanent records for the applicable period of time; and
- Records showing the actual stamping on the nameplate.

Comparison of the requirements for the technical content of welding procedure specifications and the qualification of welding procedures:

The qualification of welding or brazing procedure is specified in Section 9.3 of CSA Standard N285.0. Except for the in-service plugging fusion welding of Class 1 heat-exchanger tube or tube sheet holes with a one-inch maximum diameter, all welding procedures are required to be qualified in accordance to ASME BPVC Section III Class I. This requirement has to be met by the licensee either the procedure has been qualified in or outside Canada. In addition, the licensee is required to retain records of welding or brazing procedure qualification registered by the authorized inspection agency. In Canada, the authorized inspection agencies are established by the Canadian jurisdiction of each Province or Territory that regulates the technical requirements of the ASME BPVC Section III for qualification of welding procedures.

Note that ASME BPVC Section III references ASME BPVC Section IX for qualification of welding procedures.

Figure 6-6: Section III and CSA Requirements for the Technical Content of Welding Procedure Specifications and the Qualification Thereof

ASME Equivalent Section	CSA N285.0 "Fabrication and Installation"	Section Title	Description
ASME BPVC Section III	Clause 9.3 "Welding and Brazing"	Clause 9.3.1	The licensee shall retain records in accordance with Clause 12 to demonstrate that, for welding or brazing procedure performed inside Canada on Class 1 component meets the requirements of the ASME BPVC Section III Division 1, and that procedure has been registered with the authorized inspection agency.
ASME BPVC Section III	Clause 9.3 "Welding and Brazing"	Clause 9.3.2	The licensee shall retain records in accordance with Clause 12 to demonstrate that, for welding or brazing procedure performed outside Canada on Class 1 component meets the requirements of the ASME BPVC Section III Division 1.

In addition to the above requirements, CSA N285.0 specifies in Annex J provisions for in-service plugging fusion welding of Class 1 heat-exchanger tube or tube sheet holes with a one-inch maximum diameter. Annex J is an informative (non-mandatory) annex written in normative (mandatory) language to facilitate adoption where users of the Standard or regulatory authorities wish to adopt it formally.

According to Annex J, the qualification of welding procedures is required to be qualified in accordance to ASME BPVC Section IX and the following additional requirements:

- Separate qualification shall be required for any change in welding processes, P-number, A-number, SFA-number, or F-number;
- Additional to the Essential variable listed in ASME BPPV Section IX, QW-250, a separate qualification shall be required when any the following occur:
  - A change of more than 1.6mm in the extension or recess of wither the tube relative to the tube sheet or the plug relative to the material being joined;
  - A change of 10% or more in the nominal plug wall thickness at the weld location;
  - A change of 10% or more in the nominal wall thickness of the tube, when the tube is welded to the tube;
  - A decrease of 10% or more in the specified width of the ligament between tube holes when specified width is less than 9.5mm or three times the specified tube wall thickness, whichever is greater.
- The tube sheet in the test assembly shall be at least as thick as the production tube sheet or 38.1mm, whichever is less;
- The welding of the procedure qualification test assembly shall simulate the welding position of the production tube sheet;
- Five consecutive welds of the test assembly shall be made and examined using liquid penetrant in accordance with ASME BPVC Section V.

6.7 ASME BPVC Section III&IX versus KEPIC

Highlights:

- ASME Code inserted many variables for the new welding process such as LBW in QW-200, 300 & 400. However, most of KEPIC code's variables were not reflected or treated as non-essential variables.
- KEPIC is considered that it is necessary to reflect it to follow the newly reflected ASME Code contents.

There is little that changed on the contents of the ASME code and KEPIC. The requirements for temper bead weld repair that were subdivided in the existing ASME code, however, was integrated into the new ASME. In addition, detailed information about welding procedure qualification has been reflected in ASME IX, and KEPIC code follows the old version of ASME. It should also be reflected in the KEPIC code.

7 COMPARISON OF THE REQUIREMENTS FOR A SYSTEM FOR TECHNICAL MANAGEMENT AND SUPERVISION OF WELDING AS A MANUFACTURING / CONSTRUCTION TOOL

7.1 General

Overall quality assurance requirements for ASME nuclear type (N-type) certificate holders are provided in the ASME NQA-1 regulatory standard 'Quality Assurance Requirements for Nuclear Facility Applications'. This standard has been endorsed by the US Nuclear Regulatory Commission (NRC) in its Regulatory Guide 1.28 (RG 1.28), which specifies additional requirements and ensures compliance with the criteria provided by Appendix B to the NRC regulation 10 CFR 50 'Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants'.

Section III provides requirements for Quality Assurance in Division 1 Subsection NCA Article NCA-4000 (hereafter referred to as NCA-4000), this was revised for the first time in the 1977 Edition, Winter 1978 Addenda to match the "18 criteria" provided by 10 CFR 50, Appendix B (see list below). In the winter 1982 Addenda, NCA-4000 adopted NQA-1 for the first time. Several editions of NQA-1 have since being adopted by Section III, the most recent being the 2008 Edition with 2009 Addenda (see table NCA-7100-2). In addition, responsibilities and duties regarding welding and subcontracting during construction are defined in NCA-3131.

The activities performed as part of the technical management and supervision of welding are defined in an organization's quality assurance program. Therefore, the comparison between Sections III&IX and the RCC-M code, as well as Sections III&IX and ISO 3834, presented in section 7.2 and 7.6 below was been carried out by initially reviewing all '18 requirements' addressed by NCA-4000, these were then grouped into three categories, as shown in Figure 7-1. The categories were defined as follows:

- Requirements directly related to technical management and supervision of welding: detailed comparison;
- Requirements indirectly related to technical management and supervision of welding: general comparison (limited to comments in comparison tables, e.g. Figure III-1 for ASME v RCC-M);
- Requirements not related to technical management and supervision of welding: comparison was not carried out;
- The comparison between the ASME and JSME code requirements was limited in scope, for the reasons explained in Section 1.1. The main findings are presented.

Figure 7-1: Classification of Quality Assurance Requirements of NCA-4000 (NQA-1) for the Purpose of Comparing the Technical Management and Supervision of Welding between Codes/Standards

Directly related	Indirectly related	Non related
1 Organization 5 Instructions, Procedures and Drawings 7 Control of Purchased Material, Equipment and Services 9 Control of Special Processes 10 Inspection (see also NCA-5000) 14 Inspection, Test and Operating Status	2 Quality Assurance Program 6 Document Control 8 Identification and Control of Materials Parts and Services 12 Control of Measuring and Test Equipment 13 Handling, Storage and Shipping 15 Control of nonconforming Items 16 Corrective Action 17 Quality Assurance Records	3 Design Control 4 Procurement Document Control 11 Test Control 18 Audits

Note: The numbering of requirements refers to NQA-1.

7.2 ASME BPVC Section III&IX versus RCC-M

Highlights

- Section III requires organizations to comply with the N-Type system. This is significantly different from the RCC-M approach, which requires the qualification of technical workshops, although both aim at achieving the same objective.
- Section III does not explicitly address the roles, responsibilities and duties of welding supervisors; these are addressed by RCC-M.

The results of the comparison between Section II&IX and RCC-M are presented in Figure III-1.

As stated in the Code Comparison Report, ASME BPVC and RCC-M define significantly different systems for quality assurance to achieve the same objective. Whilst the first defines a certification program (N-stamp), the latter gives more responsibility to contractors, manufacturers and suppliers, as specified in Section I A-5100. It is the responsibility of the owner to prepare and implement a quality system that is compliant with the code, to notify the various contractors, suppliers, and manufacturers that it interfaces with of the quality system used and, finally, verify that they all are compliant with the defined quality system.

With regards to the technical management of welding, both codes require qualification of welding performance and welding procedures (compared in detail in sections 5.3 and 6.3), as well as work instructions or specifications to cover production welding (see NCA-3853.2 for Section III and Section IV S7120 and S7431 for RCC-M). These can be considered equivalent in scope, although they are technically different in their content and requirements.

A significant difference is found when the supervision of welding is considered. This is addressed in Section III, NCA-5000, which describes the role of the Authorized Inspection Agency, (AIA), Authorized Nuclear Inspector Supervisor and Authorized Nuclear Inspector (ANI), which shall not be in the employ of an N Certificate Holder (NCA-5123). In general, the duties of witnessing, monitoring and verifying examinations and inspections listed in NCA-5200. With regards to welding, it requires that welding performance and welding procedures have been qualified under the provisions of an ANI according to requirements defined in Section III. As such, the ANI does not direct and/or oversee production of welding activities. Section IX QG-106 states that each organization is responsible for the supervision and control of procedure and performance qualifications and does not permit delegating such responsibility to other organizations. No specific provisions are given with regards to the personnel assigned to the supervision and control of welding activities, however, by making it mandatory for an organization to supervise and control its own qualifications, the code implicitly requires that the organization should employ sufficiently competent and skilled supervision personnel. This aspect is more explicitly dealt with by RCC-M, which includes in the requirements for the qualification of workshops (Section IV, Clause S6220) that "*the welding and test personnel (and their supervisors) must possess the necessary skill and authorization. They must in general belong to the workshop; temporary outside assistance, duly qualified according to RCC-M requirements, will nevertheless be allowed.*" Although somewhat loose, this requirement has two important implications:

- It makes it mandatory for welding supervisors to be suitably 'skilled' and places this responsibility on the manufacturer. This is not explicitly addressed by Section III&IX.
- It permits the temporary employment of external personnel for welding, testing and for welding supervision. Section III permits engaging of welders or welding operators by contract (NCA-3131), however, these shall be qualified by the Certificate Holder (NCA-3131d). Section II&IX do not address the possibility of engaging welding supervisors by contract.

7.3 ASME BPVC Section III&IX versus JSME

Highlights

- The JSME code does not define authorized inspection as in Section III. Inspection is carried out by the governmental regulatory authority or it's approved third party agencies.
- Neither ASME or JSME provide specific requirements for directing and/or overseeing production welding activities.

As summarized in a presentation by Morishita, Miyaguchi and Nagata at an MDEP meeting [3] in Japan, a system for authorized inspection has not been established. In lieu of authorized inspection as defined by ASME, the governmental regulatory authority or its third party approved agencies conduct final inspections of nuclear components and supervise welding and examination of weld during construction of the item. Such requirements are not stated in the JSME code. Quality Assurance programs are based on ISO 9001.

Moreover, JSME code does not specify any requirements for qualification and responsibility of welding coordination personnel, e.g. welding engineers, welding supervisors and welding inspectors. It is the opinion of the authors that specific requirements on the technical management and supervision of welding will not be introduced in the foreseeable future.

7.4 ASME BPVC Section III&IX versus PNAE G-7

Highlights

- The requirements on quality assurance programs for any activity related to nuclear power are contained in NP-090-11.
- The most comparison lines have a B2 rating because generally the same requirements have the technical differences in quality assurance procedures implementation.
- The usual practice for Russian Manufacturers is to be certified in accordance with ISO 9001, and to use ISO 9001 QMS as the part of their quality assurance programs.

The main Russian normative document on quality assurance is NP-090-11 "Requirements on Quality Assurance Program for Nuclear Facilities". It contains the general requirements on quality assurance procedures. The technical requirements on quality control are included in PNAE G-7-009-89 "Components and Pipelines of Nuclear Power Facilities. Welding and Cladding. General rules" and PNAE G-7-010-89 "Components and Pipelines of Nuclear Power Facilities. Welding and Cladding. Examination rules", which cover the welding processes. The results of the comparison between Section III&IX and NP and PNAE G-7 documents are presented in Figure III-2.

The following is a brief description of Russian quality assurance procedure during the fabrication.

The NP-090-11 normative document requires that for any activity related to nuclear power, the Quality Assurance Program (POKAS) shall be prepared. The description of POKAS types may be found in chapter 8.10.2 of "Codes Comparison Report". It should be noted that the previous normative document NP-011-99 on Quality Assurance Program was upgraded and renamed to NP-090-11 in 2012.

In accordance with NP-090-11, any Manufacturer has to develop its own Quality Assurance Program on Fabrication POKAS (I). The Quality Assurance Program should consist of the following sections:

- Policy on quality assurance;
- Interaction in Organization related to the quality assurance;
- Personnel management;
- Documentation control;
- Design control;

- Control of purchased components, materials, semi-products and software as well as services;
- Process control (including welders and welding procedure qualifications, tests and examinations);
- Metrological control;
- Maintenance of reliability;
- Software quality assurance;
- Management of non-conformances;
- Audits.

If Manufacturer uses any QMS, it shall be briefly described in POKAS (I). The usual practice of Russian manufactures is to use the ISO 9000 series of standards for their quality system.

For any fabricated item, the Manufacturer shall prepare a detailed Quality Plan. All quality related controls, examinations and tests during fabrication should be done in accordance with the Quality Plan. The control during fabrication is carried out by the Manufacturer Technical Control Service. The final control documentation shall be checked by the Inspector of the Authorized Organization. The Inspector of the Authorized Organization may participate in particular examinations during fabrication. The types of conformity assessment are described in chapters 8.10.4 – 8.10.7 of "Codes Comparison Report".

Related to welding procedure, PNAE G-7-008/009/010-89 includes special requirements on quality assurance. In accordance with these requirements:

- The Manufacturer is responsible for the quality of welded joints;
- The Manufacturer shall have the skilled personnel (including the qualified welders) and be licensed by a Regulatory Authority;
- The Manufacturer shall qualify the particular welding procedures and obtain the Regulatory Authority permission to carrying out the welding;
- The Manufacturer shall provide the incoming inspection of base, filler and others materials, and control the handling and storage of such materials;
- The Manufacturer shall control the equipment used for fabrication, tests and examinations;
- The Manufacturer shall control the welding and heat treatment processes;
- The Manufacturer shall make the necessary tests and examinations of fabricated items;
- The Manufacturer shall prepare the necessary documentation with description of all fabrication processes with quality assurance records, as well as documentation on performance and procedure qualifications.

7.5 ASME BPVC Section III&IX versus CSA

Comparison of the requirements for a system for technical management and supervision of welding as a manufacturing/construction tool:

The system for technical management and supervision of welding as a construction tool is specified in Clause 10 of CSA N285.0 "General requirements for quality assurance". This Clause states that the construction, repair, replacement and modification of Class 1 components shall be carried out in accordance with ASME BPVC Section III Division 1, Article NC-4000.

Figure 7-2: Section III and CSA General Requirements for Quality Assurance

ASME Equivalent Section	CSA N285.0 "Fabrication and Installation"	Section Title	Description
ASME BPVC Section III	Clause 10 "General requirements for quality assurance"	Clause 10.2 "Construction of Class 1 components"	Construction of Class 1 components shall be carried out under a quality manual program that satisfies the requirements of ASME BPVC Section III Divisions 1, Article NCA-4000.
		Clause 10.3 "Repair, replacement, and modification of Class 1 components"	Repair, replacement, and modification of Class 1 components shall be carried out under a quality assurance (QA) program that satisfies the requirements of ASME BVC Section III Division 1, NCA-4000.

The requirements applicable for the supply of materials and welding consumables to be used in Class 1 components are covered by the CSA N285.0 in its section 10.6. Alternatively to the ASME BPVC Section III Divisions 1, Article NCA-3800 that applies to the requirements for the supply of materials and welding consumables, CSA N285.0 also accepts a quality program that satisfy requirements of CAN / ISO 9001 with specific additional requirements specified in ASME BPVC Section III Divisions 1. These requirements are outlined below:

Figure 7-3: Section III and CSA Requirements for the Supply of Materials and Welding Consumables

ASME Equivalent Section	CSA N285.0 "Fabrication and Installation"	Section Title	Description
ASME BPVC Section III	Clause 10 "General requirements for quality assurance"	Clause 10.6 "Class 1 material"	The manufacturer or supply of material (including welding consumables) for use in Class 1 components and their supports shall meet one of the following:
			(a) activities shall be carried out under a quality program that satisfies the requirements of the ASME BPVC Section III Divisions 1, Article NCA-3800; or
			(b) activities shall be carried out under a quality program that satisfies the requirements of CAN / ISO 9001, and the following additional requirements of the ASME BPVC Section III Division 1: (i) sources of material, source of material, and services-NCA3855.2;

ASME Equivalent Section	CSA N285.0 "Fabrication and Installation"	Section Title	Description
			(ii) identification and material control-NCA-3856; (iii) internal audits-NCA-3859.1(e) Note: This requirement may be satisfied by annual audits conducted by other parties that are permitted by the ASME BPVC Section III Division 1, to qualify material or service suppliers. (iv) certification requirements-NCA-3860; (v) where utilization of unqualified source material is involved, the requirements of the ASME BPVC Section III Division 1, NCA-3855.5 shall also apply; and (vi) where welding is involved, the requirements of the ASME BPVC Section III Division 1, NCA-3857.3 shall also apply.

The quality assurance programs acceptable for use are defined in Clause 10.7 of CSA N285.0. These quality assurance programs have to be accepted by the Authorized Inspection Agency (AIA) designated by the regulatory authority of each Canadian province or territory responsible for design, procedure, inspection, etc.

Figure 7-4: Section III and CSA Requirements for Quality Assurance Programs

ASME Equivalent Section	CSA N285.0 "Fabrication and Installation"	Section Title	Description
ASME BPVC Section III	Clause 10.7 "QA programs acceptable for use"	Clause 10.7.1	QA programs that are deemed acceptable to meet requirements listed in Clauses 10.1, 10.2, 10.3, 10.4, 10.5, or 10.6, and any additional N285 scope requirements may be used when surveyed and conclusions are confirmed and recorded in writing by an AIA in Canada (this may be by issuance of a certificate).
		Clause 10.7.2	ASME BVC Section III Division 1, NCA QA programs certified by ASME may be used.
		Clause 10.7.3	A QA program for servicing pressure relief valves certified the national Board may be used.

Conclusion:

Although CSA N285.0 has some additional requirements to the ASME BPVC Section III requirements with respect to registration of welding procedures, welding personnel and quality assurance programs as required by each Canadian jurisdiction, overall it relies heavily on the ASME approach for construction, repairs or modification of Class 1 components.

From the Canadian perspective, these differences result either from different regulatory requirements or technical differences that are a result of the different concepts not addressed in ASME Section III.

7.6 ASME BPVC Section III&IX versus ISO 3834

Highlights:

- Section III is specific to nuclear components. ISO 3834 can be applied to any fusion-welded product.
- Section III provides requirements for a quality system program. ISO 3834 does not require a quality management system; however, it may complement a quality system that does not address welding activities.
- ISO 3834 does not require formal certification, although this is more and more often required by contracts or application standards.
- ISO 3834 permits the use of 'non-ISO' standards and documents, provided these are technically equivalent to the correspondent ISO standards. Section III does not permit the use of standards outside those specifically referenced by the ASME BPVC.
- ISO 3834 defines the role of responsible welding coordinators in reference to ISO 14731 and makes it the central element of a welding quality system. Section III&IX imply that suitably competent individuals are employed by a Certificate Holder, however, no specific requirements are given.

ISO 3834 deals with quality requirements in welding and has been prepared in order to identify those controls and procedures. ISO 3834 is not a quality system standard intended to take the place of ISO 9001, but a useful, additional tool for use when ISO 9001 is applied by manufacturers, in which case the meeting of its requirements needs to be recorded in certificates or documentation. However, ISO 3834 can be used independently of ISO 9001. ISO 3834 is intended for the fusion welding of metallic materials, and its application is independent of the products manufactured. However, its principles and many of its detailed requirements are also relevant for other welding and welding-related processes.

One of the aims of ISO 3834 is to define requirements in the field of welding so that contracting parties or regulators do not have to define these requirements themselves. A reference to a particular part of ISO 3834 should be sufficient to demonstrate the capabilities of the manufacturer to control welding activities for the type of work being done; external assessment or certification is not required. However, assessments by customers and certification by independent bodies are growing trends in commercial relations and the standard can serve as a basis for these purposes, as well as for the demonstration of performance by those manufacturers implementing it.

ISO 3834 identifies measures that are applicable for different situations. Typically, they may be applied in the following circumstances:

- in contractual situations: specification of welding quality requirements;
- by manufacturers: establishment and maintenance of welding quality requirements;
- by committees drafting manufacturing codes or application standards: specification of welding quality requirements;
- by organizations assessing welding quality performance, e.g. third parties, customers, or manufacturers.

The ISO 3834 standard is composed of a series of parts, which are published as individual documents, as follows:

- Part 1: Criteria for the selection of the appropriate level of quality requirements
- Part 2: Comprehensive quality requirements
- Part 3: Standard quality requirements
- Part 4: Elementary quality requirements
- Part 5: Documents with which it is necessary to conform to claim conformity to the quality requirements of ISO 3834-2, ISO 3834-3 or ISO 3834-4

Part 6 is also published, however, this provides guidelines on implementing the standard, and therefore, it is not mandatory.

According to ISO 3834-1, the selection of the appropriate part, specifying the required level of quality requirements, should be in accordance with the product standard, specification, regulation or contract. Because ISO 3834 may be used in a variety of situations and for different applications, definitive rules on the level of quality requirements to be adopted in individual circumstances cannot be given. The manufacturer (or the applicable product standard and specification) therefore selects one of the three parts specifying different levels of quality requirements, based on the following criteria related to products: the extent and significance of safety-critical products, the complexity of manufacture, the range of products manufactured, the range of different materials used, the extent to which metallurgical problems may occur, and the extent to which manufacturing imperfections, e.g. misalignment, distortion or weld imperfection, affect product performance.

As this code comparison project focused on nuclear components, the comprehensive requirements provided in ISO 3834-2 were considered as the most appropriate. Therefore, ISO 3834 parts 3 and 4 were not considered. It should be noted that, as Part 2 of this standard provides the most stringent requirements, compliance with Part 2 implies compliance with Parts 3 and 4.

The results of the comparison between Section III and ISO 3834 are presented in Figure III-3. A first significant difference is that Section III is specific to nuclear components, whereas ISO 3834 can be applied to any fusion-welded product. Therefore, with regards to procedure and performance qualifications, Section III provides additional requirements to those of Section IX, whereas ISO 3834 references the relevant ISO standards, with no additional requirements. With regards to the overall scope, whilst Section III defines requirements for a quality program, ISO 3834 does not specifically require a quality management system. However, if a quality management system were to be adopted which did not include specific requirements for welding activities, ISO 3834 could still be used.

With regards to the technical management of welding, both codes require qualification of welding performance and welding procedures (compared in detail in sections 5.2 and 6.2), as well as work instructions or specifications to cover production welding (see NCA-3853.2 for Section III and Clauses 10.2 and 10.4 for ISO 3834-2). As observed above, when specific activities are covered by an ISO standard (e.g. procedure and performance qualification, calibration,) ISO 3834 refers to the applicable standard in part 5 and does not provide supplementary requirements. It should be noted that ISO 3834-5 (Clause 2.1) permits the use of standards other than ISO, when these are referenced in the product standards for the products being made by the manufacturer, provided that these result in technically equivalent conditions. It is the responsibility of the manufacturer to demonstrate technically equivalent conditions when documents other than those specified in ISO 3834-5 are employed. Certificates issued following assessment by independent certification organizations, or claims of compliance by a manufacturer with any part of ISO 3834, shall clearly identify the documents used by the manufacturer. This practice is not permitted by Section III.

Similar to Section 7.2 (ASME BPVC Section III&IX versus RCC-M) above, when defining the role of AIAs and ANIs, Section III addresses independent inspection. However, it does not cover supervision, intended as effectively directing and overseeing of welding activities. No specific provisions are given with regards to the personnel assigned to the supervision and control of welding activities, however, by making it mandatory for an organization to be able to supervise and control its own qualifications, the code implicitly states that the organization should employ sufficiently competent and skilled supervision personnel. ISO 3834 defines welding coordination activities and makes the welding coordinator (or welding coordination team), the central and most important element of a welding quality system. The tasks and

responsibilities of the welding coordination personnel are defined in ISO 14731. ISO 14731 uses the term "responsible welding coordinator" (RWC) to identify the person or persons having an adequate level of welding technical knowledge for the range of products manufactured. It allows welding coordination to be sub-contracted, while the responsibility for maintaining compliance with ISO 14731 remains with the manufacturer. All manufacturers should appoint at least one RWC. The expectation is that a responsible welding coordinator is the person nominated by the manufacturer as having the competence to make decisions and to sign documents which affect product quality. The responsible welding coordinator has an overall responsibility for monitoring welding activities and for taking action when welding has not been correctly performed. This standard provides three levels of knowledge requirements for responsible welding coordination personnel:

a) Personnel with comprehensive technical knowledge, where full technical knowledge is required for the planning, executing, supervising and testing of all tasks and responsibilities in welding fabrication.
b) Personnel with specific technical knowledge, where the level of technical knowledge needs to be sufficient for the planning, executing, supervising and testing of the tasks and responsibilities in welding fabrication within a selective or limited technical field.
c) Personnel with basic technical knowledge, where the level of technical knowledge needs to be sufficient for the planning, executing, supervising and testing of the tasks and responsibilities within a limited technical field, involving only simple welded constructions.

A direct correlation between the three levels of knowledge quoted above and the three levels of quality requirements in ISO 3834 parts 2 to 4 applies to some applications, but not all. Guidance on the appropriate level of knowledge for the RWC is provided in ISO 3834-6, table 4. ISO 14731 (Annex A) correlates the three levels of knowledge defined by ISO 3834 to the International Institute of Welding (IIW) qualifications for welding coordination personnel, i.e. International Welding Engineer (IWE), International Welding Technologist (IWT), International Welding Specialist (IWS). However, ISO 3834 does not mandate specific qualifications and holding one of these IIW qualifications does not give automatic presumption that a certain level of knowledge has been attained.

Other significant differences between Section III&IX and ISO 3834 are:

- Calibration: ISO 3834 is more stringent as it requires the application of specific standards for calibration and validation of measuring and test equipment.
- Audits: requirements for auditors are not addressed in ISO 3834 (they are in NQA-1). However, the standard requires that the welding coordination team is involved in audits.
- Requirements for weld repairs are generic in ISO 3834 (under corrective actions), whereas NB-4450 gives specific requirements, as expected from a Construction Code.

7.7 ASME BPVC Section III&IX versus KEPIC

Highlights:

- KEPIC has adopted the technical requirements of ASME BPVC without modification, following the spirit of safety of ASME BPVC, and has customized the requirements of system and operation for the local environment. As a result, it was found that there was no difference in technical requirements, with the exception of system requirements, and it has been concluded that there are no technical issues in applying equipment manufactured in accordance with KEPIC to nuclear power plants where ASME is applied.
- In addition, in terms of QA and the administrative requirements related with nuclear safety, KEPIC-MNB adopted and has operated the requirements of ASME in most of the parts. However, it reflected the differences resulting from different laws and regulations and education systems in Korea from those of the U.S.A. KEPIC introduced ASME's code symbol system and operates

independent code symbol systems through simplification. However, there are no requirements that have been relaxed from ASME levels regarding safety.

- In terms of the systematic parts, both have the same basic contents. However, KEPIC tried to be more subjective, relating to the regulations with regard to nuclear power safety, system operation, qualification entitlement, etc. by naturally applying Korean domestic laws, albeit through the same basic frameworks. In conclusion, KEPIC and ASME have no noticeable differences regarding nuclear safety.

8 UPCOMING CHANGES IN CODES AND STANDARDS AFFECTING HARMONIZATION

8.1 Requirements for Welder and Welding Operator Qualifications

A comparison exercise carried out by the ASME BPVC Section IX committee and by a JWES task group (distributed to committee and task group members only) has shown that welder and welding operator qualifications carried out according to Section IX and ISO 9606-1 (qualification of welders, fusion welding of steels) showed the latter is comparable to Section IX or it exceeds it in all but one area: the acceptance standards for radiographs and ultrasonic examination allow slag lines to be equal in length to the thickness of the test coupon, whereas Section IX limits slag lines to a length not exceeding the test coupon thickness divided by 3 (t/3). This difference can be overcome, however. Some of the differences identified in Section 5.2, such as the requirement in Section IX that a welder is qualified under the supervision and control of his/her employer, cause administrative issues when attempting to cover both standards with a single qualification. As a consequence, JWES requested that specific guidance is included in Section IX and a similar request was made by European members of the ISO TC44 committee (Welding and allied processes). This request extended to ISO 14732 (qualification of welding operators), to reflect the scope of Section IX.

As a result, guidance will be included in the 2015 Edition of Section IX in the form of a non-mandatory appendix. This appendix will detail administrative, technical and testing requirements for an organization that is testing welders and welding operators to the abovementioned ISO standards, to certify that the welders and welding operators are also qualified to Section IX.

From the 2015 Edition of the RCC-M code, EN 1418 will be replaced by ISO 14732. It is also expected that EN 287 1 will be replaced by ISO 9606-1, see Figure 1-1 and Section 5.2.2(c) above.

8.2 Requirements for the Technical Content of Welding Procedure Specifications and the Qualification Thereof

At the time of writing this report, the most common ISO standard for welding procedure qualification (ISO 15614-1, arc welding of steels and Ni-alloys) is in its final stage of revision. This was the result of a comparison with Section IX carried out by the ISO/TC 44 committee, the outcome of which has been used for some parts of Section 6.2. Unlike with the welding performance qualification standard, the ISO and ASME requirements for qualification of welding procedures were not similar enough for one to fulfil the other or vice versa and could not be merged. Therefore, the next edition of ISO 15614-1 will effectively be present a two-level approach, with a ‘Level 1’ based on Section IX and a ‘Level 2’ based on the current edition of the ISO standard. It is expected that RCC-M will only permit qualifications according to Level 2.

Similarly to what observed for welder and welding operator qualifications (Section 8.1), it is expected that the next edition of ISO 15614-1 will facilitate the use of existing ISO procedure qualifications when Section IX is required, as qualifications to ISO 15614-1 Level 1 will satisfy the requirements of Section IX. In addition, Level 2 will automatically qualify for Level 1; but not vice-versa. Therefore, the use of existing Section IX procedures when ISO 15614-1 is required will not be permitted.

Another standard considered in the scope of this project: ISO 15614-7 for the qualification of overlay welding procedures is being revised at the time of preparing this report. No major changes are expected.

8.3 Requirements for a System for Technical Management and Supervision of Welding as a Manufacturing/Construction Tool

The need for standardization of requirements for the technical management and supervision of welding beyond procedure and performance qualifications has been recognized by a number of industry sectors in recent years, including the nuclear sector. In this context, the ISO 3834 series of standards has been identified as a sufficiently flexible and robust set of requirements and guidelines, encompassing the most important aspects of welding quality.

At the time of preparing this report, a working group within the RCC-M subcommittee is considering the inclusion of requirements from ISO 3834 in the RCC-M code, either by direct reference, or by extracting specific requirements.

In addition, the ISO committee for welding qualifications (ISO TC44/SC10) has recognized some shortcomings in the current standard for welding coordinating personnel (ISO 14731), hence a working group for its revision has been created.

MANDATORY APPENDIX I: COMPARISON OF THE REQUIREMENTS FOR WELDER AND WELDING OPERATOR QUALIFICATIONS

I.1 ASME BPVC Section IX versus ISO Standards

Figure I-1: Comparison Of The Requirements For Welder And Welding Operator Qualifications

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
Test coupons and test methods					
QW-300.1	Qualification test coupon Welders and operators may prepare a test coupon or may be qualified on their initial production welding	6.2 (9606)	Welders shall prepare a test piece	B2	Test coupon are referred to as 'test pieces' in ISO standards
		4.1 (14732)	Welding operators shall be qualified by: • Welding procedure test to ISO 15614 • Pre-production welding test to ISO 15613 • Test piece to ISO 9606 • Production test or production sample test	A2	None
QW-301.2	The qualification test coupon shall be welded in accordance with a qualified welding procedure specification (WPS) or standard welding procedure specification (SWPS). Preheat or PWHT may be omitted	6.3 (9606) 4.1 (14732)	The qualification test piece shall be welded in accordance with a preliminary welding procedure specification (pWPS) or welding procedure specification (SWPS) PWHT may be omitted	B2	pWPS is not defined in Section IX. The definition of 'standard welding procedure specification' given in Section IX is: "welding procedure specification, published by the American Welding Society, that is made available for production welding by companies or individuals without further qualification, and that may be used in Code applications in accordance

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
					with the restrictions and limitations of Article V.
QW-301.2	The welder or welding operator who prepares the WPS for the procedure qualification test coupons is also qualified within the limits of performance qualification.	Introduction (9606)	The qualification test can be used to qualify a welding procedure and a welder provided that all the relevant requirements, e.g. test piece dimensions and testing requirements are satisfied	A1	None
		4.1 (14732)	Welding operators may be qualified by a welding procedure test to ISO 15614	A1	None
QW-301.3	Qualified welders or welding operators shall be assigned an identifying number, letter or symbol, which shall be used to identify the work of that welder or welding operator.	6.1 (9606)	The test pieces shall be marked with the identification of the examiner and the welder	A2	None
		Annex C (14732)	The welding operator identification is required in the suggested certificate form	A2	None
QW-301.4	The welder/welding operator performance qualification (WPQ) record shall include type of test, test results and ranges of qualification. A recommended form is provided.	10 (9606)	The welder's qualification test certificate shall include all essential variables, as well as the following non-essential variables: • Type of current and polarity • Parent material group/subgroup • Shielding gas	B2	None

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
			A recommended form is provided. The welder certificate shall include all information listed in the form.		
		6 (14732)	The welding operator qualification test certificate shall include all relevant testing conditions. A recommended form is provided.	B2	None
QW-302.1 QW-452.1	Mechanical tests: groove-weld test. Visual examination and bend test (side, face or root bend, depending on test coupon thickness) are required	6.4 and Table 13 (9606) 4.1 (14732)	Visual test is mandatory. In addition, radiographic examination, bend or fracture testing shall be used. Ultrasonic testing is also permitted for thicknesses ≥8mm on ferritic steel.	B2	ISO qualification based on bend test would also satisfy Section IX, provided the conditions described in Section 8 are met. See QW-304 below for qualification based on radiographic testing and ultrasonic testing.
				B2	Appendix L of Section IX states that ISO qualifications based on fracture test to ISO 9017 do not satisfy the requirements of Section IX. The intent of this requirement is that fracture tests as an alternative to bend tests when testing groove welds, (Figure associated with Table 14 in 9606-1) does not satisfy Section IX. For fillet weld tests, if a fracture test and a

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
					macro examination are, the requirements of Section IX would be satisfied.
QW-302.1 QW-302.4 QW-452.5	Mechanical tests: fillet-weld test. Visual test is required (QW-302.4). One macro examination and one fracture test are required (QW-452.5)	6.4 and Table 13 (ISO 9606) 4.1 (14732)	Visual test is mandatory. In addition, either one fracture test or two macro examinations are required, including one section in the start/stop location.	B2	ISO qualifications based on macro examinations and fracture testing would also satisfy Section IX, provided the conditions described in Section 8 are met.
				B2	Appendix L of Section IX states that ISO qualifications based on fracture test to ISO 9017 do not satisfy the requirements of Section IX. The intent of this requirement is that fracture tests as an alternative to bend tests when testing groove welds, (Figure associated with Table 14 in 9606-1) does not satisfy Section IX. For fillet weld tests, if a fracture test and a macro examination are, the requirements of Section IX would be satisfied.
QW-302.2	When a welder is qualified by volumetric NDE, the minimum length of coupon to be examined shall be 6in (150mm) and shall include	6.2 and 6.5.2.1 (9606) 4.1 (14732)	The examination length is 150mm. For pipe of circumference less than 150mm, additional test pieces are required (maximum three)	A2	Identical, with the exception of the maximum number of test pieces.

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
	the entire weld circumference for pipe(s). Multiple test coupons may be required for small diameter pipe (maximum four).		When radiographic test is used, the examination length of the weld shall be radiographed.		
QW-302.3	Test coupons in pipe. The number of bend test may be two, four or six depending on the test positions.	6.5.1 and 6.5.2.3 (9606) 4.1 (14732)	Four bend tests are required. At least one specimen shall be taken from a stop/start location.	B2 (or A2)	A2: when both Section IX and ISO 9606-1 require four bend tests.
QW-303.5	Tube-to-tubesheet welder and welding operator qualification QW-193.2 applies when QW-193 is required by the applicable Code Section. Otherwise, qualification shall be by groove weld (QW-303.1) or mockup (QW-193.2).	Not addressed (9606)	Tube-to-tubesheet welding is not specifically addressed by ISO 9606-1. Requirements may be provided in the applicable product standard(s) as per section 5.4 d).	B1	A specific BS standard exists: BS 4871-3:1985 'Specification for approval testing of welders working to approved welding procedures. Arc welding of tube to tube-plate joints in metallic materials'. However, in the authors' experience, this is not widely used. Note that ISO 9606-1, clause 5.4 d) allows tube to tubesheet welding to be qualified by means of a specific weldment: this could be defined by a product standard or any other dispositions.
	The tests listed in QW-193.1 are: visual	ISO 14732 (section 4.1)	The current edition of ISO 15614-8 refers to EN 1418, which has been superseded by	A2	The test piece and testing requirements broadly overlap and an ISO qualification may

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
	examination, liquid penetrant and macro-examination.	refers to ISO 15614-8	ISO 14732. It is the opinion of the author that the intent of ISO 14732 is that all tests specified in ISO 15614-8 shall be carried out. These include visual testing, penetrant testing, radiography, macro examination, hardness and pull-out test (if required by the application standard).		potentially satisfy the requirements of Section IX. See also Figure 6-2.
QW-362	Electron Beam Welding, Laser Beam Welding, Hybrid Welding and Friction Welding	Not addressed (9606)	None	B1	Most applications of LBW are automatic or machine processes. All applications of EBW and Friction Welding are automatic or machine processes. No ISO standards address hybrid welding. Also, hybrid welding will not be specifically address from the 2015 Edition of Section IX.
		ISO 14732 (section 4.1) refers to relevant part of ISO 15614	None	None	Outside the scope of this project
QW-380	Corrosion resistant weld-overlay Refers to QW-453 for size of test coupon, limits of base metal thickness,	Not addressed (9606)	Corrosion resistant weld-overlay is not specifically addressed. With regards to the test piece, clause 5.4(d)	B2	ISO qualification based on bend test would also satisfy Section IX, provided the conditions described in Section 8 are met.

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
	testing and test specimens. Requires bend testing only.		may be applied, which requires a specific test piece. Additional requirements may be provided in the applicable product standard(s).		See Figure I-2 for a comparison between essential variables.
		ISO 4732 (section 4.1) refers to ISO 15614-7	Test piece as required by ISO 15614-7. Tests required include bend testing (see ISO 15614-7 Table 1 for full list). Visual testing, surface (magnetic particle/liquid penetrant) and bend testing are required only when a qualified WPS is used.	B2	ISO qualification would also satisfy Section IX, provided the conditions described in Section 8 are met. With regards to essential variables, see Figure I-3.
QW-382	Hard-facing weld metal overlay. Refers to QW-453 for size of test coupon, limits of base metal thickness, testing and test specimens. Requires macro examination and liquid penetrant testing.	Not addressed (9606)	Hard-facing weld-metal overlay is not specifically addressed. With regards to the test piece, clause 5.4(d) may be applied, which requires a specific test piece. Additional requirements may be provided in the applicable product standard(s).	B2	ISO qualification based on bend test would also satisfy Section IX, provided the conditions described in Section 8 are met. See Figure I-2 for a comparison between essential variables.
		ISO 14732 refers to ISO 15614-7	Test piece as required by ISO 15614-7. Tests required include macro examination and surface	B2	ISO qualification would also satisfy Section IX, provided the conditions described in Section 8 are met.

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
			testing (see ISO 15614-7 Table 1 for full list). Visual testing, surface (magnetic particle/liquid penetrant) and bend testing are required only when a qualified WPS is used.		With regards to essential variables, see Figure I-3
QW-383	Joining of clad materials	Not addressed	None	B1	None
Ranges of qualification and essential variables					
QW-303.1	Type of weld. Groove welds also qualify fillet welds in all thicknesses and pipe diameters of any size	5.4 (9606)	Butt welds do not qualify fillet welds or vice-versa. Qualification of a fillet weld in combination with a butt weld is permissible, as per the provisions in Annex C or if a supplementary fillet weld test is prepared as per Clause 5.4(e).	B2	None
		4.2 (14732)	Type of weld is not an essential variable	A1	None
QW-303.1	Limits of qualified positions, refers to QW-461.9.	5.8 (9606)	Limits of qualified positions, refers to Tables 9 and 10	B2	Qualification ranges for positions are mostly equivalent. Main differences: • ISO testing position PE and (ASME 4G or 4F) qualifies for horizontal position • ASME qualified positions for groove welds depend on pipe diameter, ISO qualified position depend on pipe diameter for

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
					positions PA, PB, PC and PD (see 5.3c)
		4.2 (14732)	Limits to qualified positions according to ISO 9606-1, only for mechanized welding.	B2	None
	Position is not a variable for automatic welding under Section IX.		Position is not an essential variable for automatic welding.	A1	None
QW-303.1	Limits of qualified diameters, refers to QW-461.9, who in turn refers QW-452.3, -4 and -6.	5.3 and Table 7 (9606)	Section 5.3 addresses product types (plate or pipe), table 7 addresses the qualified ranges for outside diameter pipe	B2	The philosophy is similar (plate qualifies pipe above a certain OD); however, the qualification ranges are different. For pipe test coupon, ASME has two thresholds (1 and 27/8in), ISO has one threshold (25mm), also, ASME has no limit on maximum diameter qualified.
	Diameter is not a variable for either machine or automatic welding	4.2 (14732)	Diameter is not an essential variable	A1	None
QW-304 305 for	Addresses qualification of welders and operators by volumetric NDE, including testing methods and acceptance criteria.	7 and Table 13 (9606)	Table 13 allows radiographic testing, in lieu of bend test or fracture test. Ultrasonic testing is also permitted for thicknesses ≥8mm on ferritic steel.	A2 provided conditions are met	Radiographic and ultrasonic examination satisfying the requirements of ISO 9606-1 and ISO 14732 also satisfy the requirements of Section IX, except that indications characterized as linear slag may not exceed the thickness of the test coupon divided by three. When using ultrasonic
		4.1 (14732)	Volumetric NDE is applied according to the selected testing route		

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
					testing, the test coupon shall be ½in thick or thicker.
QW-306	Combination of welding processes. • The welding process is an essential variable • Permits qualification of each individual welding process to be used in production on separate test coupons • Permits combination of welding processes in a single test coupon	5.2 (9606)	Welding processes. • The welding process is an essential variable • States that normally each test qualifies only one welding process • Permits combination of welding processes in a single test coupon (see clause 6.3) • Does not address two or more welders qualified in combination in a single test coupon	B2	The philosophy is similar; however, the ISO system for classifying welding processes presents some significant differences (ISO 4063). For instance, Section IX considers GMAW and FCAW as the same welding process for the purpose of welder qualification, whereas these are two different processes according to ISO 4063. ISO 9606-1 clause 6.3 requires a start and stop in root and capping pass: this implies that the test coupon is performed by the same welder. Thus, the standard does not allow more than one welder per coupon.
	• Permits two or more welders and operators qualified in combination in a single test coupon	Not addressed (14732)	It is the opinion of the authors that the combination of welding processes is permitted.		
QW-310	Qualification test coupons Provides specific requirements on pipe sizes and welding grooves.	6.2 and 6.3 (9606) 4.1 (14732)	Test pieces	B2	No comparable requirements. The dimensions of test coupons as per ISO 14732 refer to ISO 9606-1 or 15614-1, depending on the method of qualification used.

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
Other requirements (responsibility, validity, extension, retests, etc.)					
QG-106.2	Organizational responsibility Each organization is responsible for the supervision and control of performance qualification. Production of test joints under the supervision and control of another organization is not permitted.	6.1, 10 (9606) 5, 6 (14732)	ISO 9606-1 and ISO 14732 define the examiner/examining body as a person/organization appointed to verify compliance with the applicable standard. The welding of test pieces shall be witnessed and the testing shall be verified by an examiner/examining body. The certificate shall be issued under the sole responsibility of the examiner/examining body. NOTE: contractual requirements often state that the examiner/examining body shall be an independent third party; this is mandatory when the PED applies (see Section 4.4.2). Therefore, it is common practice to request an independent third party to act as examiner/examining body.	B2	Major difference: a welder must be qualified under the supervision and control of the organization according to Section IX, whereas this responsibility lies with an examiner/examining body according to ISO 9606-1 and ISO 14732. These can be internal or external to the organization. Often contractual requirement prescribe that the examining body is an independent third party. It should be noted that Clause 9.3(c) of ISO 9606-1 and Clause 5.3(c) of ISO 14732, are applicable only if a welder is working for the same manufacturer for whom he or she qualified, and who is responsible for the manufacture of the product, amongst other conditions.

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
QG-106.3	Simultaneous performance qualifications	Not addresses	Not specifically addressed but implicitly allowed.	B2	According to the comment in the previous row, ISO 9606-1 implicitly allows simultaneous performance qualifications.
QG-108	Performance qualifications dated as far back as 1962 may be used. Qualifications dated prior to 1962 may be used provided the requirements of the 1962 Edition or later have been met.	Introduction in both ISO 9606-1 and ISO 14732	Existing qualifications in accordance with a national standard may be revalidated according to ISO 9606-1 or ISO 14732, provided the technical intent of these standards is satisfied.	A2	None
QW-197.2	For LBW, a peel test specimen and macro specimens are required	ISO 14732	No specific testing requirements for laser beam welding	B1	As per clause 4.1 of ISO 14732, the manufacturer may select the appropriate standard for processes not explicitly described in the standard: For instance, ISO 15614-11 or an internal procedure may be used, provided the acceptance criteria are specified in the WPS. As a minimum, visual test and macro-examination on one cross section of the weld, or a radiographic examination for butt welds are required.

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
QW-320	Retests Provides specific requirements for retesting, depending on the cause of failure. Generally, it is required that he welder makes two consecutive test coupons and that retesting shall be by the same testing method that failed. Retesting may be by further examination for welder who has failed the production.	8 (9606)	Retests Retesting is permitted once by repeating the qualification test, without further training.	B2	The requirements for retest are essentially different.
		Not addressed (14732)	Not addressed	B1	Section 6 of ISO 14732 specifies that the qualification report is not established if one the required test associated to the qualification test fails. This could implicitly indicate that there is no limitation to the number of performance retests.
QW-322	Expiration and renewal of qualification	9 (9606) 5 (14732)	Period of validity	See next two rows	None
QW-322.1	Expiration of Qualification. The performance qualification expires when a welder has not welded with a process during a period of six months or more. Any weld made with that process and supervised and control by the qualifying organization, extends all qualifications with that process for a period of six months.	9.1 and 9.2 (9606) 5.1 and 5.2 (14732)	Initial qualification and confirmation of validity. A welder certificates is valid for six months from the date of welding, and the person responsible for welding activities, or the examiner/examining body need to confirm that the welder has worked within the range of qualification; this extends the validity of the qualification for a further six months.	B2	Extension is 6-monthly for both systems. However, there is a major difference: • Extension is 'process based' in Section IX, any weld made with a specific process extends all qualifications with that process. • Confirmation is 'certificate based' in ISO 9606-1, each qualification can be extended separately by welding

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 ISO 14732 corresponding paragraph**	**Description**		
					within the ranges of qualification in the corresponding certificate.
QW-322.2	Renewal of qualification may be made for any process by welding and testing a single test coupon using that process, no specific provisions are given on product form, material, size, and position.	9.3 (9606) 5.3 (14732)	Revalidation of qualification shall be carried out by an examiner/examining body and may follow any of these three routes: a) Retesting every three years b) Revalidation every two years based on volumetric NDE or destructive testing evidence from the previous six months. c) Conformation every six months according to 9.2 (see above), provide specific conditions are met.	B2	General difference, renewal is the responsibility of the qualifying organization for Section IX, whether it shall be carried out by an examiner/examining body according to ISO 9606-1. B2 if routes (a) or (b) in ISO 9606-1 are considered. B1 if route (c) in ISO 9606-1 is considered, as this is broadly in line with Section IX (unlimited extension based on 6-monthly confirmation).
QW-362	Performance qualification for EBW, LBW, hybrid welding, FRW. Requires testing to QW-452	See QW-452 above			

Figure I-2: Comparison between Section IX Requirements for Welders versus ISO 9606-1

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	Description	ISO 9606 corresponding paragraph	Description		
QW-350	Essential variables for welders	5	Essential variables	None	Oxyfuel welding was not considered as it is not applied to nuclear power plant components.
QW-381.1	Limits of base metal thickness for performance qualification, refers to QW-453	Not addressed	ISO 9606-1 does not address base metal thickness.	B1	None
QW-402.4	The deletion of backing in single-sided welds (QW-402.4)	5.9 and Table 11	Welding with backing qualifies welding with backing or from both sides. A matrix table is provided.	A1	
QW-403.16 QW-405.2	A change in pipe diameter	Table 7	A change in pipe diameter, as defined in Table 7	B2	See QW-303.1 above
QW-403.18	A change from one P-Number to any other P-Number or to an unassigned base metal, except as permitted in QW-423, and in QW-420. Table QW-423 permits qualification to be done on any material P-1 through P-15F and welders are qualified to weld on all base metals from P-1 through P-15F since 9606 -1 is for welding.	5.5.1	The parent material shall be any suitable material from groups 1 to 11 in ISO/TR 15608 and all materials listed in Groups 1 through 11 are qualified.	B2	ISO 9606-1 is limited to steels. EN 287-1, currently referred to by RCC-M, includes specific ranges of qualification for parent materials.
QW-404.14	The deletion or addition of filler metal	5.6	Welding with filler material qualifies for welding without filler	B2	None

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 corresponding paragraph**	**Description**		
			material, but not vice versa		
QW-404.15	A change from one F-Number in Table QW-432 to any other F-Number or to any other filler metal, except as permitted in QW-433.	5.5	Filler metals are grouped within 'FM numbers', which correspond to F-Numbers in Section IX.	B2	ISO 9606-1 is more stringent (e.g. FM1 only covers FM1 and FM1, whereas F-number 1 covers all F-Nos 1 through 5)
QW-404.22	For GTAW and PAW, the omission or addition of consumable inserts. Welding with consumable insert qualifies welding with backing and double-sided welding.	Table 11	Welding with consumable insert qualifies welding with consumable insert, welding with backing and double-sided welding.	A2	None
QW-404.23	For GTAW and PAW, a change in filler metal product form.	Table 5	A matrix is provided.	B2	According to Section IX, solid wire, metal and flux cored do not affect welder qualification. According to ISO 9606-1, solid wire and metal cored do not cover flux cored and vice versa.
QW-404.30	A change in weld deposit thickness beyond the ranges in QW-452. The maximum thickness is 2t if t<1/2in (13mm), otherwise it is 'unlimited'. No minimum limit is given.	Table 6	Weld metal deposited thickness=s. The maximum qualified thickness is 2s (or 3 mm) for s<12mm or unlimited for s≥12mm. The minimum qualified thickness is s (for s<3mm) otherwise 3mm.	A2 or B2	Maximum limit: A2 Minimum limit: B2

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 corresponding paragraph**	**Description**		
QW-404.32	Limits on thickness qualified for short-circuiting type GMAW	Not addressed	None	B1	None
QW-405.1	See QW-303 above	-	-	-	-
QW-405.3	A change from upward to downward weld progression and vice-versa for vertical welds.	Tables 9 and 10	'Vertical up' does not cover 'vertical down'# and vice-versa.	A2	None
QW-408.8	For GMAW, FCAW, GTAW and PAW, omission of inert gas backing. Requalification is not required when welding with backing strip or double-sided welding.	Table 11	A test piece made with gas backing covers welding with gas backing, material backing and double-sided welding	A2	
QW-409.2	For GMAW, FCAW, GTAW, a change from globular, spray or pulsed spray transfer welding to short circuiting transfer welding or vice-versa.	5.2	Short circuiting transfer welding cover all other transfer modes, but not vice-versa	B2	None
QW-409.4	For GTAW, a change from AC to DC, or vice-versa; and in DC welding, a change from electrode negative (straight polarity) to electrode positive (reverse polarity), or vice-versa.	10	Type of current and polarity are nonessential variables	B2	Current type and polarity are listed in ISO 9606, so if someone wanted to create a Section IX record from an ISO 9606 one, these variables could be easily retrieved.

Figure I-3: Comparison between Section IX Requirements for Welding Operators versus ISO 14732

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	**Description**	**ISO 9606 corresponding paragraph**	**Description**		
QW-381.1	Limits of base metal thickness for performance qualification, refers to QW-453. Test piece thickness = T For T<1in (25mm), the range of qualification is t to unlimited. For T≥1in (25mm), the range of qualification is 1in (25mm) to unlimited.	ISO 14732 (Section 4.1) refers to ISO15614-7.	Test piece thickness = t For t<1in (25mm), the range of qualification is 0.8t to 1.5t. For t≥1in (25mm), the range of qualification is 1in (25mm) to unlimited.	B2	A difference is observed in the qualified base metal thickness range when the test coupon thickness is <25mm.
QW-382	See QW-381.1 above	See QW-381.1 above	See QW-381.1 above	B2	See QW-381.1 above
QW-361.1	Provides essential variables for automatic welding, e.g. welding process. Includes specific variables for Electron Beam Welding, Laser Beam Welding, Hybrid Welding and Friction Welding.	4.2.2	Welding process is an essential variable. Does not directly address Electron Beam Welding, Laser Beam Welding, Hybrid Welding and Friction Welding, as per clause 4.1 of ISO 14732, ISO 15614-11 could be applied for LBW and EBW.	A2 or B1	For arc welding, ISO qualification would also satisfy Section IX, provided the conditions described in Section 8 are met.
QW-361.2	Provides essential variables for machine welding	4.2.3	With the exception of difference in terminology and the lack of a specific reference to hybrid	A2	None

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW paragraph	Description	ISO 9606 corresponding paragraph	Description		
			plasma-GMAW, the list of essential variables is identical to that in Section IX.		

Figure I-4: Materials Groups according to Section IX and ISO

ASME P-Numbers	ISO Group numbers
1 Carbon steels	1 Steels with C - 0.25, Si - 0.60, Mn - 1.8, etc. with yield strength
2 Wrought iron (No longer used)	specified as below:
3 Nominal 1/2% Mo and/or Cr Alloy steel	2 Thermo-mechanically treated fine grain steels and cast steels
4 Nominal l-1/4 % Cr, l/2% Mo, Alloy steel	with as below:
5A Nominal 2-1/4 and 3% Cr, 1 % Mo Alloy steel	3 Quenched and Precipitation hardened fine grain steels (except
5B Nominal 5 to 10% Cr, 1 Mo Alloy steel	stainless steels)
5C All 5A and 5B metals heat treated	with yield strength > 360 N / mm2
6 Martensitic stainless steel	4 Low Vanadium Alloyed Cr-Mo-(Ni) steels with MO - 0.7 %
7 Ferritic stainless steel	and V - 0.1 %
8 Austenitic stainless steel	5 Cr-Mo steels free of Vanadium and C - 0.35 %
9A 2 % Nickel Alloy steel	6 High Vanadium alloyed Cr-Mo-(Ni) steels.
9B 3.5% Nickel Alloy steel	7 Ferritic, Martensitic or Precipitation hardened stainless steels
9C 4.5% Nickel Alloy steel 8 and 9 Ni,	with C < 0.35 % and 10.5 % < Cr < 30 %
10A Mn, V, 75 to 105 ksi	8 Austenitic Stainless Steels, Ni < 31 %
10B 1Cr, V, 60 ksi	9 Nickel Alloy steels.
10C C, Mn, Si	10 Austenitic – Ferritic (duplex) stainless steels.

ASME P-Numbers	ISO Group numbers
10D No longer used	11 Steels covered by 1 with 0.25 % - C - 0.85 %
10E No longer used	21 Pure Aluminum with < 1 % impurities or alloy content.
10F Mn, 1/4Cr, V, 85 to 95 or 1/2Ni, 1/2Cr, 1/4Mo, 90 ksi	22 Non Heat Treatable Al alloys Al – Mn & Al - Mg alloys.
10G 36Ni, 65ksi	23 Heat Treatable Al alloys, Al – Mg -Si, Al – Zn - Mg alloys.
10H 18 to 27 Cr, 4 to 10 Ni, 1.5 to 4 Mo, N, 87 to 110 ksi (Duplex SS)	24 Al – Si alloys.
10I 26 to 27 Cr, 1 Mo, 60 to 70 ksi	25 Al-Si-Cu alloys.
10J 29Cr, 4 Mo, 70 to 80 ksi	26 Al – Cu alloys.
10K 26 to 29 Cr, 3 to4 2 to 2.5 Ni, 70 to 85 ksi	31 Copper with - 6 % Ag and - 3 % Fe
11A Low alloy steel, Quenched and Tempered, 95 ksi min	32 Copper – Zinc alloys.
11B Low Alloy steel, Quenched and Tempered 105ksi min.	33 Copper – tin alloys.
15 Creep Strength Enhanced Ferritic Steels	34 Copper – Nickel alloys.
21 Unalloyed, 1 .2% Mn alloy Al, 8 to 14 ksi	35 Copper – Aluminum alloys.
22 1 .2%Mn and 2.5 to 3.5 Mg .25 Cu Al, 21 to 31 ksi	36 Copper – Nickel – Zinc alloys.
23 1 .3Mg, .7%si .25Cr Al, 17 to 24 ksi	37 Copper alloys, low alloyed.
25 4.5%Mg, 0.8%Mn, 0.15Cr Aluminum, 34 to 41 ksi	38 Other Copper alloys.
31 Copper, < 0.8 Ag, 30 to 45 ksi, and 2.5 Fe+Zn, 45 to 50 ksi	41 Pure Nickel
32 Admiral, Naval, Al Brass, Muntz Metal	42 Nickel – Copper alloys.
33 Copper-silicon, 1 .6 to 3.5 Si Alloys, 40 to 85 ksi (includes Cold Hardened)	43 Nickel – Chromium alloys.
34 Copper-Nickel, 5.5 to 3O Ni, Fe, Mn, 38 to 81 ksi (includes Cold Hardened)	44 Nickel – Molybdenum alloys.
35 Aluminum Bronze Alloys, 5.8 to 11 Al, 5Ni, 3 Fe, 5O to 9O ksi	45 Nickel – Iron Chromium alloys.
41 Nickel, Unalloyed, 50 to 70 ksi	46 Nickel – Chromium – Cobalt alloys.
42 Monel, 67 Ni, 30 Cu, 70 to 110 ksi, (includes Cold Hardened)	47 Nickel – Iron – Chromium – Copper alloys.
	48 Nickel – Iron – Cobalt alloys.

ASME P-Numbers	ISO Group numbers
43 NiCrFe, 47 to 72 Ni, 15 to 29 Cr, 8 to 9 Mo, 8 to 18 Fe, 3.5 Cb, 75 to120 ksi	51 Pure Titanium
	52 Alpha alloys.
44 NiMo, NiMoCr, Ni, 13.5 to 28 Mo, 7 to 21 Cr, 4 to 5.5 Fe, 3W, 100 to115 ksi	53 Alpha – Beta alloys.
	54 Near Beta and Beta alloys.
45 NiCrFe (33N1), NiFeCrMoCu, Fe, 20.75 to 49 Ni, 21 to 27 Cr, 3.5 to 35Mo, 0 to 3 Cu, O to 18.5 Co, 85 to 104 ksi	61 Pure Zirconium
	62 Zirconium with 2.5 % Nb.
46 NiCrSi, 35 Ni, 19 Cr, 1.25 Si, 7O ksi	71 Grey Cast Iron.
47 NICrWMo, Ni. 22Cr, 14W, 2Mo, Al, La, 11O ksi	72 Spheroidal Graphitic Cast Iron.
51 Titanium, unalloyed and 0.18Pd) 35 to 50 ksi, (Alpha Alloys)	73 Malleable Cast Iron.
52 Titanium, unalloyed and 0.3%MO, 0.8Ni%, 65 to 70 ksi, (Alpha)	74 Austempered ductile Cast Iron.
53 Titanium, 3Al, 2.5V, 90 ksi (Alpha-Beta alloys)	75 Austenitic Cast Iron.
61 Zirconium, Unalloyed, 55 Ksi	76 Cast Irons except 71 – 75.
62 Zirconium 2.5%Nb, 80 ksi	

Note: For subgroups, see QW-422 and ISO/TR 15608, respectively.

I.2 ASME BPVC Section III&IX versus AFCEN RCC-M

Figure I-5: Comparison between Section III-NB Requirements for Welding Performance Qualification versus RCC-M

ASME		RCC-M		Comparison (see 1.2)	Comments
ASME Section III NB par.	Description	RCC-M corresponding paragraph	Description		
NB-4321	Requires the application of Section IX	S4110 S4210	Requires the application of EN 287-1 and EN 1418, both superseded at the time of writing this report. See	B2	RCC-M is considered more stringent as it requires a number of supplementary requirements to the general qualification standards. Due to differences in administrative and

ASME		RCC-M		Comparison (see 1.2)	Comments
ASME Section III NB par.	**Description**	**RCC-M corresponding paragraph**	**Description**		
			discussion in Section 5.3 above.		technical requirements, a qualification to RCC-M will not satisfy the requirements of Section IX.
NB-4321	Responsibility for performance qualification lies with the Certificate Holder	S4120 S4210	Responsibility for performance qualification lies with the Manufacturer. Inspection bodies put forward by the Manufacturer and approved by the Contractor may approve the qualifications.	B2	RCC-M does not have a system equivalent to the ASME stamp system.
NB-4322	Provisions for maintenance and certification of qualification records	A3502 S1120	Describes the content of the welding data package. This may include welder and welding operator qualifications, as well as evidence of their confirmation, although these are not specifically addressed.	B2	None
NB-4323	Welding prior to qualification is not permitted.	S4110 S4120	The qualification procedure must take place prior to any fabrication work.	A1	-
NB-4324	Welding qualifications cannot be transferred between Certificate Holders unless as provided in Section IX QG-106.2	S4110 S4120	The qualification of welder is the responsibility of the manufacturer.	B2	QG-106.2 refers to different organizations under the same corporate ownership. RCC-M only refers to a Manufacturer. Provided a qualification procedure is available as per RCCM S4120, the Manufacturer may employ a welder

ASME		RCC-M		Comparison (see 1.2)	Comments
ASME Section III NB par.	**Description**	**RCC-M corresponding paragraph**	**Description**		
					qualified by other organizations. The company that employs the welder is not an essential variable in the qualification process. However, it is common practice for each Manufacturer to qualify welder internally, to ensure sufficient control.
NB-4350	Performance qualification for tube-to-tubesheet welds	S4320	Welding of heat exchangers or steam generators tube to tubesheet	A2	See Figure I-6, the requirements are considered technically equivalent, with the exception of a minimum limit on the mean throat thickness, which is required by RCC-M only.
NB-4360	Specially designed welded seals	S3520	Canopy and omega welds	B2	RCC-M requires identical conditions as section III for performance qualification, with specific exceptions.
NB-4453.2	Qualification of welders and welding operators for repair welds	S7600	Qualification of welders and welding operators for repair welds	A1	

Figure I-6: RCC-M and ASME III-NB Requirements for Welding Performance Qualification of Tube to Tubesheet Welds

Topic	ASME		RCC-M	
	Required	Reference	Required	Reference
Welder qualification test piece	Five demonstration mock-ups	Section IX, QW-303.5	Six tubes to be welded	S4322
Visual test	Yes	QW-193.1.1	Yes	S3834a
Liquid penetrant test	Yes	QW-193.1.2	Yes	S3834b
Leak test	Not required	-	Yes, as in production	S3834c
Macro-examination	Yes, four cross sections shall be subject to examination. Minimum leakage path (weld throat) 2/3 specified tube wall thickness	QW-193.1.3 NB-4350	Two macro examinations on a diametrical section. Mean weld throat thickness 0.8e and no individual value below 0.66e (e=nominal tube wall thickness)	S4322 S3834d

I.3 ASME BPVC Section III&IX versus JSME

Figure I-7: Comparison between Section III-NB Requirements for Welding Performance Qualification versus JSME S NB1

ASME		JSME		Comparison (see 1.2)	Comments
ASME Section III or IX paragraph	Description	JSME corresponding paragraph	Description		
NB-4321 (Section III)	Requires the application of Section IX	Part 1 (N-0050)	Requires the application of JSME S NB1 Part 3	A1	None
QW-350 (Section IX)	Welding processes	Part 3	See above.	B2	None
QW-303 QW-310 (Section IX)	Welding Position and Test Coupons	Part 3	See above.	B2	
QW-432 (Section IX)	Filler Metal F-numbers	Part 3	Exx19 Ilmenite electrode is F-No.0.	A2	

ASME		JSME		Comparison (see 1.2)	Comments
ASME Section III or IX paragraph	**Description**	**JSME corresponding paragraph**	**Description**		
	Carbon Steel Ilmenite type SMAW Electrode (Exx19) is designated as F-No.2. SMAW F-Nos. qualifications are limited by QW-433.		SMAW F-Nos. qualifications are specified in JSME S NB1 Part 3.		
QW-451	Qualification tests. Requires bend test or volumetric NDE.	Part 3	Bend test is mandatory.	B2	None
QW-360	Welding variables for welding operators	Part 3	Welding operators for Automatic/Mechanized welding processes shall be qualified as per the JSME qualified Automatic/Mechanized WPSs, which is the same system as Section IX.	A2	None
QW-320	Renewal of welder qualifications	Part 1 (N-0050)	JSME specifies that the validation of welders and welding operators' qualification shall be carried out every 2 years and 10 years, respectively. Renewal of welders and welding operators assigned to nuclear power plant are subject to their work experience for welding of nuclear power equipment.	B2	None

Figure I-8: Variables for Welding Process (JSME S NB1). Manual/Semi-automatic Welder Performance Qualification

JSME S NB1 Part 3 WQ-311-1 [Note (1)]			Section IX
Variables (Qualified Welding Process)		Welding Process to be used for Test	
A		A	SMAW
A_0 and A		A_0	
G		G	OFW
T, T_B, T_F and T_{FB}	Manual - T	Manual - T	GTAW
	Semi-automatic - T	Semi-automatic - T	
T_B and T_{FB}	Manual - T_B	Manual - T_B	
	Semi-automatic - T_B	Semi-automatic - T_B	
T_F and T_{FB}	Manual - T_F	Manual - T_F	
	Semi-automatic - T_F	Semi-automatic - T_F	
T_{FB}	Manual - T_{FB}	Manual - T_{FB}	
	Semi-automatic - T_{FB}	Semi-automatic - T_{FB}	
M		M	GMAW
M_0 and M		M_0	
PA	Manual - PA	Manual - PA	PAW
	Semiautomatic - PA	Semiautomatic - PA	

Note (1): Regarding the definition of each welding process, see Figure I-9.

Figure I-9: Test Coupons and Welding Position (JSME S NB1). Manual/Semi-Automatic Welder Performance Qualification

JSME S NB1 Part 3			Section IX
Test Coupon Variable	Test Position	Welding Position and Base Metal Thickness Qualified	Qualified Position
W-0 (Plate with 3~3.2mm thickness)	f	Flat position with plate less than 7mm thick	Flat
	v	Vertical position with plate less than 7mm thick	Flat & vertical
	h	Horizontal position with plate less than 7mm thick	Flat & Horizontal
	o	Overhead position with plate less than 7mm thick	Flat & Overhead
W-1 (Plate with 9mm thickness)	f	Flat position with plate less than 19mm thick	Flat
	v	Vertical position with plate less than 19mm thick	Flat & vertical
	h	Horizontal position with plate less than 19mm thick	Flat & Horizontal
	o	Overhead position with plate less than 19mm thick	Flat & Overhead
W-2	f	Flat position with plate without thickness limit	Flat
	v	Vertical position with plate without thickness limit	Flat & vertical

JSME S NB1 Part 3			Section IX
(Plate with 25mm thickness and over)	h	Horizontal position with plate without thick. limit	Flat & Horizontal
	o	Overhead position with plate without thick. limit	Flat & Overhead
W-3-0 (4" OD Pipe with 4~5.3mm thick.)	e (1G + 5G) [Note (1)]	No limit for welding position with base metal thickness less than 11mm	All Positions
W-3 (6" OD Pipe with 10~12mm thick.)	e (1G + 5G)	No limit for welding position with base metal thickness less than 19mm	All Positions
W-4 (8~10" OD Pipe with 20mm thick and over)	e (1G + 5G)	No limit for welding position and no limit for base metal thickness	All Positions

Note (1): Position "e" is defined only in the JSME Code, as follows: 1/3 of circumferential joint shall be welded in the 1G position and 2/3 of circumferential joint shall be welded in the 5G position.

Figure I-10: F-Nos for Welder Performance Qualification (Manual/Semi-Automatic Welders only)

JSME S NB1 Part 3		Section IX (QW-433)	
Test Coupon F-No. In WPQ	Qualified F-Nos. in WPS	Test Coupon F-No. In WPQ	Qualified F-Nos. in WPS
F-No.0	F-No.0	-	-
F-No.1	F-No.0 and F-No.1	F-No.1	F-No.1 only
F-No.2	F-Nos. 0 to 2	F-No.2	F- No.1 & 2
F-No.3	F-Nos. 0 to 3	F-No.3	F-No.1, 2 & 3
F-No.4	F-Nos. 0 to 4	F-No.4	F-No.1, 2, 3 & 4
F-No.5	F-No.5 only	F-No.5	F-No.5 only

N.B.: F-No.0 is assigned to Ilmenite type SMAW electrode, equal to AWS Exx19 classification.

I.4 ASME BPVC Section III&IX versus PNAE G-7

Figure I-11: Comparison between Section III-NB Requirements for Welding Performance Qualification versus PNAE G-7

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section III NB par.	Description	PNAE G-7 corresponding paragraph	Description		
NB-4321	Requires the application of Section IX	PNAE G-7-008-89 (2.4.1.1)	Requires the application of PNAE G-7-009-89 for matters related with welding	NA	None
		PNAE G-7-009-89 (4.1)	Requires the application of PNAE G-7-003-87 for welding performance qualification		
NB-4321	Responsibility for performance qualification lies with the Certificate Holder	PNAE G-7-008-89 (1.4)	Responsibility for performance qualification lies with the Manufacturer	B2	None
NB-4453.2	Qualification of welders and welding operators for repair welds	PNAE G-7-008-89 (1.2.5)	Requires the application of PNAE G-7-009-89 for welds repairing	NA	None

Figure I-12: Comparison between Section IX Requirements common to Welders and Welding Operators, versus PNAE G-7

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
Test coupons and test methods					
QW-300.1	Qualification test coupon: Welders may prepare a test coupon or may be qualified on their initial production welding.	PNAE G-7-003-87 (2.2.7)	Qualification test should be carried out with the implementation test welded joints of plates or pipes.	A2	The direct translation from Russian of the term which is close by meaning to the test coupon is "test welded joint".
QW-301.2	The qualification test coupon shall be welded in accordance with a qualified welding procedure specification (WPS) or standard welding procedure specification (SWPS). Preheat or PWHT may be omitted.	PNAE G-7-003-87 (3.5)	Welding and heat treatment of the test coupons are performed by the Technological Instruction developed in accordance with the requirements of PNAE G-7-009-89 Preheat or PWHT cannot be omitted if it requires with accordance to PNAE G-7-009-89 or Technological Instruction	B2	Technological Instruction and Standard Technological Instruction are the analogues of WPS and SWPS.
QW-301.2	The welder or welding operator who prepares the WPS for the qualification test coupons is also qualified within the limits of performance qualification.	Not addressed	None	B1	None
QW-301.3	Qualified welders or welding operators shall be assigned an identifying number, letter or symbol.	PNAE G-7-003-87 (7.4)	The certificate is issued to every welder that passed the qualification test. The certificate form is provided in Appendix 2.	A2	None

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
		PNAE G-7-009-89 (4.1)	To each welder shall be given a personal stamp, which is to be registered.	A2	None
QW-301.4	The welder/welding operator performance qualification (WPQ) record shall include type of test, test results and ranges of qualification. A recommended form is provided.	PNAE G-7-003-87 (7.1, 7.2)	7.1 The record of welder performance qualification test should be processed in accordance with Appendix 1. 7.2 NDE records of welds should be attached to welder performance qualification record.	A2	None
QW-302.1 QW-452.1	Mechanical tests: groove-weld test. Visual examination and bend test (side, face or root bend, depending on test coupon thickness) are required.	Not addressed	Mechanical tests are not required by PNAE G-7-003-87.	B1	According to PNAE G-7-003-87 (4) only NDE (visual, radiographic, ultrasonic, liquid penetrant, magnetic particle examinations) is required. For radiographic and ultrasonic examinations there are some exceptions, in this case the macro examination is used.
QW-302.1 QW-302.4 QW-452.5	Mechanical tests: fillet-weld test. Visual test is required (QW-302.4). One macro examination and one fracture test are required (QW-452.5).				
QW-302.2	When a welder is qualified by volumetric NDE, the minimum length of coupon to be examined shall be 6in (150mm) and	PNAE G-7-003-87 (3.6)	The minimum length of plate test welded joint shall be 200 mm for manual welding, and 400 mm for automatic welding. The number of pipe test welded joints shall be not less than 5 (D < 25 mm), 2	B2	None

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
	shall include the entire weld circumference for pipe(s). Multiple test coupons may be required for small diameter pipe (maximum four).		(25 ≤ D ≤ 100 mm), and 1 for bigger diameter.		
QW-302.3	Test coupons in pipe. The number of bend test may be two, four or six depending on the test positions.	Not addressed	Bend tests are not required by PNAE G-7-003-87	B1	According to PNAE G-7-003-87 (4) only NDE is required.
QW-303.5	Tube-to-tubesheet welder and welding operator qualification QW-193.2 applies when QW-193 is required by the applicable Code Section. Otherwise, qualification shall be by groove weld (QW-303.1) or mock-up (QW-193.2). The tests listed in QW-193.1 are: visual examination, liquid penetrant and macro-examination.	PNAE G-7-003-87 (3.6.3, 4.1, 4.2)	3.6.3 At least 7 tubes shall be welded to tubesheet during qualification test. 4.1, 4.2 The following NDE shall be used during tube-to-tubesheet welder qualification: visual examination, any of liquid penetrant or magnetic particle examination, macro-examination.	B2 (A2)	None
QW-362	Electron Beam Welding, Laser Beam Welding,	Not addressed	Laser Beam Welding, Hybrid Welding and Friction Welding are not specifically addressed by PNAE G-7	B1	PNAE G-7-009-89 and PNAE G-7-003-87 include the list

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
	Hybrid Welding and Friction Welding				with allowable welding techniques. LBW, HW and FW are out of this list. The new welding techniques may be used after relevant qualification tests with accordance of requirements of PNAE G-7-008-89 (3.4).
QW-380	Corrosion resistant weld-overlay Refers to QW-453 for size of test coupon, limits of base metal thickness, testing and test specimens. Requires bend testing only.	PNAE G-7-003-87 (3.6.4)	The thickness of base metal plate coupon shall be not less than 40 mm. The area of cladding shall be not less than 200x150 mm for manual welding, and 400x150 for automatic welding.	B2	Only plate test coupons are considered.
QW-382	Hard-facing weld metal overlay. Refers to QW-453 for size of test coupon, limits of base metal thickness, testing and test specimens. Requires macro examination and liquid penetrant testing.	Not addressed	Hard-facing weld metal overlay is not specifically addressed by PNAE G-7-003-87.	B1	Additional requirements may be provided in applicable technical documentation.
QW-383	Joining of clad materials	Not addressed	Joining of clad materials and applied linings is not specifically addressed by PNAE G-7	B1	None

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
Ranges of qualification and essential variables					
QW-303.1	Type of weld. Groove welds also qualify fillet welds in all thicknesses and pipe diameters of any size.	PNAE G-7-003-87 (6.13)	Welder qualification on butt welds extends on fillet welds, weld-overlay (excluded corrosion resistant weld-overlay), and welds repairing.	A2	None
QW-303.1	Limits of qualified positions, refers to QW-461.9.	PNAE G-7-003-87 (6.12, table 2)	Welder qualification on qualified positions (figures 1 – 7) extends on other positions (figures 1 – 14) with accordance of table 2. Also other relevant requirements of section 6 should be taken into account.	A2	The requirements on positions are mostly equivalent.
QW-303.1	Limits of qualified diameters, refers to QW-461.9, who in turn refers QW-452.3, -4 and -6.	PNAE G-7-003-87 (2.2.5, 6.9, 6.10)	2.2.5 Qualification on pipe Arc Welding and EBW shall be done separately for the following ranges of diameters: up to 25 mm, over 25 mm to 100 mm, 100 to 500 mm. Pipe with diameter, which is over than 500 mm, is considered as a plate. 6.9 SMAW/ and Argon-Arc Welding welder qualification on pipes extends on any pipes above a certain diameter and plates. 6.10 Automatic SAW welding operator's qualification on pipes extends on any pipes and plates.	B2	None
QW-304 QW-304	Addresses qualification of welders by volumetric NDE, including testing	PNAE G-7-003-87 (4.1, 4.4)	4.1 The test welded joints shall be examined by following NDE methods: visual, volumetric and surface.	B2 (A2)	According PNAE G-7-003-87 only NDE is required.

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
	methods and acceptance criteria.		4.4 The acceptance criteria are in the PNAE G-7-010-89.		
QW-306	Combination of welding processes. • The welding process is an essential variable • Permits qualification of each individual welding process to be used in production on separate test coupons • Permits combination of welding processes in a single test coupon. • Permits two or more welders qualified in combination in a single test coupon.	PNAE G-7-003-87 (2.3)	Qualification test shall be made separately for different weld processes. Permission on combination of welding processes in a single test coupon and permission of multi welder qualification by single test coupon are not addressed by PNAE G-7-003-87.	A2, B2 (B1)	None
QW-310	Qualification test coupons Provides specific requirements on pipe sizes and welding grooves.	PNAE G-7-003-87 (3.5)	Welding of test welded joints shall be done with accordance with PNAE G-7-009-89.	B2	PNAE G-7-009-89 includes Appendix 3 "Main types of welded joints" with dimensions of the welding groove.

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
Other requirements (responsibility, validity, extension, retests, etc.)					
QG-106.2	Organizational responsibility Each organization is responsible for the supervision and control of performance qualification. Production of test joints under the supervision and control of another organization is not permitted.	PNAE G-7-003-87 (1.2, 1.4)	1.2 Qualification commission created in organization with permission of Regulatory Body performs the qualification of welders. 1.4 Commission in the organization may qualify the welders from other organization if this organization does not have its own commission.	B2	None
QG-106.3	Simultaneous performance qualifications	Not addressed	Simultaneous performance qualification is not specifically addressed by PNAE G-7-003-87.	B1 (A2)	In accordance with PNAE G-7-003-87 (1.4) one organization may qualify the welders from other organization. At the same time the qualification of its own welders may be done.
QG-108	Performance qualifications dated as far back as 1962 may be used. Qualifications dated prior to 1962 may be used provided requirements of the 1962 Edition or later have been met.	PNAE G-7-009-89 (4.1)	Welding and cladding shall be performed by welders qualified in accordance with PNAE G-7-003-87.	B2	Application of the previous edition (1971) of "Rules for Qualification of Welders" is not allowed.

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
QW-321	Retests Provides specific requirements for retesting, depending on the cause of failure. Generally, it is required that he welder makes two consecutive test coupons and that retesting shall be by the same testing method that failed. Retesting may be by further examination for welder who has failed the production.	PNAE G-7-003-87 (5.10)	Welders, who did not pass the test, may be retested only after additional training, but not earlier than a month.	B2	None
QW-322	Expiration and renewal of qualification	PNAE G-7-003-87 (5)	The procedure for admission to welders qualification	See next two rows	5.1 Welder qualification is divided on initial, additional, periodical and extraordinary qualifications. 5.2 The initial qualification is intended for welder who was not previously qualified. 5.3 The additional qualification is intended for extension of qualified welding procedures

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
					or extension in the case when the welder has not welded with a process during a period of 6 month or more. 5.4 The periodical qualification is intended for prolongation of welder certificate 5.5 The extraordinary qualification is intended for qualification renewal after revoking due to ability of welder to make welds with necessary quality.
QW-322.1	Expiration of Qualification. The performance qualification expires when a welder has not welded with a process during a period of six months or more. Any weld made with that process and supervised and control by the qualifying organization,	PNAE G-7-003-87 (5.3, 5.4, 5.5)	5.3 The additional qualification when a welder has not welded with a process during a period of six months or more. 5.4 The periodical qualification is every 24 months. The periodical qualification may be extended on additional 12 months twice if the welder produced joints with necessary quality.	B2 (A2)	The maximum period of qualification is 24+2x12=48 months.

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	Description	PNAE G-7 corresponding paragraph	Description		
	extends all qualifications with that process for a period of six months.		5.5 The qualification should be revoked if welder produces poor quality welds.		
QW-322.2	Renewal of qualification may be made for any process by welding and testing a single test coupon using that process, no specific provisions are given on product form, material, size, and position.	PNAE G-7-003-87 (5.3, 5.4, 5.9)	5.3, 5.4 Renewal of qualification is after passing additional/periodical/extraordinary qualification test. 5.9 The results of NDE of production weld may be used for periodical qualification.	B2	None

Figure I-13: Comparison between Section IX Requirements for Welders versus PNAE G-7

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	Description	PNAE G-7 corresponding paragraph	Description		
QW-350	Essential variables for welders	PNAE G-7-003-87 (2)	Welding classification used for welder qualification	None	PNAE G-7 does not use "variables" term. The close term used is "welded joint characteristics".
QW-381.1	Limits of base metal thickness for performance qualification, refers to QW-453	PNAE G-7-003-87 (3.6.4)	The thickness of base metal plate coupon shall be not less than 40 mm.	B2	None
QW-402.4	The deletion of backing in single-sided welds (QW-402.4)	Not addressed	The backing is not specifically addressed by PNAE G-7-003-87.	B1	None

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
QW-403.16 QW-405.2	A change in pipe diameter (QW-403.16 and 405.2)	PNAE G-7-003-87 (2.2.5, 6.9)	2.2.5 Qualification on pipe Arc Welding and EBW shall be done separately for the following ranges of diameters: up to 25 mm, over 25 mm to 100 mm, 100 to 500 mm. Pipe with diameter, which is over than 500 mm, is considered as a plate. 6.9 SWAW and Argon-Arc Welding welder qualification on pipes extends on any pipes above a certain diameter and plates	B2	The diameter is "essential variable", but the ranges are different.
QW-403.18	A change from one P-Number to any other P-Number or to an unassigned base metal, except as permitted in QW-423, and in QW-420.	PNAE G-7-003-87 (2.2.4)	Qualification test shall be carried out separately for each of the base material groups (table 1).	B2 (A2)	PNAE G-7 does not use "P-number" term. The close term used is "base material group".
QW-404.14	The deletion or addition of filler metal	Not addressed	PNAE G-7-003-87 does not consider the deletion or addition of filler metal as "variable".	B1 (B2)	None

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
QW-404.15	A change from one F-Number in Table QW-432 to any other F-Number or to any other filler metal, except as permitted in QW-433.	Not addressed	PNAE G-7-003-87 does not consider the grade and product form of welding material as "variable".	B2	PNAE G-7 does not use "F-number" term. According to PNAE G-7-009-89 the grade and product form sorts of welding materials are strongly associated with base materials grades (tables 1 – 8).
QW-404.22	For GTAW and PAW, the omission or addition of consumable inserts. Welding with consumable insert qualifies welding with backing and double-sided welding.	Not addressed	The consumable inserts are not specifically addressed by PNAE G-7-003-87.	B1	None
QW-404.23	For GTAW and PAW, a change in filler metal product form.	Not addressed	PNAE G-7-003-87 does not consider the filler metal product form as "variable".	B1	See QW-404.15 above
QW-404.30	A change in weld deposit thickness beyond the ranges in QW-452. The maximum thickness is 2t if t<1/2in (13mm), otherwise it is 'unlimited'. No minimum limit is given.	PNAE G-7-003-87 (6.5, 6.6, 6.8)	6.5 For manual SMAW 3<t<10 mm qualified up to t=50 mm, t>10 mm qualified t>3 mm. 6.6 For GTAW 3<t<10 mm qualified up to t=3 mm. 6.8 For ESW and EBW t qualified ±25% t.	B2	PNAE G-7-003-87 (2.2.5) states that qualification on pipe Arc Welding and EBW shall be done separately for the following ranges of thickness: 3 mm, from 3 to 10 mm, from 10 to 50 mm over 50 mm.

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
QW-404.32	Limits on thickness qualified for short-circuiting type GMAW	Not addressed	The limits on thickness qualified for short-circuiting type GMAW are not specifically addressed by PNAE G-7-003-87.	B1	None
QW-405.1	See QW-303 above	–	–	–	–
QW-405.3	A change from upward to downward weld progression and vice-versa for vertical welds.	Not addressed	PNAE G-7-003-87 does not consider the welding direction as "variable".	B1	None
QW-408.8	For GMAW, FCAW, GTAW and PAW, omission of inert gas backing. Requalification is not required when welding with backing strip or double-sided welding.	Not addressed	The inert gas backing is not specifically addressed by PNAE G-7-003-87.	B1	None
QW-409.2	For GMAW, FCAW, GTAW, a change from globular, spray or pulsed spray transfer welding to short circuiting transfer welding or vice-versa.	Not addressed	The change from globular, spray or pulsed spray transfer welding to short circuiting transfer welding is not specifically addressed by PNAE G-7-003-87.	B1	None

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	Description	PNAE G-7 corresponding paragraph	Description		
QW-409.4	For GMAW, FCAW, GTAW, a change from AC to DC, or vice versa; and in DC welding, a change from electrode negative (straight polarity) to electrode positive (reverse polarity), or vice versa.	Not addressed	The current and polarity is not specifically addressed by PNAE G-7-003-87	B1	None

Figure I-14: Comparison between Section IX Requirements for Welding Operators versus PNAE G-7

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	Description	PNAE G-7 corresponding paragraph	Description		
QW-381.1	Limits of base metal thickness for performance qualification, refers to QW-453. Test piece thickness = T For T<1in (25mm), the range of qualification is t to unlimited. For T≥1in (25mm), the range of qualification is 1in (25mm) to unlimited	PNAE G-7-003-87 (3.6.4)	The thickness of base metal plate coupon shall be not less than 40 mm	B2	The same requirement as for manual overlay cladding
QW-382	See QW-381.1 above	Not addressed	Hard-facing weld metal overlay is not specifically addressed by PNAE G-7-003-87.	B1	None

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par.	**Description**	**PNAE G-7 corresponding paragraph**	**Description**		
QW-361.1	Provides essential variables for automatic welding, e.g. welding process. Includes specific variables for Electron Beam Welding, Laser Beam Welding, Hybrid Welding and Friction Welding.	PNAE G-7-003-87 (2)	Welding classification used for welder qualification	B2 (B1)	PNAE G-7 does not use "variables" term. The close term used is "welded joint characteristics". PNAE G-7-003-87 uses the same welded joint characteristics for welder and welding operator qualification.
QW-361.2	Provides essential variables for machine welding	PNAE G-7-003-87 (2)	Welding classification used for welder qualification	B2 (B1)	PNAE G-7 does not use "machine welding" term. It uses "manual", "semi-automatic" and "automatic welding" terms. Semi-automatic welding here means that some parameters are manually controlled by welder.

I.5 ASME BPVC Section III&IX versus KEPIC MN

Figure I-15: Comparison between Section III-NB & Section IX Requirements for Welding Performance Qualification versus KEPIC

ASME III	Description	KEPIC	Description	Result	Remark
NB-4440	WELDING OF APPURTENANCES	MNB-4440	WELDING OF APPURTENANCES	A1	MNB-4440 established since KEPIC 2007 Addenda along with ASME Code 2005 Addenda NB-4440.
NB-4622.7	Exemptions to Mandatory Requirements	NB-4622.7	(6) ~ (9) (6) weld repairs to cladding after final post weld heat treatment provided the requirements of MNB 4622.10 are met; (7) weld repairs to cladding when the remaining cladding thickness after defect removal is greater than 1/8 in. (3.2 mm) provided repairs are made by either the shielded metal arc welding (SMAW) or the gas tungsten arc welding (GTAW) process; (8) weld repairs to dissimilar metal welds after final post weld heat treatment provided the requirements of MNB 4622.11 are met; (9) weld repairs to dissimilar weld or buttering when the remaining dissimilar weld or buttering thickness after defect removal is greater than 1/8, in. (3.2 mm) provided repairs are made by either SMAW or GTAW process.	A1	MNB-4622.7 (6) ~ (9) deleted since KEPIC 2011 Addenda along with ASME Code 2010 Ed NB-4622.7.
NB-4622.9	Temper Bead Weld Repair	MNB-4622.9	Temper Bead Weld Repair	A1	MNB-4622.9 modified along with ASME Code 2010 Ed NB-4622.9
		MNB-4622.10	Repair Welds to Cladding After Final Post weld Heat Treatment	A1	MNB-4622.10 deleted since KEPIC 2011 Addenda along with ASME Code 2010 Ed NB
		MNB-4622.11	Temper Bead Weld Repair to Dissimilar Metal Welds or buttering	A1	MNB-4622.11 deleted since KEPIC 2011 Addenda along with ASME Code 2010 Ed NB

ASME IX	Description	KEPIC	Description	Result	Remark
QW--300	QW-302.2 & QW-302.3 None	QW-300.2 & QW-300.3		A2	
QW-302.2	**Volumetric NDE** When the welder or welding operator is qualified by volumetric NDE, as permitted in QW-304 for welders and QW-305 for welding operators, the minimum length of coupon(s) to be examined shall be 6 in. (150 mm) and shall include the entire weld circumference for pipe(s), except that for small diameter pipe, multiple coupons of the same diameter pipe may be required, but the number need not exceed four consecutively made test coupons. The examination technique and acceptance criteria shall be in accordance with QW-191.	QW-302.2	**Radiographic Examination** When the welder or welding operator is qualified by radiographic examination, as permitted in QW-304 for welders and QW-305 for welding operators, the minimum length of coupon(s) to be examined shall be 150 mm (6 in.) and shall include the entire weld circumference for pipe(s), except that for small diameter pipe, multiple coupons may be required, but the number need not exceed four consecutively made test coupons. The radiographic technique and acceptance criteria shall be in accordance with QW -191.	B2	

ASME IX	Description	KEPIC	Description	Result	Remark
QW-321.3	**Immediate Retest Using Volumetric NDE**	QW-321.3	**Immediate Retest Using Radiographic Examination**	B2	
QW-361.2	**QW-361.2 i) Essential variable** For hybrid plasma-GMAW welding, the essential variable for welding operator qualification shall be in accordance with Table QW-357.	QW-361.2	**QW-361.2 i) Essential variable-Machine welding** (a) A change in the welding process. (b) A change from direct visual control to remote visual control and vice-versa. (c) The deletion of an automatic arc voltage control system for GTAW. (d) The deletion of automatic joint tracking. (e) The addition of welding positions other than those already qualified (see QW-120, QW-130, and QW-303). (f) The deletion of consumable inserts, except that qualification with consumable inserts shall also qualify for fillet welds and welds with backing. (g) The deletion of backing. Double-welded groove welds are considered welding with backing. (h) A change from single pass per side to multiple passes per side but not the reverse.	B2	
QW-386	Diffusion welding operation qualification Each welding operator shall be tested by welding a procedure qualification test coupon in accordance with QW-185.1. The coupon shall be	None	None	B1	

ASME IX	Description	KEPIC	Description	Result	Remark
	metallographically examined in accordance with QW-185.3.				
QB-201	Organizational responsibility The organization shall certify that they have qualified each Brazing Procedure Specification, performed the procedure qualification test, and documented it with the necessary Procedure Qualification Record (PQR).	QB-201	More specific description for Organizational responsibility	B2	
QF	Part of plastic fusing	None	None	B1	

MANDATORY APPENDIX II: COMPARISON OF THE REQUIREMENTS FOR THE TECHNICAL CONTENT OF WELDING PROCEDURE SPECIFICATIONS AND THE QUALIFICATION THEREOF

II.1 ASME BPVC Section IX versus ISO Standards

Figure II-1: Comparison between Section IX, ISO 15614-1 and ISO 15614-11 for Welding Procedure Qualifications

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
General requirements					
QG-105	Variables	8	ISO 15614-1 does not define essential, supplementary essential and nonessential variables. All variables included in Section 8 shall be addressed. See below for comparison between individual variables.	B2	None
QG-107	Ownership transfers	Not addressed	None	B1	None
QW-201 QG-106.1	Organizational responsibility	8.2	The qualification is responsibility of the manufacturer.	A2	None
	Each organization is responsible for the supervision and control of procedure qualification. Production of test joints under the supervision and control of another organization is not permitted.	6.3 and 9	ISO 15614-1 defines the examiner/examining body as a person/organization appointed to verify compliance with the applicable standard. The welding of test pieces shall be witnessed and the testing shall be verified by an examiner/examining body.	B2	Major difference: a welding procedure must be qualified under the supervision and control of the organization according to Section IX, whereas this responsibility lies with an examiner/examining body according to ISO 15614-1. These can be internal or external to the organization. Often contractual requirements prescribe that the examining body is an independent third party.

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	**Description**	**ISO 15614-1**	**Description**		
			The certificate shall be issued under the sole responsibility of the examiner/examining body.		
QG-108	Procedure qualifications dated as far back as 1962 may be used. Qualifications dated prior to 1962 may be used, provided the requirements of the 1962 Edition or later have been met.	Introduction	Existing qualifications in accordance with a national standard are still valid. Additional tests may be required to make the existing qualifications technically equivalent to ISO 15614-1.	A2	None
QW-200.1	Requirements for WPS	ISO 15614-1 Clause 4 ISO 15614-11 Clause 4	Covered by the ISO 15609 series	B2	Both Section IX and the ISO 15609 series require that all welding variables are listed in the WPS. The variables to be addressed are broadly similar, but not identical. Both provide a non-mandatory WPS form. Section IX does not define 'preliminary WPS (pWPS). Harmonization is considered difficult due to the difference in qualified ranges.

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
QW-200.2	Requirements for PQR	9	Referred to as welding procedure qualification record (WPQR)	B2	Both Section IX and the ISO 15609 series require that all essential and, when required, supplementary essential variables are listed in the WPS. Both provide a non-mandatory PQR form. Harmonization is considered difficult due to the difference in qualified ranges.
QW-200.3	Definition of P–numbers and Group numbers	8.3.1	Refers to ISO 15608	B2	Different material grouping systems are used
QW-200.4	Combination of welding procedures	8.4.1	Refers to clause 8.4.1 Not addressed for LBW or EBW in ISO 15614-11	B2	The use of combination of multiple welding procedures on the same coupon could generate some limitations in the ranges associated to the essential variables due to the requirements for destructive tests as per ISO 15614-1.
QW-202	Type of tests required, see QW-451 below	7.1 and Table 1	See QW-451 below	B2	None
QW-202.6	Tube-to-tubesheet qualification	Not addressed	Covered by ISO 15614-8	A2	See Figure 6-2 and comments in Section 6.3.
QW-203	Qualification in any position qualifies all positions, unless required by QW-250.	8.4.2	Any position qualifies for all positions except for PG and J-L045 (downhill welding). Limitations in welding positions	A2	See also QW-405 below

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
			apply if hardness properties or impact tests are required.		
QW-210	Preparation of test coupon: may be plate, pipe or other product form	6	Test pieces shall be plate or pipe as per Clause 6.2. Where the production/joint geometry requirements do not represent the standardized test pieces, the use of ISO 15613 shall be required.	A2	A single test piece may be used to carry out the tests required by both standards.
QW-214	Corrosion resistant weld metal overlay	Not addressed	Covered by ISO 15614-7	B2	The requirements of ISO 15614-7 are broadly similar to those of section IX for the qualification of corrosion-resistant weld overlay.
QW-215	Electron beam and laser beam welding	Not addressed	Covered by ISO 15614-11	B1	See LBW specific variables below. EBW is not included in the scope of this project.
QW-216	Hard-facing weld metal overlay	Not addressed	Covered by ISO 15614-7	B2	The requirements of ISO 15614-7 are broadly similar to those of section IX for the qualification of corrosion-resistant weld overlay.
QW-217	Joining of composite (clad metals)	Not addressed	None	B1	None
QW-218	Applied linings	Not addressed	None	B1	None
QW-219	Flash welding	Not addressed	Covered by ISO 15614-13	B1	Not within the scope of this project
QW-220 QW-221	Hybrid processes	Not addressed	None	B1	None

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
Common variables in Section IX					
QW-202.2	Groove weld tests joints qualify full and partial penetration groove welds and fillet welds.	8.4.3(a)	Butt welds qualify full and partial penetration butt welds and fillet welds. Fillet weld tests shall be required where this is the predominant form of production welding.	A2	None
QW-202.2(c)	Pressure retaining fillet welds may be qualified with groove welds.	8.4.3(a)	See 8.4.3(a) and (g)	A2	None
QW-202.2(c)	Non-pressure retaining fillet welds may be qualified with fillet welds only.	8.4.3(g)	Fillet welding qualifies fillet welding only. WPSs qualified by fillet weld may be used without restriction. However, Table 1, note f, states that: if the mechanical properties of a joint are relevant to the application, an additional qualification shall also be held e.g. a butt weld qualification. This effectively allows qualification of fillet weld by fillet weld testing only for non-pressure retaining (or non-loaded) welds.	A1	The ISO requirement is effectively identical to the Section IX requirement.
QW-403.9	Limits on qualified thickness if any pass is	Not addressed	None	B1	None

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
	thicker than 1/2in (13mm). Does not apply to GTAW.				
QW-403.11	A change from one P-Number to another P-Number or to an unassigned base metal, except as QW-424 of Section IX permits.	8.3	Materials are classified into groups, these do not follow the Section IX numbering system	B2	None
QW-403.5 T	A change of a Group Number within a P-Number.	Not addressed	None	B1	None
QW-424	Separate qualifications are required for materials that are not listed.	8.3.1	Separate welding procedure qualifications are required for each parent material or parent material combinations not covered by the grouping system.	A1	None
QW-403.8	A change in base metal thickness beyond the range qualified in QW-451 of SECTION IX (see Figure II-2)	8.3.2.2	Base metal qualified thickness ranges are provided in tables 5 and 6 for butt welds and fillet welds, respectively.	B2	Section IX is less restrictive (see Figure II-2).
QW-403.6 T	The minimum thickness qualified is T or 5/8 in. (16mm), whichever is less. However, where T is less than 1/4 in (6mm) the minimum is 1/2T.	8.3.2.2	Impact test requirements do not affect the qualified base metal thickness (minimum), as per Table 5. If impact tests are not performed, the maximum	B1 (B2)	Minimum qualified thickness: B1 Maximum qualified thickness: B2

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
			qualified thickness is limited to 12mm.		
QW-404.4	A change from one F-Number in QW-432 of Section IX to any other F-Number or to any other filler metal not listed in QW-432.	8.4.4 and 8.4.3	The range of qualification is specific to the filler metal designation. There is no grouping system for filler metals. The filler material make and manufacturer are essential variables if impact testing is required for SMAW, SAW, FCAW.	B2	ISO 15614 is more restrictive.
QW-404.5	For ferrous materials, a change from one A-Number to any other A-Number or to a filler metal analysis not listed in QW-432 of Section IX (the PQR and WPS shall state the nominal chemical composition or manufacturer's designation for filler metals which do not fall into an A-Number group).	Not addressed	See QW-404.4 above.	B1	None
QW-404.30	A change in deposited weld metal thickness beyond that qualified in accordance with QW-451.	8.3.2.2	Weld metal qualified thickness ranges are provided in tables 5 and 6 for butt welds and fillet welds, respectively.	B2	Section IX is less restrictive (see Figure II-2).

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
QW-405.1 QW-405.2 T QW-405.3	A change from any position to the vertical position, uphill progression. Vertical uphill progression qualifies all positions.	8.4.2	Any position qualifies for all positions except for PG and J-L045. Additional requirements are given.	B2	None
QW-405.2 T	A change from a stringer bead to a weave bead in vertical uphill welding. For Section IX applications, this limitation does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.	8.4.8	Not specifically addressed, although covered by the limits on heat input.	B2	Section IX is more restrictive.
QW-406.1	A decrease in preheat of more than 100°F from that qualified.	8.4.9	The nominal preheat used in qualification is the minimum qualified.	B2	None
QW-406.3 T	An increase of more than 100°F in the maximum interpass temperature from that recorded on the PQR. For Section IX applications, this limitation does not apply when a	8.4.10	The highest interpass temperature reached used in qualification is the maximum qualified.	B2	None

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
	WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.				
QW-407.1	For the following P-Numbers 1, 3, 4, 5, 6, 9, 10, and 11, a change from any one condition to any other requires requalification: (1) No PWHT; (2) PWHT below the lower transformation temperature; (3) PWHT within the transformation temperature range; (4) PWHT above the upper transformation temperature; (5) PWHT above the upper transformation temperature followed by treatment below the lower transformation temperature.	8.4.12	Addition or deletion of PWHT is not permitted.	B2	ISO 15614-1 does not differentiate between base material groups or between PWHT temperatures.
QW-407.2 T	The qualification test weldment shall be	8.4.12	Holding time shall be related to the product. It shall be	B2	ISO 15614-1 is more restrictive.

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
	subjected to heat treatment essentially equivalent to that of the production weldment, including at least 80% of the aggregate time at temperature.		determined based on the expected cumulative holding time in production. This variable applies regardless of whether impact testing is required. This variable applies regardless of whether impact testing is required.		
QW-409.1 T	An increase of heat input or volume of weld metal deposited per unit length of weld, over that qualified, except when a grain refining austenitizing heat treatment is applied after welding. Three methods are provided to determine the heat input, depending on whether the welding process is waveform controlled or non-waveform controlled.	8.4.8	Heat input limits depend on the testing required, and are related to the heat input recorded in qualification, as follows: • Hardness testing required: -25% permitted • Impact testing required: +25% permitted • Neither hardness or impact testing required: no limits • No specific provisions are given for waveform controlled or non-waveform controlled processes.	B2	None
QW-409.4 T	A change in type of current (ac or dc) or polarity.	8.4.7	Similar requirements, except for the SMAW (MMA) process.	A2	None
QW-410.9 T	A change from multiple-pass per side to single pass per side. This limitation does not apply when a	8.4.3(h)	Similar requirement, PWHT is not considered.	B2	None

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	**Description**	**ISO 15614-1**	**Description**		
	WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.				
QW-410.64	Use of thermal processes	Not addressed	None	B1	None
QW-451	Required tests for groove-welds: tension test and bend test.	7.1 and Table 1	Required tests for butt welds: NDE (visual, Surface and volumetric), tension test, bend test, impact test, hardness test, macroscopic examination. Required tests for T-joints: NDE (visual, Surface and volumetric), hardness test, macroscopic examination. Required tests if ISO 15613 is used (see QW-210 above): visual test, surface testing, hardness and macro examination.	B2	ISO 15614-1 is more stringent as it requires more testing.
QW-451	Required tests for fillet welds: macro examination	7.1 and Table 1	Required tests for fillet welds: NDE (visual, Surface), hardness test, macroscopic examination.	B2	ISO 15614-1 is more stringent as it requires more testing.

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
SAW-specific variables in Section IX					
QW-404.7 T	A change in the nominal diameter of the electrode to over 1/4 in. (6 mm). This variable does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.	Not addressed	None	B1	None
QW-404.12 T	A change in the filler metal classification within an SFA specification, or for a filler metal not covered by an SFA specification or a filler metal with a "G" suffix within an SFA specification, a change in the trade designation of the filler metal.	8.4.4 8.4.5	The range of qualification is specific to the filler metal designation. Changes in filler material make or manufacturer are essential variables if impact testing is required. The filler material make and manufacturer may be replaced by a different manufacturer provided the mandatory designation as per the product standard is maintained and a new qualification procedure coupon is performed.	A2	None
QW-404.9	A change in the indicator for minimum tensile	8.4.4 8.4.5		B2	Section IX has more specific requirements.

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
	strength (e.g., the 7 in F7A2-EM12K) when the flux wire combination is classified in ASME II, Part C. A change in either the flux trade name or wire trade name when neither the flux nor the wire is classified in ASME II, Part C. A change in the flux trade name when the wire is classified in ASME II, Part C, but the flux is not. A change in wire classification within the requirements of QW-404.5 does not require requalification.	8.5.1.2	SAW using solid, flux-cored electrodes, wire or strip is considered separate processes. The range of qualification is specific to the filler metal designation. There is no grouping system for filler metals. The filler material and flux make and manufacturer are essential variables if impact testing is required. No specific requirements on the use of single or multi-wire systems.		
QW-404.9	A change in either the flux trade name or wire trade name when neither the flux nor the wire is classified in ASME II, Part C.				
QW-404.9	A change in the flux trade name or when the wire is classified in ASME II, Part C but the flux is not classified. A change in the				

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
	wire classification within the requirements of QW-404.5 of SECTION IX does not require requalification.				
QW-404.9	A change in the flux trade name for A-No. 8 deposits.				
QW-404.10	If the weld metal alloy content is largely dependent upon the composition of the flux, any change in the welding procedure which would result in the important weld metal alloying elements being outside the specified chemical composition range of the WPS.				
QW-404.27	An addition or deletion of supplementary filler metal (powder or wire), or a change of 10% in the amount.				
QW-404.29	A change in the flux/wire classification or a change in either the electrode or flux trade name when not				

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
	classified in an SFA specification. Requalification is not required when the wire/flux combination conforms to an SFA specification and a change is made from one diffusible hydrogen level to another.				
QW-404.34	A change in flux type (i.e., neutral to active or vice versa) for multilayer deposits in P-No. 1 materials.				
QW-404.36	When flux from re-crushed slag is used, each batch or blend, as defined in SFA-5.01 of ASME II Part C, shall be tested in accordance with ASME II Part C by either the manufacturer or user, or qualified as an unclassified flux in accordance with QW-404.9 of Section IX.				
QW-404.35 T	A change in the flux/wire classification or a change in either the electrode or				

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
	flux trade name when not classified in an SFA specification. Requalification is not required when a wire/flux combination conforms to an SFA specification and a change is made from one diffusible hydrogen level to another (i.e., a change from F7A2-EA1-A1H4 to F7A2, EA1A1H16). This variable does not apply when the weld metal is exempt from impact testing by other Sections. This exemption does not apply to hard facing and corrosion-resistant overlays.				
QW-410.10 T	A change from single electrode to multiple electrodes, or vice versa, for machine or automatic welding only. This variable does not apply when a WPS is qualified with a PWHT above the upper transformation				

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
	temperature or when an austenitic or P-No. 10H material is solution annealed after welding.				
QW-407.4	For ferrous base metals other than P-No. 7, P-No. 8, and P-No. 45, when a procedure qualification test coupon receives a post-weld heat treatment exceeding the upper transformation temperature or a solution heat treatment for P-No. 10H materials, the maximum qualified base metal thickness, T, shall not exceed 1.1 times the thickness of the test coupon.	Not addressed	The qualified base material thickness is independent of the process.	B1	None
GMAW and FCAW-specific variables in Section IX					
QW-404.24	An addition or deletion of supplementary filler metal (powder or wire), or a change of 10% in the amount.	8.5.2.2	The qualification given is restricted to the wire system used in the welding procedure test (e.g. single wire or multiple-wire system).	B2	None
QW-404.23	A change from one of the following filler metal product forms to another:	8.4.1 8.5.2	GMAW with solid wire or metal cored wire and FCAW are considered as different	B2	ISO 15614-1 is more restrictive

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	**Description**	**ISO 15614-1**	**Description**		
	(1) Flux cored, (2) Bare (solid) or metal cored, (3) Powder.		processes. GMAW with solid wire and inert or active gas are considered as different processes.		
QW-408.2	A change in shielding gas from a single gas to any other shielding gas or mixture of gas, or in the specified nominal composition of a gas mixture, or to no shielding gas, and vice versa.	8.5.2.1	Qualification limited to the symbol of the shielding gas according to ISO 14175. CO_2 content shall not exceed 10% of that used in qualification.	B2	Section IX is more restrictive
QW-404.32 QW-409.2	Thickness limit for short circuiting arc welding. A change from globular, spray or pulsed spray transfer welding to short circuiting transfer welding or vice versa.	8.5.2.3	Short circuiting arc welding qualifies short circuiting arc welding only. Spray or globular qualify both spray and globular	B2	Section IX is more restrictive
QW-410.10 T	A change from single electrode to multiple electrodes, or vice versa, for machine or automatic welding only. This variable does not apply when a WPS is qualified with a PWHT above the upper transformation	8.5.2.2	Qualification restricted to wire system used (e.g. multiple or single).	A2	None

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
	temperature or when an austenitic or P-No. 10H material is solution annealed after welding.				
GTAW-specific variables in Section IX					
QW-404.14	The addition or deletion of filler material.	8.5.3.3	Identical to Section IX	A1	None
QW-404.23	A change from one of the following filler metal product forms to another: (1) Flux cored, (2) Bare (solid) or metal cored, (3) Powder.	8.4.4 8.4.5	The range of qualification is specific to the filler metal designation. There is no grouping system for filler metals. The filler material and flux make and manufacturer are essential variables if impact testing is required.	B2	None
QW-408.2	A change in shielding gas from a single gas to any other shielding gas or mixture of gas, or in the specified nominal composition of a gas mixture, or to no shielding gas, and vice versa.	8.5.3.1	Equivalent to Section IX, except for the gas symbol, which refers to ISO 14175.	A2	None
QW-408.9	For groove welds in P-No. 41 through P-No. 49 and all welds of P-No. 10I, P-No. 10J, P-No.10K, P-No. 51 through P-No. 53, and P-No. 61 through P-No.	8.5.3.2	Welding without backing gas qualifies welding with backing gas, whichever the material. The additional gas composition is not addressed.	B2	None

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
	62 metals, the deletion of backing gas or a change in the nominal composition of the backing gas from an inert gas to a mixture including non-inert gas(es).		However, the shielding gas and the backing gas used during the qualification shall remain the same as per ISO 14175 or nominal composition, depending on the specificity of the gas (see clause 8.5.3.1).		
QW-408.10	For P-No. 10I, P-No. 10J, P-No. 10K, P-No. 51 through P-No. 53, and P-No. 61 through P-No. 62 metals, the deletion of trailing shielding gas, or a change in the nominal composition of the trailing gas from an inert gas to a mixture including non-inert gas(es), or a decrease of 10% or more in the trailing gas flow rate.	Not addressed	None	B1	None
QW-410.10 T	A change from single electrode to multiple electrodes, or vice versa, for machine or automatic welding only. This variable does not apply when a WPS is qualified with a PWHT above the upper	Not addressed	None	B1	None

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-1	Description		
	transformation temperature or when an austenitic or P-No. 10H material is solution annealed after welding.				
QW-410.11	A change from closed chamber to out of chamber conventional torch welding in P-No. 51 through P-No. 53 metals, but not vice versa.	Not addressed	None	B1	None

LBW-specific variables in Section IX

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-11	Description		
QW-197.1	Laser beam welding lap joint tests. Procedure qualification. Requires six tension shear specimens and eight macro specimens.	6.2 Figure 4 Tables, 1, 2 and 3	Test requirements depend on the quality level specified (B, C or D). The most stringent level (B) prescribes macro sections (two for plates and 3 for pipes) and permits other tests "if required".	B2	ISO 15614-11 is intended for the qualifications any beam weld, including non-pressure retaining or load bearing. Hence it is intrinsically less

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-11	Description		
					stringent than Section IX.
QW-215.1	Test coupon to include a lap-over, if this is to be included in production.	6.2.2	'Overlap' to be included in the test piece for pipe butt welds	A1	None
QW-402.2	Addition or deletion of backing	8.8	Addition or deletion of backing	A1	None
QW-402.6	An increase in fit-up gap	8.7	The qualified WPS is valid only for the joint geometry and within the limits of clearance and misalignment defined in the welding procedure specification.	B2	Section IX is more stringent
QW-402.18	For lap joints, (a) a decrease of more than 10% in the distance to the edge of the material (b) an increase in the number of layers of material (c) a change in surface preparation or finish from that qualified	Not addressed	No specific variables for lap joints	B1	None
QW-402.25	A change from lap joint to groove welding, and vice versa.	8.7	The qualified WPS is valid only for the joint geometry and within the limits of clearance and misalignment defined in the welding procedure specification.	A2	None
QW-402.26	A reduction of more than 5 deg. in the edge preparation bevel angle for groove welds.	Not addressed	None	B1	None
QW-403.1	A change from a base metal listed under one P-Number in Table	8.5.1	A qualified WPS is valid only for the grade of parent material (or	B2	ISO 15614-11 is more stringent

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-11	Description		
	QW/QB-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.		grades, in the case of heterogeneous assemblies) of the test piece. The qualification could be extended to equivalent grades defined in the specification.		
QW-403.3	Range of qualification for parent metal thickness	8.5.2.1	Range of qualification for parent metal thickness	B2	The range of qualification depends on the depth of penetration and on the parent metal thickness for both standards, but the extent of qualification is different.
QW-404.1	An increase of greater than 10% in the Cross-sectional area of the filler metal added (excluding buttering) or in the wire-feed speed beyond that qualified.	8.6 8.11.2	The qualified WPS is valid only for the approved filler material (grade or designation, shape and sizes). The qualification of a WPS obtained is valid only insofar as the specified range of the welding parameters defined in the WPS (see 4.13 in ISO 15609-4:2000)	B2	ISO 1564-11 is more stringent

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-11	Description		
			and the tolerances specified are met.		
QW-404.2	Thickness or chemical composition of weld metal buttering	Not addressed	None	B1	None
QW-404.8	Addition or deletion, or a change of more than 10% in the nominal amount or composition of supplementary de-oxidation material (in addition to filler metal) beyond that qualified.	Not addressed	None	B1	None
QW-404.14	The deletion or addition of filler metal.	8.6	The qualified WPS is valid only for the approved filler material (grade or designation, shape and sizes).	A1	None
QW-404.20	Any change in the method by which filler metal is added, such as preplaced shim, top strip, wire, wire feed, or prior weld metal buttering of one or both joint faces.	8.6	The qualified WPS is valid only for the approved filler material (grade or designation, shape and sizes).	B2	None
QW-408.2	A change in shielding gas from a single gas to any other shielding gas or mixture of gas, or in the specified nominal composition of a gas mixture, or to no shielding gas, and vice versa.	8.11.2	The qualification of a WPS obtained is valid only insofar as the specified range of the welding parameters defined in the WPS (see 4.13 in ISO 15609-4:2000) and the tolerances specified are met.	B2	None
QW-408.6	A change of environment shielding such as from vacuum to an inert gas, or vice versa.				
QW-408.11	The addition or deletion of one or more of the following:				

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-11	Description		
	(a) shielding gas (b) trailing shielding gas (c) backing gas (d) plasma-removing gas				
QW-408.12	A decrease of more than 10% in the flow rate of one or more of the following: shielding gas, trailing shielding gas, backing gas, and plasma-removing gas.				
QW-409.19	Any change of more than ±10% in the beam pulsing frequency and pulse duration from that qualified.				
QW-409.20	Any change in the following variables: mode of operation (from pulsed to continuous and vice versa), energy distribution across the beam (i.e., multimode or Gaussian).				
QW-409.21	A decrease of more than 10% in the power delivered to the work surface as measured by calorimeter or other suitable methods.				
QW-410.7	For the machine or automatic welding process, a change of more than ±10% in width, frequency, or dwell time of oscillation technique.				
QW-410.14	For full penetration groove welds, a change of more than ±10 deg. in the				

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description	ISO 15614-11	Description		
	relative angle between the axis of the beam and the workpiece.				
QW-410.20	The addition of a wash pass.				
QW-410.21	For full penetration groove welds, a change of welding from both sides to welding from one side only, but not vice versa.	Not addressed	None	B1	None
QW-410.37	A change from single to multiple pass or vice versa.	8.14	The qualification of a WPS obtained is valid only insofar as the number of passes is the same as the one used for the procedure test.	A1	None
QW-410.66	A change of more than ±10% in the travel speed, the ratio of the beam diameter to focal length, or the lens to work distance.	8.11.2	The qualification of a WPS obtained is valid only insofar as the specified range of the welding parameters defined in the WPS (see 4.13 in ISO 15609-4:2000) and the tolerances specified are met.	B2	None
QW-410.67	A change in the optical technique used to focus the welding energy from that qualified.	8.3	A qualification of a WPS is valid only for the laser system type used, according to 4.11 of ISO 15609-4, WPS for laser beam welding. This qualification can be extended to similar equipment from the same manufacturer	A1	None
QW-410.68	A change in welding equipment type (e.g., YAG, TAG, etc.).				

ASME		ISO		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	**Description**	**ISO 15614-11**	**Description**		
			using selected tests defined in the specification.		
QW-410.77	A change in the laser wavelength (e.g., CO2, Nd: YAG, fiber, disk, diode) from that qualified.	8.11.2	The qualification of a WPS obtained is valid only insofar as the specified range of the welding parameters defined in the WPS (see 4.13 in ISO 15609-4:2000) and the tolerances specified are met.	B2	None
QW-410.80	A change of ±5% in the diameter of the focused spot size.				

Note (1): T= applies if impact testing is required.

Figure II-2: Comparison of Test Coupon Ranges Qualified for ISO 15614-1 and ASME Section IX (Procedure Qualification)

Test Coupon	ASME Section IX	ISO 15614-1	ISO 15614-1
Thickness (t for ISO, T for ASME/AWS) [Note (1)]		with Single run	with multiple runs and fillet welds [Note (2)]
t ≤ 3 mm	-	0.7t to 1.3t	0.7 to 2t
<1.5 mm	T to 2T, 2t	-	-
3 < t < 12 mm	-	0.5t to 1.3t	3 to 2t
1.5 < t ≤ 10 mm	1.5 to 2T, 2t	-	-
10 < t < 19 mm	5 to 2T, 2t	-	-
12 < t < 100 mm	-	0.5 to 1.1t	0.5 to 2t
19 ≤ t < 38 mm	5 to 2T, 2t or 2T	-	
t > 100 mm	-	-	50 to 2t
38 ≤ t ≤ 150 mm	5 to 200, 2t or 200	-	-
> 150mm	5 to 1.33T, 2t or 1.33T	-	-
Diameter (D)			
D < 25 mm	No Requirements	0.5D to 2D	0.5D to 2D
D ≥ 25 mm	No Requirements	0.5D to D, 25mm min.)	0.5D to D, 25mm min.)

Note

(1) Section IX has provisions for qualification of thickness of weld metal (t) that neither of the EN or ISO standards have.

(2) According to Section IX, groove welds qualify fillet welds of all sizes on all base material thicknesses and all diameters.

II.2 ASME BPVC Section III & IX versus AFCEN RCC-M

Figure II-3: Comparison of the Requirements of Section III-NB and RCC-M for the Technical Content of Welding Procedure Specifications and the Qualification Thereof for Class 1 Nuclear Equipment

ASME		RCC-M		Comparison (see 1.2)	Comments
ASME Section III-NB par.	Description	RCC-M paragraph	Description		
NB-4310	General requirements for procedure and performance qualifications, defines the types of processes permitted, with specific requirements for stud welding, capacitor discharge welding and inertia and continuous drive friction welding.	S3100 S3550	S3100 provides general requirements for procedure qualifications. Includes specific requirements for: repair by welding, documents, qualification tests, reports and validity of the qualification. Friction welding is addressed by S3350.	B1 or B2	B1 for Stud welding and capacitor discharge; but B2 for the standard processes and Friction welding.
NB-4320, see NB-4321 to 4324 below	-	-	-	-	-
NB-4321(a)	Required qualifications: assigns responsibility to the Certificate Holder and refers to the requirements of Section IX and III-NB.	S3100 S3200	S3100 refers to ISO 15614-1, S3200 provides additional requirements. Para 8 of S3200 requires that procedure qualification is carried out in the same workshop as the production welds, subject to the requirements of S6000. This places the responsibility on the Manufacturer.	B2	The responsibility for procedure qualification is assigned to the manufacturer, although the systems to qualify manufacturers are different: N-Certificate in the ASME system and qualification of workshops in RCC-M, see also Section 7.2.
NB-4321(b)	Requires qualification for procedures, welders and	S3531	S3531 addresses attachment welded by fillet welds not	B2	RCC-M exempts from qualification if the weld

ASME		RCC-M		Comparison (see 1.2)	Comments
ASME Section III-NB par.	Description	RCC-M paragraph	Description		
	welding operators used for permanent or temporary attachments to pressure parts and permanent or temporary tack welds.		subjected to mechanical stress.		metal and unaffected base metal are removed when a temporary attachment is removed. Such distinction is not made by Section IX.
NB-4321(c)	Addresses the effect of restrain on test plates	S1320	Restraint of the test coupon is mentioned in S1320 in reference to the determination of the minimum preheat.	B2	-
NB-4321(d)	Subcontracting to non-Certificate Holders	Not addressed	Subcontracting of activities related to procedure qualification is not specifically addressed in Section IV.	B1	See comparison on subcontracting requirements in Section 7.2.
NB-4322	Maintenance and certification of records. Records of procedure qualifications shall be maintained by the Certificate Holder.	S3150	Describes the content of the welding procedure qualification report.	B1	-
NB-4323	Welding prior to qualification is not permitted.	B4321	Requires that all qualifications listed in S1000 are carried out before fabrication.	A1	-
NB-4324	Welding qualifications cannot be transferred between Certificate Holders unless as provided in Section IX QG-106.1.	S6500	Welding procedure qualifications can be transferred between qualified workshops belonging to the same manufacturer. Transfer between different manufacturers is not permitted.	A2	QG-106.1 refers to different organizations under the same corporate ownership. RCC-M only refers to workshops belonging to a manufacturer. However, the intent is the same.

ASME		RCC-M		Comparison (see 1.2)	Comments
ASME Section III-NB par.	Description	RCC-M paragraph	Description		
NB-4331	Refers to the requirements of Section IX and III-NB.	S3100 S3200	S3100 refers to ISO 15614-1, S3200 provides additional requirements.	B2	-
NB-4333	Heat treatment of qualification welds for ferritic materials: refers to NB-4620 and Section IX. Requires that the heat treatment time at temperature in qualification is at least 80% of the maximum to be applied to the component weld material.	S3200 Para 6(c)	Refers to fabrication requirements for PWHT, requires the same '80% rule' as ASME. Specifically addresses qualifications when production welds are subject to stress relieving at different holding temperatures.	A2	-
NB-4334	Preparation of test coupons and specimens, see below.	-	-	-	
NB-4334(a)	Refers to Section IX, except for impact test specimens, see below.	S3200 Paras 6 and 7	Refers to ISO 15614-1 Paras 6 and 7 provide additional requirement or explain the requirements of ISO 15614-1.	B2	-
NB-4334(b)	Addresses impact testing of multiple process welds.	Addressed by ISO 15614-1 (referenced in RCC-M), Clause 7.4.5	Addressed by ISO 15614-1 (referenced in RCC-M), Clause 7.4.5	B1	None
NB-4334.1	Impact testing of weld deposits. Requires transverse impact test specimens with the longitudinal axis at 1/4t	S3200 Paras 7.1 and 7.4.5(a1), Tables S3201.a and S3202	Impact testing of weld metal. For class 1, impact testing and drop-weight testing are required. The location of impact test specimens is	B2	RCC-M requires multiple test specimens' location for test piece thickness >30mm. Section III-NB requires a single location

ASME		RCC-M		Comparison (see 1.2)	Comments
ASME Section III-NB par.	**Description**	**RCC-M paragraph**	**Description**		
	from the weld surface of the test assembly. Refers to NB-2321 for test specimens and testing methods.		shown in Table S3202 and depends on the thickness of the qualification test piece. Test performance and methods are given in Annex SI 300.		regardless of the test piece thickness. A detailed comparison between the test methods is outside the scope of this project.
NB-4334.2	Impact testing of HAZ. Requires transverse impact test specimens with the longitudinal axis at 1/2t. Requires base metal test specimens for comparison. Refers to NB-2321.2 for test specimens and testing methods.	S3200 Paras 7.1, Tables S3201.b and S3202	Impact testing of HAZ. For class 1, impact testing is required; drop weigh testing is not required. The location of impact test specimens is shown in Table S3202 and depends on the thickness of the qualification test piece. Test performance and methods are given in Annex SI 300.	B2	
NB-4335	Impact test requirements, see below.	-	-	-	-
NB-4335.1	Impact test of weld metal is required for weld procedure qualification for production joints exceeding 16mm. Acceptance criteria for weld metal shall be established in accordance with NB-2330. For vessels, the test temperature is to be established through drop-	S3200 Paras 7.1 and 7.4.5(a1),	Impact test of weld metal is required for weld procedure qualification for production joints equal to or exceeding 12mm. Acceptance criteria for weld metal are as follows: • At 0°C: 60J min average and 42J min individual value. • At -20°C, when required by B4230: 40J min average and 28J min individual value.	B2	RCC-M summary applies to steels from groups 1 to 6 only (ferritic steels) NOTE: according to information available to the authors, the thickness limit under which the impact test is required is to be lowered to 5mm in the 2016 Edition of RCC-M edition 2016 when Appendix ZZ or ZY is applicable.

ASME		RCC-M		Comparison (see 1.2)	Comments
ASME Section III-NB par.	**Description**	**RCC-M paragraph**	**Description**		
	weight testing according to NB-2331. The minimum required lateral expansion is 0.89mm and the minimum required absorbed energy is 68J.		• For pressure joints, RT_{NDT} determination via drop-weight and impact test is required. • Lateral expansion and % fibrosity are required.		
NB-4335.2	Impact test of HAZ is required for weld procedure qualification for production joints exceeding 16mm. Impact test temperature and acceptance criteria for HAZ shall be established in accordance with NB-4335.2 The test temperature is to be established through drop-weight testing. The minimum required lateral expansion is 0.89mm.	S3200 Paras 7.1 and 7.4.5(a2),	Impact test of weld metal is required for weld procedure qualification for production joints equal to or exceeding 12mm. Acceptance criteria for weld metal are as follows: • At 0°C: minimum specified for base metal. • At -20°C (reactor pressure vessel only), when required by B4230: 40J min average and 28J min individual value. • Lateral expansion and % fibrosity are required.	B2	RCC-M summary applies to steels from groups 1 to 6 only (ferritic steels) NOTE: according to information available to the authors, the thickness limit under which the impact test is required is to be lowered to 5 mm in the 2016 Edition of RCC-M edition 2016 when Appendix ZZ or ZY is applicable.
NB-4336	Build up weld deposit for base metal reinforcement are qualified according to NB-4331 through NB-4335	S3590	Build-ups are qualified by a butt-welded test coupon on plate or pipe.	A2	See comparison of items NB-4331 through NB-4335.
NB-4337	Welding of instrument tubing	Not addressed	None	B1	-
NB-4350	Tube-to-tubesheet welds	S3800	Tube-to-tubesheet welds	Mostly A2	Equivalent, with the exception of the leak test (not required by ASME) and

ASME		RCC-M		Comparison (see 1.2)	Comments
ASME Section III-NB par.	**Description**	**RCC-M paragraph**	**Description**		
				B2 for specific requirements	the required throat thickness which is average 0.8 (min 0.66) times the nominal wall thickness of the tubes for RCC-M and minimum 0.66 for ASME (no requirements on average). See Figure 6-2.
NB-4360	Specially designed welded seals	S3520	Canopy and omega welds	B2	RCC-M requires identical conditions as section III for performance qualification, with specific exceptions.
-	Weld overlay. Section III-NB does not provide specific requirement for procedure qualification of weld overlay, as these are provided by Section IX.	S3600	Weld overlay. RCC-M provides specific requirements for qualification.	B2	See Figure 6-3
NB-4622.9	Qualification of temper bead repairs. Specific requirements are provided.	S7620	Qualification of temper bead repairs. Specific requirements are provided.	B2	See Figure 6-1

II.3 ASME BPVC Section III & IX versus JSME S NB1

Figure II-4: Comparison between Section III-NB Requirements for Welding Procedure Qualification versus JSME S NB1 [Note (1)]

ASME		JSME		Comparison (see 1.2)	Comments
ASME Section III or IX par. [Note (2)]	Description	JSME paragraph	Description		
NB-4321 (Section III)	Requires the application of Section IX	Part 1 (N-0050)	Requires the application of JSME S NB1 Part 2	A1	None
QW-250 (Section IX)	Welding processes	Part 2	See above	B2	None
QW-422 (Section IX)	Base metal P-number [Note (~~2~~3)]		P-No 1 and P-No 8 have no Group No. Each material combination for dissimilar Joint is an essential variable.	A2	None
QW-432 (Section IX)	Filler metal F-Numbers		F-Nos. apply to SMAW electrodes only. R-Nos. apply to GTAW/PAW rods E-Nos. apply to other electrodes/wires.	B2	None
QW-406.1 (Section IX)	The preheat temperature is an essential variable		The addition or deletion of preheat is an essential variable. When preheat is applied, the minimum preheat temperature is an essential variable.	B2	None
QW-407.1 (Section IX)	PWHT PWHT temperature is classified into five ranges.		PWHT temperature ranges are the same as per Section IX	A1	None
QW-407.2 ~~T~~ (Section IX)	PWHT holding time at least 80% of total cumulative in production		The minimum holding time is an essential variable.	B2	None
QW-408.5 (Section IX)	The addition/deletion of gas backing is a nonessential variable		The addition/deletion of gas backing is an essential variable.	B2	None

ASME		JSME		Comparison (see 1.2)	Comments
ASME Section III or IX par. [Note (2)]	**Description**	**JSME paragraph**	**Description**		
QW-410.10 ~~T~~ (Section IX)	A change of single/multiple electrodes for machine or automatic welding is a supplementary essential variable.		A change of single/multiple electrodes is an essential variable.	B2	None
QW-404.9 QW-404.10 QW-404.27 QW-404.34 Qw-404.36	Various essential variables are assigned for SAW/ESW flux. The biggest change in filler metal is that the WPS is limited to the AWS classification qualified, not just P-and A-numbers. If there is no AWS classification, then the WPS is limited to the trade name product qualified (QW-404.12)		The only essential variable for SAW/ESW flux is the brand name.	B2	None
QW-410.9 ~~T~~ (Section IX)	A change from multiple to single passes per side is a supplementary essential variable.		A change from multiple to single passes per side is an essential variable.	A2	None
QW-451 (Section IX)	Generally, the maximum qualified thickness is 2T for groove welds, when T<38mm T=thickness of test coupon		For groove welds, the maximum qualified thickness is basically 2T, regardless of T, with some exception.	B2	None
NB-2330 (Section III)	The impact test temperature is based on T_{NDT}		Impact test temperature shall be as follows: Class 1: MDMT -33°C Class 2, 3: MDMT -17°C	B2	None

Notes
(1) There are no "supplementary essential variables" in JSME S NB1.
(2) T= applies if impact testing is required.
See Figure II-6 for P-Nos. of JSME S NB1.

Figure II-5: Welding Process Variables

JSME S NB1 Part 2 WP-301-1		Section IX
Variables	**Contents of Welding Process**	
A	Shielded Metal Arc Welding (Double sided or Single sided with backing materials)	SMAW
A_0	Shielded Metal Arc Welding (Single sided without backing materials)	
G	Gas Welding	OFW
T	TIG Welding (Single sided without backing materials)	GTAW
T_B	TIG Welding (Double sided or Single sided with backing materials)	
T_F	TIG Welding (Root pass only without backing materials)	
T_{FB}	TIG Welding (Root pass only with backing materials)	
M	MIG/MAG Welding (Double sided or Single sided with backing materials)	GMAW [Note (1)]
M_0	MIG/MAG Welding (Single sided without backing materials)	
PA	Plasma Arc Welding	PAW
J	Submerged Arc Welding	SAW
E_S	Electroslag Welding	ESW
E_G	Electrogas Welding	EGW
ST	Automatic/Machined TIG Welding	GTAW
SM	Automatic/Machined MIG/MAG Welding	GMAW
SPA	Automatic/Machines Plasma Arc Welding	PAW
EB	Electron Beam Welding	EBW
LB	Laser Beam Welding	LBW

Note (1): Flux-cored Arc Welding Process is not included in category "M", and individual qualification for FCAW is necessary.

Figure II-6: Base Material P-Numbers and Gr-Numbers According to JSME S NB1 Part 2

JSME S NB1 Part 2		
Base Metal P-No.	**Group No.**	**Material grade(s)**
P-1	- - -	Carbon Steel
P-3	1	Molybdenum Steel having alloy contents less than 2.75% and minimum specified tensile strength less than 480MPa (Except Chromium contents more than 0.75%)
	2	Molybdenum Steel having alloy contents less than 2.75% and minimum specified tensile strength of 480MPa and over and less than 550MPa (Except Chromium contents more than 0.75%)

JSME S NB1 Part 2		
Base Metal P-No.	**Group No.**	**Material grade(s)**
	3	Molybdenum Steel having alloy contents less than 2.75% and minimum specified tensile strength of 550MPa and over and less than 660MPa (Except Chromium contents more than 0.75%)
P-4	- - -	Chromium-Molybdenum Steel having alloy contents less than 2.75%. (Except Chromium contents more than 2.0% and designated in P-3)
P-5	1	Chromium-Molybdenum Steel having alloy contents of 2.75% and over and less than 5% (Except Chromium contents more than 3.5%)
	2	Chromium-Molybdenum Steel having alloy contents of 5% and over and less than 12%
P-6	- - -	Martensitic Stainless Steel
P-7	- - -	Ferritic Stainless Steel
P-8	- - -	Austenitic Stainless Steel
P-9A	- - -	Nickel Steel having Nickel contents less than 2.50%
P-9B	- - -	Nickel Steel having Nickel contents of 2.50% to 3.50%
P-11A	1	Nickel Steel having Nickel contents more than 3.50% and up to 9.0%
	2	Alloy Steel having minimum specified tensile strength of 660 MPa and over and less than 730MPa (Except designated in P-11 Group-1.)
P-11B	- - -	Alloy Steel having minimum specified tensile strength of 730MPa and over
P-21	- - -	Aluminum with Aluminum contents not less than 99%, and Aluminum-Manganese Alloy having Manganese contents of 1.0% to 1.5%
P-22	- - -	Aluminum-Magnesium Alloy having Magnesium contents of 2.0% to 3.9%
P-23	- - -	Aluminum-Magnesium-Silicon Alloy having Magnesium contents of 0.45% to 1.4% and Silicon contents of 0.2% to 0.8%
P-25	- - -	Aluminum-Magnesium Alloy having Magnesium contents more than 3.9% and not more than 5.6%
P-31	- - -	Copper and Copper Alloy except for designated as P-32, P-34 & P-35
P-32	- - -	Naval Brass or Aluminum Brass for heat exchanger
P-34	- - -	Cupronickel
P-35	- - -	Aluminum Bronze
P-42	- - -	Nickel-Copper Ally having Nickel contents less than 66.5% and Copper contents more than 25% and not more than 33%
P-43	- - -	Nickel-Chromium-Ferrous Alloy
P-45	- - -	Ferrous-Nickel-Chromium Alloy
P-51	- - -	Titanium having minimum specified tensile strength not more than 340MPa
P-52	- - -	Titanium having minimum specified tensile strength more than 340MPa

II.4 ASME BPVC Section III & IX versus PNAE G-7

Figure II-7: Comparison between Section IX and PNAE G-7 for Welding Procedure Qualifications

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description		Description		
General Requirements					
QG-105	Variables	PNAE G-7-010-89 (App. 1-4)	Groups of Single-type Welded Joints	B2	PNAE G-7 does not use "essential variables" term. The close term used is "group of single-type welded joints". App. x-y here and below mean the article"y" of appendix "x".
QG-107	Ownership transfers	Not addressed	Ownership transfers are not addressed by PNAE G-7 documents.	B1	None
QW-201 QG-106.1	Organizational responsibility Each organization is responsible for the supervision and control of procedure qualification. Production of test joints under the supervision and control of another organization is not permitted.	PNAE G-7-010-89 (3.1.3, 3.1.4)	3.1.3 The procedure qualification is undertaken in order to check the possibility of Manufacturer to process the welding in accordance with requirements of PNAE G-7-009-89, PNAE G-7-010-89, other design and manufacturing documentation. 3.1.4 The procedure qualification should be carried	A2	None

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description		Description		
			out by the Manufacturer dealt with welding of components by making test welded joints with subsequent examination inspection, which should be carried out for each group of single-type welded joints.		
QG-108	Procedure qualifications dated as far back as 1962 may be used. Qualifications dated prior to 1962 may be used provided the requirements of the 1962 Edition or later have been met.	Not addressed	PNAE G-7-009-89 does not include the allowance to use the previous edition of the document.	B2	Application of the previous edition of PNAE G-7-010-89 (PK 1514-72 "Examination rules for welding and cladding of NPP components") is not allowed.
QW-200.1	Requirements for WPS	PNAE G-7-009-89 (1.3)	Welding and cladding shall be conducted in accordance with the Process and Technological Documentation (Technological Instruction, etc.) developed considering the requirements of PNAE G-7-009/010-89 and design documentation.	B2 (A2)	Technological Instruction is the analogues of WPS.
		PNAE G-7-010-89 (3.2.8, 3.2.15, 10.3.3)	3.2.8 Requirements on procedure qualification program.		PTD is the acronym of Process and Technological Documentation.

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	**Description**		**Description**		
			3.2.15 The list of welding processes to be qualified shall be included in the PTD. 10.3.3 Test welds shall be conducted in accordance with the PTD.		
QW-200.2	Requirements for PQR	PNAE G-7-010-89 (3.2.10, Appendix 2)	The results of the procedure qualification shall be recorded in accordance with form given in Appendix 2.	B2 (A2)	Appendix 2 includes the requirements for record contents.
QW-200.3	Definition of P–numbers and Group numbers	PNAE G-7-010-89 (App. 1-4.1.2)	Grade (group of grades) of the base metal.	B2	PNAE G-7 does not use "P-number" term. The close term used is "base material group"
QW-200.4	Combination of welding procedures	Not addressed	Combination of welding procedures is not addressed by PNAE G-7-010-89	B1	None
QW-202	Type of tests required, see QW-451 below	PNAE G-7-010-89 (10.3)	Mechanical tests for welding procedure qualification	B2	None
QW-202.6	Tube-to-tubesheet qualification	Not addressed	Tube-to-tubesheet procedure qualification is not specially addressed by PNAE G-7-010-89	B1	Additional requirements may be provided in applicable technical documentation
QW-203	Qualification in any position qualifies all positions, unless required by QW-250.	Not addressed	Qualification extension by position is not specially	B1	None

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description		Description		
			addressed by PNAE G-7-010-89.		
QW-210	Preparation of test coupon: may be plate, pipe or other product form	Not addressed	Preparation of test coupon is not specially addressed by PNAE G-7-010-89	B1	Requirements on test coupon are in the Process and Technological Documentation.
QW-214	Corrosion resistant weld metal overlay				
QW-215	Electron beam and laser beam welding				
QW-217	Joining of composite (clad metals)				
QW-218	Applied linings				
QW-220 QW-221	Hybrid processes				
QW-216	Hard-facing weld metal overlay	Not addressed	Hard-facing weld metal overlay is not specially addressed by PNAE G-7-010-89.	B1	None
QW-219	Flash welding	Not addressed	Flash welding is out of scope PNAE G-7-009/010-89.	B1	None
Common variables in Section IX					
QW-202.2	Groove weld tests joints qualify full and partial penetration groove welds and fillet welds.	Not addressed	There are no such provisions in PNAE G-7-010-89.	B1 (B2)	Full and partial penetration groove welds and fillet welds shall be qualified separately.
QW-202.2(c)	Pressure retaining fillet welds may be qualified with groove welds.				

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description		Description		
QW-202.2(c)	Non-pressure retaining fillet welds may be qualified with fillet welds only.				
QW-403.9	Limits on qualified thickness if any pass is thicker than 1/2in (13mm). Does not apply to GTAW.	Not addressed	None	B1	None
QW-403.11	A change from one P-Number to another P-Number or to an unassigned base metal, except as QW-424 of ASME IX permits.	PNAE G-7-010-89 (App. 1-4.1.2)	Grade (group of grades) of the base metal. It is permitted to include in one group the steels of different grades which may be welded using the same welding material	B2	PNAE G-7-010-89 does not include the list of grouped base materials grades.
QW-403.5 T	A change of a Group Number within a P-Number.				
QW-424	Separate qualifications are required for materials that are not listed.	PNAE G-7-008-89 (3.4)	New materials	A2	The procedure for permission to use of new base and/or filler materials for NPP components manufacturing
QW-403.8	A change in base metal thickness beyond the range qualified in QW-451 of ASME IX (see Figure II-2)	PNAE G-7-010-89 (App. 1-4.1.4)	Base metal thickness ranges	B2	None
QW-403.6 T	The minimum thickness qualified is T or 5/8 in. (16mm), whichever is less. However, where T is less than 1/4 in (6mm) the minimum is 1/2T.	Not addressed	None	B1	None
QW-404.4	A change from one F-Number in QW-432 of ASME IX to any other	PNAE G-7-010-89	Grade (group of grades) of filler materials. It is permitted to include in one group the	B2	PNAE G-7-010-89 does not include the list of

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description		Description		
	F-Number or to any other filler metal not listed in QW-432.	(App. I-4.1.3)	filler materials which may be used for welding the steel of the same grade.		grouped filler materials grades.
QW-404.5	For ferrous materials, a change from one A-Number to any other A-Number or to a filler metal analysis not listed in QW-432 of ASME IX (the PQR and WPS shall state the nominal chemical composition or manufacturer's designation for filler metals which do not fall into an A-Number group).	Not addressed	None	B1	PNAE G-7 does not use "A-number" term, and does not divide filler metals by chemical composition
QW-405.1 QW-405.2 T QW-405.3	A change from any position to the vertical position, uphill progression. Vertical uphill progression qualifies all positions.	Not addressed	Position and welding direction is not specially addressed by PNAE G-7-010-89.	B1 (B2)	PNAE G-7-010-89 does not recognize position and welding direction as "essential variables", but additional requirements may be provided in the Process and Technological Documentation.
QW-405.2 T	A change from a stringer bead to a weave bead in vertical uphill welding. For ASME IX applications, this limitation does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.				

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description		Description		
QW-406.1	A decrease in preheat of more than 100°F from that qualified.	PNAE G-7-010-89 (App. I-4.1.9, 3.3.2)	App. I-4.1.9 Preheat shall be done if it is required. 3.3.2 The qualification of cladding production process with preheating may be extended to the one done without preheating.	B2	None
QW-406.3 T	An increase of more than 100°F in the maximum interpass temperature from that recorded on the PQR. For ASME IX applications, this limitation does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.	Not addressed	Interpass temperature is not specially addressed by PNAE G-7-010-89.	B1	Additional requirements may be provided in the Process and Technological Documentation.
QW-407.1	For the following P-Numbers 1, 3, 4, 5, 6, 9, 10, and 11, a change from any one condition to any other requires requalification: (1) No PWHT; (2) PWHT below the lower transformation temperature; (3) PWHT within the transformation temperature range; (4) PWHT above the upper transformation temperature; (5) PWHT above the	PNAE G-7-010-89 (App. I-4.1.10)	PWHT shall be done if it is required	B2	None

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description		Description		
	upper transformation temperature followed by treatment below the lower transformation temperature.				
QW-407.2 T	The qualification test weldment shall be subjected to heat treatment essentially equivalent to that of the production weldment, including at least 80% of the aggregate time at temperature.	Not addressed	Decreasing the PWHT duration is not specially addressed by PNAE G-7-010-89.	B2 (B1)	PNAE G-7-010-89 does not recognize PWHT hold time as the "essential variable". The PWHT parameters shall be in accordance with Process and Technological Documentation.
QW-409.1 T	An increase of heat input or volume of weld metal deposited per unit length of weld, over that qualified, except when a grain refining austenitizing heat treatment is applied after welding. Three methods are provided to determine the heat input, depending on whether the welding process is waveform controlled or non-waveform controlled.	Not addressed	Heat input is not addressed by PNAE G-7-010-89.	B2 (B1)	PNAE G-7-010-89 does not recognize heat input as the "essential variable".
QW-409.4 T	A change in type of current (ac or dc) or polarity.	Not addressed	Polarity and type of current are not addressed by PNAE G-7-010-89.	B2 (B1)	PNAE G-7-010-89 does not recognize polarity and type of current as the "essential variable".

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description		Description		
QW-410.9 T	A change from multiple-pass per side to single pass per side. This limitation does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.	Not addressed	The number of welding passes is not addressed by PNAE G-7-010-89.	B1	Requirements on welding technique may be provided in the Process and Technological Documentation.
QW-410.64	Use of thermal processes	Not addressed	None	B1	Additional requirements may be provided in applicable technical documentation.
QW-451	Required tests for groove-welds: tension test and bend test.	PNAE G-7-010-89 (Tables 2-3, 10.3.7, 10.3.9, 10.3.10)	10.3.7 The test welds shall be exanimated by suitable NDE methods (visual, volumetric and surface examinations for groove welds). 10.3.9 The following mechanical test shall be carrying out for butt welds: tensile tests for determination of ultimate strength at normal and high temperature, and the bend test. 10.3.9 The tensile test at high temperature carries out only if	B2 (A2)	None

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	**Description**		**Description**		
			it required by Design Documentation.		
QW-451	Required tests for fillet welds: macro examination	PNAE G-7-010-89 (Table 6, 10.3.7, 10.3.11)	10.3.7 The test welds shall be exanimated by suitable NDE methods (visual and surface examinations for fillet weds). 10.3.11 For fillet welds only macro examination should be carrying out.	B2 (A2)	None
SAW-specific variables in Section IX					
		Not addressed	The SAW-specific requirements on process qualification are not specially addressed by PNAE G-7-010-89.	B1	The SAW-specific requirements are be provided in the particular Process and Technological Documentation.
GMAW and FCAW-specific variables in Section IX					
		Not addressed	The GMAW and FCAW-specific requirements on process qualification are not specially addressed by PNAE G-7-010-89.	B1	GMAW and FCAW-specific requirements are be provided in the particular Process and Technological Documentation.
GTAW-specific variables in Section IX					
		Not addressed	The GTAW-specific requirements on process qualification are not specially	B1	GTAW-specific requirements are be provided in the particular

ASME		PNAE G-7		Comparison (see 1.2)	Comments
ASME Section IX QW par. [Note (1)]	Description		Description		
			addressed by PNAE G-7-010-89.		Process and Technological Documentation.
LBW-specific variables in Section IX					
		Not addressed	The LBW is out of PNAE G-7-009/010-89 scope.	B1	None

Figure II-8: Comparison of Test Coupon Thickness Ranges Qualified for PNAE G-7-010-89 and ASME Section IX (Procedure Qualification)

ASME Section IX		PNAE G-7-010-89		
Test Coupon	Extension	Test Coupon	Extension	
<1.5 mm	T to 2T, 2t	≤ 3 mm	–	
1.5 < t ≤ 10 mm	1.5 to 2T, 2t	3 < t ≤ 10 mm	–	
10 < t < 19 mm	5 to 2T, 2t	10 < t ≤ 50 mm	3 < t ≤ 10 mm [Note (1)]	0,75 t ≤ t ≤ 1,25 t [Note (2)]
19 ≤ t < 38 mm	5 to 2T, 2t or 2T			
38 ≤ t ≤ 150 mm	5 to 200, 2t or 200	> 50 mm	–	
> 150mm	5 to 1.33T, 2t or 1.33T			

Notes
(1) For Arc Welding only
(2) For ESW only

II.5 ASME BPVC Section III & IX versus KEPIC

Figure II-9: Comparison between Section III & IX and KEPIC Requirements for Welding Procedure Qualification

ASME III	Description	KEPIC	Description	Result	Remark
NB-4337	Welding of Instrument Tubing	MNB-4337	Welding of Instrument Tubing	A1	MNB-4337 established since KEPIC 2007 Addenda along with ASME Code 2005 Addenda NB-4337.
NB-4350	SPECIAL QUALIFICATION REQUIREMENTS FOR TUBE TO TUBESHEET WELDS (Section III -> IX Transfer)	MNB-4350	Welding of Instrument Tubing	A1	MNB 4351 ~ MNB 4358 deleted since KEPIC 2008 2nd Addenda along with ASME Code 2006Ed Addenda NB.

ASME IX	Description	KEPIC	Description	Result	Remark
QW-191.1	Ultrasonic Examination	None	None	B1	
QW-201	Organizational Responsibility	QW-201	Manufacturer's or Contractor's Responsibility	B2	
QW-220	HYBRID PLASMA-GMAW Welding Hybrid laser-GMAW is limited to the combination of automatic LBW and automatic GMAW. The GMAW process shall not be applied using the short-circuiting arc transfer mode. All hybrid laser-GMAW procedures for welding groove and fillet welds shall be qualified in accordance with the rules in QW-202. Table QW-268 lists the essential, supplementary essential and nonessential variables that apply for hybrid laser-GMAW qualification.	None	None	B1	
QW-261 SW	QW-409.4 Essential variable A change from AC to DC, or vice versa; and in DC welding, a change from electrode negative (straight polarity) to electrode positive (reverse polarity), or vice versa.	QW-261 SW	QW-409.4 Non-essential variable The addition or deletion of pulsing current to dc power source.	B1	
QW-261 SW	QW-409.8 Essential variable A change in the range of amperage, or except for SMAW, GTAW, or waveform controlled welding, a change in the range of voltage. A change in the range	QW-261 SW	QW-409.8 Non-essential variable A change in the range of amperage, or except for SMAW and GTAW welding, a change in	B1	

ASME IX	Description	KEPIC	Description	Result	Remark
	of electrode wire feed speed may be used as an alternative to amperage. See Nonmandatory Appendix H.		the range of voltage. A change in the range of electrode wire feed speed may be used as an alternative to amperage.		
QW-264 LBW	QW-402.1 None A change in the type of groove (V-groove, U-groove, single-bevel, double-bevel, etc.).	QW-264 SW	QW-402.1 Essential variable A change in the type of groove (V-groove, U-groove, single-bevel, double-bevel, etc.).	B2	
QW-264 LBW	QW-402.25 Essential variable A change from lap joint to groove welding, and vice versa.	QW-264 LBW	QW-402.25 None	B1	
QW-264 LBW	QW-402.26 Essential variable A reduction of more than 5 deg. in the edge preparation bevel angle for groove welds.	QW-264 LBW	QW-402.26 None	B1	
QW-264 LBW	QW-403.15 Essential variable	QW-264 LBW	QW-403.15 Non-essential variable	B1	
QW-264 LBW	QW-404.4 change of F-Number Essential variable	QW-264 LBW	QW-404.4 None	B1	
QW-264 LBW	QW-404.5 change of A-Number Essential variable	QW-264 LBW	QW-404.5 None	B1	
QW-264 LBW	QW-404.21 None	QW-264 LBW	QW-404.21 Essential variable For filler metal additions, any change from the nominal specified analysis of the filler metal qualified.	B2	
QW-264 LBW	QW-404.33 None	QW-264 LBW	QW-404.33 Non-essential variable A change in the filler metal classification within an SFA specification, or, if not conforming to a filler metal classification within an SFA specification, a change in the manufacturer's trade name for the filler metal. When optional	B1	

ASME IX	Description	KEPIC	Description	Result	Remark
			supplemental designators, such as those which indicate moisture resistance (i.e., XXXXR), diffusible hydrogen (i.e., XXXX H16, H8, etc.), and supplemental impact testing (i.e., XXXX-1 or EXXXXM), are specified on the WPS, only filler metals which conform to the classification with the optional supplemental designator(s) specified on the WPS shall be used.		
QW-264 LBW	QW-408.13 None	QW-264 LBW	QW-408.13 Essential variable A change in the position or orientation of plasma-removing gas jet relative to the workpiece. (e.g., coaxial transverse to beam)	B2	
QW-264 LBW	QW-410.67 Essential variable A change in the optical technique used to focus the welding energy from that qualified.	QW-264 LBW	QW-410.67 None	B1	
QW-264 LBW	QW-410.68 Essential variable A change in welding equipment type (e.g., YAG, TAG, etc.).	QW-264 LBW	QW-410.68 None	B1	
QW-264 LBW	QW-410.77 Essential variable A change in the laser wavelength (e.g., CO2, Nd: YAG, fiber, disk, diode) from that qualified.	QW-264 LBW	QW-410.77 None	B1	
QW-264.1 LBW	QW-410.88 Essential variable	QW-264 LBW	QW-410.88 None	B1	
QW-266 DFW	Diffusion Welding	None	None	B1	
QW-267 FSW	Friction Stir Welding	None	None	B1	
QW-268	HYBRID Laser-GMAW	None	None	B1	
QW-269	HYBRID Plasma-GMAW	None	None	B1	
QW-269.1	HYBRID Plasma-GMAW	None	None	B1	

ASME IX	Description	KEPIC	Description	Result	Remark
QW-290.5	Test Coupon Preparation and Testing (c) When hardness testing is specified by a Construction Code or Design Specification or no specific testing is required, measurements shall be taken across the weld metal, heat-affected zone, and base metal using the Vickers method with a 10-kg load. Increments between measurements shall be as specified in ASTM E384. As an alternative to the Vickers method, Instrumented Indentation Testing in accordance with ASTM E2546 may be used with test forces in the macro range of 2.2 lbf to 265 lbf (1 kgf to 120 kgf) and increments between measurements as determined in accordance with ASTM E2546. (1) Measurements shall be taken along a line at approximately mid-plane of the thickness of the test coupon weld metal. Along this line, there shall be (-a) a minimum of two measurements in the weld metal fill layers. (-b) at least one measurement on each: the weld beads against base metal, first-layer tempering beads, and the second-layer tempering beads. (-c) a minimum of three measurements in the heat-affected zone. These measurements may be taken in a line approximately parallel to the HAZ when spacing between impressions does not allow for three measurements to be taken in a single line transverse to the HAZ. (-d) a minimum of two measurements in the unaffected base metal. (2) Additional measurements shall be taken along a line approximately 0.04 in. (1 mm) below the original base metal surface. Along this line, there shall be (-a) a minimum of two measurements in the weld metal fill layers	QW-290.5	Test Coupon Preparation and Testing (c) When hardness testing is specified by a Construction Code or Design Specification or no specific testing is required, measurements shall be taken across the weld metal, heat-affected zone, and base metal using the Vickers method with a 10 kg load. Increments shall be not greater than 0.25mm (0.010 in.) apart and shall include (1) a minimum of two measurements in the weld metal fill layers (2) measurements across all weld metal temper bead layers (3) measurements across the heat-affected zone (4) a minimum of two measurements in the unaffected base metal The measurements shall be taken along a line at approximately mid-plane of the thickness of the test coupon weld metal, along a line 1mm (0.040 in.) below the original base metal surface and, when the coupon was welded using a full-penetration groove weld made from one side, 1.5mm (1/6 in.) above the root side surface. The path of HAZ hardness measurements may	B1	Hardness test specification is different.

ASME IX	Description	KEPIC	Description	Result	Remark
	(-b) at least one measurement on each: the weld beads against base metal, first-layer tempering beads, and the second-layer tempering beads (-c) one measurement located immediately below the toe of the weld bead and at least one measurement on each side of that impression (3) When the coupon is a full-penetration groove weld made from one side, additional measurements shall be taken along a line approximately 0.04 in. (1 mm) above the root side surface. Along this line, there shall be a minimum of two measurements in the weld metal, two in the heat-affected zone, and two in the unaffected base metal. Full-penetration groove weld test coupons qualify full and partial penetration groove welds, fillet welds, and weld build-up. Partial penetration groove weld test coupons only qualify partial penetration groove welds, fillet welds, and build-up. Overlay test coupons only qualify overlay welds. Hardness readings shall not exceed the hardness limits specified by the Construction Code or Design Specification. Where hardness is not specified, the data shall be reported.		angle across the HAZ as necessary to obtain the required spacing without interference of one impression with others. Full-penetration groove weld test coupons quality full and partial penetration groove welds, fillet welds, and weld build-up. Partial penetration groove weld test coupons only qualify partial penetration groove welds, fillet welds, and build-up. Overlay test coupons only qualify overlay welds. Hardness readings shall not exceed the hardness limits specified by the Construction Code or Design Specification. Where hardness is not specified, the data shall be reported.		
QW-302.2	Volumetric NDE When the welder or welding operator is qualified by volumetric NDE, as permitted in QW-304 for welders and QW-305 for welding operators, the minimum length of coupon(s) to be examined shall be 6 in. (150mm) and shall include the entire weld circumference for pipe(s), except that for small diameter pipe, multiple coupons of the same diameter pipe may be required, but the number need not exceed four consecutively made test coupons. The examination technique and acceptance criteria shall be in accordance with QW-191.	QW-302.2	Radiographic Examination When the welder or welding operator is qualified by radiographic examination, as permitted in QW-304 for welders and QW-305 for welding operators, the minimum length of coupon(s) to be examined shall be 150mm (6 in.) and shall include the entire weld circumference for pipe(s), except that for small diameter pipe, multiple coupons	B2	

ASME IX	Description	KEPIC	Description	Result	Remark
			may be required, but the number need not exceed four consecutively made test coupons. The radiographic technique and acceptance criteria shall be in accordance with QW-191.		
QW-321.3	Immediate Retest Using Volumetric NDE	QW-321.3	Immediate Retest Using Radiographic Examination	B2	
QW-361.2	QW-361.2 i) Essential variable For hybrid plasma-GMAW welding, the essential variable for welding operator qualification shall be in accordance with Table QW-357.	QW-361.2	QW-361.2 i) Essential variable-Machine welding (a) A change in the welding process. (b) A change from direct visual control to remote visual control and vice versa. (c) The deletion of an automatic arc voltage control system for GTAW. (d) The deletion of automatic joint tracking. (e) The addition of welding positions other than those already qualified (see QW-120, QW-130, and QW-303). (f) The deletion of consumable inserts, except that qualification with consumable inserts shall also qualify for fillet welds and welds with backing. (g) The deletion of backing. Double-welded groove welds are considered welding with backing. (h) A change from single pass per side to multiple passes per side but not the reverse.	B1	

ASME IX	Description	KEPIC	Description	Result	Remark
QW-386	Diffusion welding operation qualification Each welding operator shall be tested by welding a procedure qualification test coupon in accordance with QW-185.1. The coupon shall be metallographically examined in accordance with QW-185.3.	None	None	B1	
QW-402.18	For lap joints, (d) None	QW-402.18	d) a change in the method of surface conditioning at the metal-to-metal interfaces	B2	
QW-402.25~30	QW-402.25 A change from lap joint to groove welding, and vice versa. QW-402.26 A reduction of more than 5 deg. in the edge preparation bevel angle for groove welds. QW-402.27 A change in material of fixed backing anvils (when used). A change in backing anvil design that affects the weld cooling rate (e.g., a change from air-cooled to water-cooled, and vice versa). This variable is not applicable to tube-to-tubesheet or double-sided welds with overlapping fusion zones, or welds completed using self-reacting pins. QW-402.28 A change in joint design from that qualified, including edge preparation geometry (e.g., a change from square butt edge to beveled edge), reductions in the smallest joint path radius to less than the shoulder radius, or joint paths crossing themselves or another HAZ. QW-402.29 A change in joint spacing greater than ±10% of the qualification test coupon thickness. For WPSs qualified using intimate edge contact, the maximum allowable joint spacing is 1/16 in. (1.5mm). QW-402.30 A change from a groove weld to a fillet weld, or vice versa, from that qualified. For groove welds, a change in any of the following variables: (a) backing to no backing, or vice versa (b) a change of ±10% in the root face thickness (c) a change of ±10% in the root gap	None	None	B1	

ASME IX	Description	KEPIC	Description	Result	Remark
	(d) a change in bevel angle > 5%				
QW-403.28~30	QW-403.28 A change to another base metal type, grade, or UNS number. QW-403.29 A change in the surface finish as defined by the material specification or established surface roughness range as measured in accordance with ASME B46.1–2006. QW-403.30 A change in base metal thickness greater than 20% (a) of the test coupon thickness for fixed-pin and retracting-pin rotating tools (b) beyond the minimum and maximum thickness or thickness transition slopes of the test coupon for self-reacting rotating tools	None	None	B1	
QW-404.22	Adding of SFA 5.30 content	QW-404.22	No description of SFA 5.30	B1	
QW-404.53~54	QW-404.53 The addition or deletion of filler metal and, when used, a change in the filler metal nominal composition. QW-404.54 An increase in the deposited weld metal thickness qualified.	None	None	B1	
QW-407.10	The addition or deletion of PWHT, or a change of ±45°F (±25°C) in PWHT temperature or an increase in the holding time by more than 25% or change in the method of cooling (e.g., furnace, air, quench).	None	None	B1	
QW-408.13	None	QW-408.13	A change in the position or orientation of plasma-removing gas jet relative to the workpiece (e.g., coaxial transverse to beam).	B2	
QW-408.25~26	**QW-408.25** A change in the furnace atmosphere from that qualified. **QW-408.26** For friction stir welding of P-No. 6, P-No. 7, P-No. 8, P-No. 10H, P-No. 10I, P-No. 41 through P-No. 47, P-No. 51 through P-No. 53, and P-No. 61 through P-No. 62, the addition or deletion of	None	None	B1	

ASME IX	Description	KEPIC	Description	Result	Remark
	trailing or tool shielding gas, or a change in gas composition or flow rate.				
QW-409.1	Adding of (c) Heat input (c) Heat input determined using instantaneous energy or power by (1) for instantaneous energy measurements in joules (J) Heat input [J/in. (J/mm)] $= \frac{Ennergy(J)}{Wel\ Bead\ Length[in.(mm)]}$ (2) for instantaneous power measurements in joules per second (J/s) or Watts (W) Heat input [J/in. (J/mm)] $= \frac{Power(J/s\ or\ W)\ \times arc\ time(s)}{Weld\ Bead\ Length\ [in.(mm)]}$	QW-409.1	None	B1	
QW-410.67~84	**QW-410.67** A change in the optical technique used to focus the welding energy from that qualified. **QW-410.68** A change in welding equipment type (e.g., YAG, TAG, etc.). **QW-410.70** A change in the method of preparing the base metal surface prior to insertion into the furnace. **QW-410.71** A decrease in the percentage of block compression (original stack height compared to height after welding) from that of the test coupon. **QW-410.72** A decrease in the welding temperature or time from that used on the procedure qualification test coupon. **QW-410.73** A change in joint restraint fixtures from that qualified (e.g., fixed anvil to self-reacting, and vice versa) or from single-sided to two-sided welding, and vice versa. **QW-410.74** A change in the welding control method from that qualified (e.g., force control method to position control method, or vice versa, in the plunge direction; and force control method to travel control method, or vice versa, in the travel direction). **QW-410.75** A change in the rotating tool	None	None	B3	

ASME IX	Description	KEPIC	Description	Result	Remark
	QW-410.76 A change in the rotating tool operation from that qualified beyond the following limits. **QW-410.77** A change in the laser wavelength (e.g., CO2, Nd: YAG, fiber, disk, diode) from that qualified. **QW-410.78** A change in the process sequence from that qualified. **QW-410.79** A change in the distance between the laser beam and the welding arc of more than 10%. **QW-410.80** A change of ±5% in the diameter of the focused spot size. **QW-410.81** A change in the alignment of the plasma torch and GMAW torch with respect to travel direction by more than 10 deg., or a change from a leading or lagging plasma or the addition/deletion of a leading or lagging plasma. **QW-410.82** A change in the distance between the plasma and the GMAW torches by more than 10%. **QW-410.83** A change in the height differential of the plasma contact tip to the GMAW contact tip by more than 10%. **QW-410.84** A change in the angle between the leading and/or trailing plasma and GMAW torches by more than 10 deg.				
QW-420	Base Metal groupings Adding of "ISO/TR 15068 Group" The column "ISO/TR 15608 Group" in Table QW/QB-422 is a listing of the assignments of materials in accordance with the grouping criteria of ISO/TR 15608:2005, Welding—Guidelines for a metallic materials grouping system, and it is consistent with the assignments found in ISO/TR 20173:2008, Grouping systems for materials — American materials.	Base Metal groupings	None	B1	
QW-424.2	Adding of base metal substitution For welds joining base metals to weld metal build-up or corrosion-resistant weld metal overlay, the build-up or	None	None	B1	

ASME IX	Description	KEPIC	Description	Result	Remark
	overlay portion of the joint may be substituted in the test coupon by any P-Number base material that nominally matches the chemical analysis of the build-up or overlay.				
QW-442	A-Numbers: Adding of specific chemical range	QW-442	None	B1	
QW-451.1	**Note (6)** For test coupons over 6 in. (150mm) thick, the full thickness of the test coupon shall be welded.	QW-451.1	None	B1	
QW-461.10	Rotating tool design (FSW)	None	None	B1	

MANDATORY APPENDIX III: COMPARISON OF THE REQUIREMENTS FOR A SYSTEM FOR TECHNICAL MANAGEMENT AND SUPERVISION OF WELDING AS A MANUFACTURING / CONSTRUCTION TOOL

III.1 ASME BPVC Section IX versus AFCEN RCC-M

Figure III-1: Comparison between Section III and RCC-M Requirements for Technical Management and Supervision of Welding

ASME		RCC-M		Comparison (see 1.2)	Comments
ASME par.	**Description**	**RCC-M par.**	**Description**		
NCA-4134.1	Organization. Refers to NQA-1, Requirement 1. This describes the structure and responsibility within an organization and interfaces between organizations and organizational units.	Section I A5100	Refers to ISO 9001 and assigns responsibility for quality management to the "contractor, manufacturer or supplier".	B2	See also Code Comparison Report Section 4.10.
NCA-4134.2	Quality Assurance program. Refers to NQA-1, Requirement 2. Gives general requirements, as well as specific provisions for indoctrination, training and qualification for personnel performing NDE, inspection and tests to verify quality, and auditing. Records of qualification are addressed.	Section I A5200	General quality management system requirements are covered by A5200, which refers to ISO 9000.	B2	None
NCA-4134.3	Design control. Refers to NQA-1, Requirement 3.	Not compared A5230 clause 7.3.5 bis			
NCA-4134.4	Procurement Document Control. Refers to NQA-1, Requirement 4.	Not compared A5230 clause 7.3.5 bis			
NCA-4134.5	Instructions, Procedures, and Drawings. Refers to NQA-1, Requirement 5. Generic requirements are provided for activities affecting quality and services.	Section I A3200 B1200 Section IV S7120 S7431	A3200 and B1200 provide general requirements on technical documents. S7120 and S7431 provide general requirements on welding documentation.	B2	None
NCA-4134.6	Document Control. Refers to NQA-1, Requirement 6.	Section I A5230	Refers to ISO 9000 4.2.3bis, adds that documents and data verification shall be performed by	A2	Requirements are considered equivalent.