

WELDING CODES FOR INFRASTRUCTURE INDUSTRIES

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WELDING IN THE INDUSTRY

Welding is the most popular, economical and efficient method of joining metals.

The most common welding process that we encounter in Indian Industry is the MMA (Manual Metal Arc) Process although various other welding processes such as MIG/MAG and FCAW have now increasingly replaced the good old MMA or SMAW in the developed world. For sophisticated work it is not uncommon to see Industry deploying SAW, GTAW and PAW processes.

Welding

Welding is the joining of two or more pieces of metal by applying heat or pressure or both, with or without the addition of filler metal, to produce a localized union through fusion or recrystallization across the interface.

During welding, the metal or metals being joined are melted with the heat applied and forms a metallurgical bond between metals, and together with the filler metal, if added.

Weldability

Weldability, as the name suggests, is a specific or relative measure of the ability of the material to be welded under a given set of conditions.

When dissimilar metals are joined, each one of them must be weldable, and/or the filler metal should be so selected as to be compatible with both the metals.

Also the weldment produced should match the physical properties of the base metals. Ideally it is required that metallurgically, a defect-free, stable bond be formed between the materials to be joined. In case of carbon steels, a simple bend test would prove weldability of metals to be joined.

Welding processes

Manual welding is the most prevalent method, however for increased economy, and higher productivity, automatic-welding modes should be considered in process selection.

Most welding processes generally can be automated through the use of robotics, mechanical indexing and positioning systems.

Welding processes that employ an electric arc are the most widely used in the Indian industry.

Arc Welding

The arc may be established between an electrode and the base material as in SMAW - shielded metal arc welding and GTAW - gas tungsten arc welding, and GMAW - gas metal arc welding.

The arc and the molten metal is protected by an inert gas as in GTAW & GMAW, and by granulated flux as in SAW, or by gaseous slag products of a consumable electrode as in SMAW.

Flux in the core of filler wire with or without additional inert gas envelope shields the arc & weld pool in FCAW.

Welding consumables

Ideally, welding of a particular alloy with filler metal that matches exactly

provides several advantages: Uniform composition throughout the weld joint, excellent match of physical attributes such as colour, density, electrical & thermal conductivities, and uniform mechanical properties throughout the weld joint and the base metal, after appropriate post weld heat treatment. However, heterogeneous welds are common, so far as the chemistry and physical properties are compatible.

Welding in the industry

The industrial usage of a welding process depends to a great extent on the following considerations:

The material and its weldability, Production requirements, Design specifications and intended service, Size and complexity of weldments, Fabrication site - shop or field, Cost of welding equipment, Welder skill and training required.

Welding is deemed to be a Special Process and each type of Welding work needs to be pre-qualified, and must be conducted in controlled conditions, with the established parameters monitored for compliance to qualified procedures.

Records of qualified process, equipment and the qualified personnel need to be maintained. Infrastructure Industries cannot be an exception to this philosophy.

Infrastructure industries: could be broadly defined as comprising

Civil construction where welded steel structures and steel reinforced cement concrete is used. for Buildings, Bridges, Dams, Roads, Highways etc.

Power plants of which weld fabricated Boilers, Process Vessels, Heat Exchangers, and Piping are integral part

Railways where welding is the preferred metal joining process for rails, bogies, wagons and passenger coaches

Shipbuilding where now all the Ships built of steel are constructed using Welding as the prime metal joining method

Automobile Industry widely uses automatic, semi-automatic and robotic welding for mass manufacture of vehicles & its components

Waterworks employs welding as the joining process for tanks and piping

Welding codes

A Code of Construction is a set of Rules, Regulations and Ethical Practices, required to be observed by Manufacturers either as a statutory requirement; or as a Contractual Obligation to Statutory Authorities.

Public Sector Organizations and Engineering Societies such as:

- Indian Boiler Regulations (IBR)

- Indian Railway Services (IRS)
- Bureau of Indian Standards (BIS)
- American Welding Society (AWS)
- American Society of Mechanical Engineers (ASME)
- American Petroleum Institute (API)

have established Committees for the purpose of formulating Standard Rules for the Construction of Welded Vessels & Structures.

Primary aim of these Societies is to establish Rules of Safety governing Design, Fabrication and Inspection during Construction and Interpretation of the Rules and their Intent.

ASME CODE SECTION VIII DIV 1 & ASME SEC IX

The American Society of Mechanical Engineers set up a committee in 1911 to formulate standard rules for construction of steam boilers and other pressure vessels. The committee is called the BPV Committee.

The ASME Boiler and Pressure Vessel Code establishes rules of safety governing the design, fabrication and inspection during construction of boilers and pressure vessels. The ASME Code is a statutory code of construction for Boilers and pressure vessels in USA and Canada.

The BPV Committee interpretes the rules when questions arise regarding their content. Code Cases are used to amplify the rules.

ASME Code Rules are assembled into following eleven Sections :

Section I : Power Boilers

Section VII : Recommended Rules for care of Power Boilers

Section IV : Heating Boilers

Section VI : Recommended Rules for Care of Heating Boilers

Section II : Material Specifications :

Part A : Ferrous Mat'ls (ASTM Specs with SA prefix)

Part B : Non-Ferrous Mat'ls (Prefix SB)

Part C : Welding Consumables (AWS Specs: prefix SFA)

Part D : Material Properties & Allowable Stress Values.

Section III : Rules for Construction of Nuclear Power Plant

Division 1 : Components:

Subsection NB : Class I Components

Subsection NC : Class II Components

Subsection ND : Class III Components

Subsection NE : Metal Containment (MC)

Subsection NF : Component Supports

Subsection NG : Core Support Structures

Division 2 : Concrete Reactor Vessels & Containments

Division 3 : Containment & transport of spent nuclear fuel.

Section XI : In-service Inspection of Nuclear Power Plant Components

Section V : Non Destructive Examination

Section VIII : Divisions 1, 2 & 3: Unfired Pressure Vessels

Section IX : Welding and Brazing Qualifications

Section X : Fiberglass Reinforced Plastic Pressure Vessels.

About ASME Section IX: Welding and Brazing Qualifications

While ASME Code Section VIII Div. 1 gives the requirements for unfired pressure vessels fabricated by welding, it makes reference to ASME Code Section IX for qualification of welding procedures and welders. Specific requirements for qualifying

welding procedures, welders and welding operators, are spelled out in Section IX.

Each manufacturer or contractor is responsible for welding work done by his organization, and must conduct the training and tests required to qualify in advance the welding procedure he will be using in construction and the performance of his welding personnel.

Welding parameters (also called welding variables) which affect the quality of weldment are listed in great detail in the Section IX of the Code

The major variables can be identified as,

Welding Process, Base/ Parent Material quality & grade, Base Material thickness, Welding consumable grade/class, Application or lack of pre-heat, interpass temperature maintenance, post heat and post-weld heat treatment. and

Notch-toughness of weldment at sub-zero applications

AWS STRUCTURAL WELDING CODE: AWS D 1.1

First edition 1972; Combination of 1928 " Building Code" and 1936 "Bridge Specifications" Now it is a statutory Code in USA, and the designated Welding Inspector needs to be certified by American Welding Society (AWS)

Commonly used procedures and joint designs using proven welding processes such as SMAW, GMAW, SAW, FCAW do not need qualifications afresh, if variables are within stated limits. All welds must conform to drawing requirements; only approved WPSs, PQRs and WPQRs shall be employed;

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

American Standards Association (ASA) has over the years evolved into ANSI. This organization publishes national standards, which are mostly recommendatory, except as in the case of ANSI Z-49.1. "Safety in Welding and Cutting", which has become a law in USA.

ANSI B31.1 Standard for Power Piping (deemed to be an ASME Code complimentary to ASME Section 1 for Power Boilers), and

ANSI B31.3 Standard for Refinery and Process Piping, refer to ASME Section IX for Welding Procedure & Performance Qualifications of Welders and welding operators.

AMERICAN PETROLEUM INSTITUTE (API)

API sets standards and performance requirements for the Oil Industry. Important standards for Welding inspection are: API Standard 1104, API Standard 620, API Standard 650, ANSI/ASME B31.3, API Standards 620 and 650. as well as

ASME/ANSI B 31.3 make reference to ASME Section IX for welding qualifications.

U.S. DEPARTMENT OF DEFENCE - US MIL SPECIFICATIONS

The Welding fabricator will find US-MIL specifications similar to AWS and ASME specifications, except that there are usually some differences, as specially required for military applications.

SHIP CLASSIFICATION SOCIETIES

ABS, LRS, BVS, NKK etc. are ship classification societies, who survey & certify safe and sound construction of merchant ships & marine engineering structures, while under new construction or inservice, with view to safeguard safety of life and property at sea.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA has published a standard for welding fabrication of Water Tanks, in co-operation with AWS. This standard is: AWWA D100 (with AWS D 5.2): "Standard for Welded Steel Elevated Tanks, Stand Pipes, and Reservoir for Water Storage"

Local municipal bodies require that this standard be adhered to.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC. (AISC)

AISC specification for Design, Fabrication and Erection of

Structural Steel for Buildings: 1978 edition has now incorporated AWS D 1.1 provisions for principal reference, except that criteria for workmanship are more liberal than AWS D 1.1.

AD MERK BLATTER: GERMAN CODE FOR PVs

For qualification of a Welding Procedure, following essential welding variables are identified:

- Welding Process
- Material groups
- **Welding Conditions**, including aggravating conditions: Multi-pass welding does not qualify singlepass welds. Welding constraints, such as restricted
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- **Base metal thickness** : thickness range qualified is 0.75 to 1.5 t.
- **Working Temperatures** : PQRs are valid normally from -10 C to applicable upper operating temperature for the base or filler metal. For design metal temperatures less than -10 C (as permissible for the material grade) impact tests at the referred temperature are required.
- Welding Consumables
- Heat Treatment Condition

DIN 8563 : GERMAN STANDARD FOR WELDER QUALIFICATIONS

Unlike ASME Code Section IX, this standard does not require welder qualifications under auspices of a particular employer. Individual welder may qualify himself independently, to a stipulated set of welding variables. There need not be particular reference to a previously approved/established WPS or PQR. The Acceptance Criteria for qualifying the Welder's tests, however, are rigorous.

Four categories for butt-welding and three for fillet welding are specified, based on criticality (type and degree of stress level) of service. These are given below for information:

BIS : IS 2825 : 1969 : AMENDMENTS UP TO OCT 1988

Welding Procedure and Welder Performance qualification requirements in Section 11 Clause 7 of the Code were fully revised in October 1988, apparently to bring them closer to the more popularly used ASME Section IX.

Following seven (7) Essential variables are identified :

Welding Process, Base Metal, Filler Metal, Preheat, Post Weld Heat Treatment, Shielding Gas, Electrical Characteristics, and supplementary essential variable: Position (for Low Temperature only)

Severity Level of Application

Weld Category

	Groove / Butt	Fillet
Pressure Vessels & Components Subject to Tensile / Cyclic Loading	AG	AF
Structures predominantly subject to BG AF Dynamic/tensile/cyclic loading	BG	AF
Structures subject to Static/compressive loading	CG	BF
Others	DG	CF

INDIAN BOILER REGULATIONS : 1950 EDITION

Rules of Indian Boiler Regulations are primarily aimed at safeguarding the life and property in and around a boiler plant. IBR requires Welders and the Welding Contractors to prequalify the welding work through Welding Qualification Tests.

The skill of the Welders is tested and proven in normal as well as in difficult positions, with obstructions hampering manipulation of the welding torch. And through tests which also verify the weldability of materials being welded, and the strength & ductility of the weldment.

INDIAN RAILWAY SERVICE- IRS & RDSO REQUIREMENTS FOR WELDING

IRS Standard Specification M28-76 covers welding requirements adopted by Indian Railways, and its standardization body Research Designs and Standards Organization (RDSO).

SUMMARY

Welding is a special process, and as such welding procedures and welders' performances (skill) must be pre-qualified and the parameters established during procedure qualification tests must be maintained during actual production.

Infrastructure industries must follow this philosophy in all those areas, where welding fabrication is undertaken and be guided by the stipulations of Welding Codes.