

# Quality Assurance in Welding

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## 1.0 Definition of Quality Assurance

Quality Assurance is defined variously by various authors though they all mean the same thing. Two definitions most commonly used are :

- Quality Assurance is the activity of providing, to all concerned, the evidence needed to establish confidence that the quality function is being adequately performed.
- All those planned and systematic actions necessary to provide adequate confidence that a structure, system or component will perform satisfactorily in service.

## 2.0 Proof for Fitness for use

In order to ensure fitness for use, it is essential to formulate and implement the following :

- A formal plan which spells out for all phases of product progression “from cradle to grave” how fitness for use will be achieved.
- A system of reviews to verify that the plan, if followed, will result in fitness for use.
- A system of audits to verify that the plans are actually being followed.

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## 2.1 Joint Quality Planning

This is a vital step in achieving the desired quality and calls for extensive interaction between the various departments of the buyer and vendor. The two most important elements are—

- Pre contract Planning
- Pre production planning.

### 2.1.1 *Pre contract planning*

The most important steps in achieving fitness for use in pre-contract stage are to formulate correct and complete specifications and to evolve a quality assurance system which will establish that all specification requirements including design, material, fabrication, inspection and testing will be met.

Careful pre contract planning helps to achieve the following :

1. Correct and complete technical specification giving—
  - (a) Codes/specifications/standards.
  - (b) Design/operating parameters.
  - (c) Terminal points.
  - (d) Dimensions and tolerances.

- (e) Inspection and test requirements.
  - (f) Performance requirements.
  - (g) Test standards and acceptance levels.
  - (h) Preservation, packing and shipping requirements.
  - (i) Special information/requirements, if any.
  - (j) Documentation requirements.
2. Clear understanding by the vendor of—
- (a) Buyers specifications.
  - (b) Usage requirements.
  - (c) Interface requirements.
  - (d) Main requirements for performance, quality, reliability, maintainability safety etc.
  - (e) Meaning of key words, phrases and symbols.
3. Preparation of a quality manual by the manufacturer and its approval by the buyer or code authority. The quality manual shall include the following :
- (a) Authority and responsibility of those performing quality functions.
  - (b) Organisational structure showing the relationship between the management and the various departments.
  - (c) Design and Engineering control to ensure that these are correctly executed and to ensure that only the latest documents are available to all concerned departments.
  - (d) Material control to ensure that only materials as per code/specification are procured and materials are properly identified and supported by necessary test certificates.
  - (e) Quality control, inspection and test programme.
  - (f) Correction of non-conformities.
  - (g) Welding control to ensure that welding conforms to the requirements. This includes formulation of welding procedures, qualification of welding procedures and personnel.
  - (h) Non-destructive examination control—This includes preparation of NDE procedures, technique sheets, final approval of the techniques and qualification of NDE personnel as per agreed codes.
  - (i) Heat treatment control—preparation of heat treatment procedures and identifying the means by which it can be ensured that specification requirements for heat treatment have been met. This includes procedures and frequency of calibration of measuring and recording devices.
  - (j) Calibration of measurement and test equipments.
  - (k) Records retention.
  - (l) Sample forms.
- 2.1.2 *Pre-production planning*
- The quality assurance departments of the buyer and vendor have a major role to play in preproduction planning. This phase consists of :
1. Evaluation of manufacturing procedures, processes, personnel etc.
  2. Capability study and approval of processes, procedures, personnel, jigs, patterns, instruments etc.
  3. First off/prototype approval.
  4. Identification of characteristics to be controlled and seriousness classification of these characteristics (such as critical, major and minor) to help all concerned understand where to concentrate efforts.
  5. Establishment of sampling plans, AQL and other criteria pertaining to inspection and test activity.
  6. Determining the extent of history docketing, record keeping, reporting and certification necessary and establishing formats thereof.
  7. Establishing a system of lot/part identification and traceability.
  8. Establishing channels of communication between the buyer and vendor and identifying the areas

requiring two way communication such as design changes, deviations, corrective actions, inspection/test reports, progress reports etc.

9. Calibration and approval of measuring instruments, gauges, testing equipments etc.

## 2.2 Quality Control

After completion of the pre-contract and pre-production planning stages, there arises the need to establish a mechanism to ensure that the manufacturing operations are being carried out in accordance with the agreed quality plans and to provide proof that the plan has been followed.

The functions of quality control include the following :

1. To observe the manufacturing procedures, processes and operations to ensure that these are according to the approved/established requirements.
2. Measurement of characteristics at appropriate stages as per agreed/established quality plans and check lists and recording the observations in prescribed formats.
3. Constant evaluation of the manufacturing procedures, processes and operations including awareness to situations which might result in non-conformance and taking preventive measures.
4. Keeping the management informed of quality problems which might affect production and delivery schedules.
5. Taking decisions on non-conformities in consultation with design department and the buyer if necessary, including follow up in implementation of decisions.
6. Coordination with buyer for inspection at appropriate stages.
7. Release for shipment of only those items which are found acceptable for use as defined by the specifications, drawings or samples.
8. Analysis of quality problems and finding solutions thereof.

When well carried out, quality control can provide the buyer and vendor with early warnings of problems prior to the occurrence of non-conformance.

## 2.3 Quality Audit

Quality audit is an independent review conducted to compare some aspects of quality performance with a standard for that performance.

Quality audit is a tool by which the management evaluates the performance of the company's quality function. The audit team shall comprise of independent (other than the function audited), experienced and trained personnel. The audit may be anyone or a combination of the following :

1. Audit of quality system implementation vis-a-vis the quality manual.
2. Audit of procedures and processes vis-a-vis the approved/established ones.
3. Audit of quality records vis-a-vis the quality plan, specifications and drawings.
4. Audit of product with respect to the codes, specifications and drawings.

## 3.0 Welding Control

For carrying out welded constructions, attention shall be paid to the following points.

### 3.1 Preparatory Documents

3.1.1 Approval of fabrication drawings to ensure that design, materials of construction, fabrication details like joint configuration etc. meet the codes and specifications. The design department/buyer shall accord approval thereof.

3.1.2 Preparation of welding schedules indicating joint number, material specification, size, type of joint, position of welding and welding procedure specification number.

3.1.3 Preparation of WPS and approval by appropriate agency.

3.1.4 Preparation of NDT schedule, indicating joint number, stage of check, type/method of check, test procedure number and acceptance code number.

3.1.5 Preparation of check list indicating the stages of control from raw material to despatch to keep track of the status of operations done.

### 3.2 Material Identification

3.2.1 Examination of materials of construction and identification with material test certificates. Test certificates must be scrutinized for size, specification, grade process of steel making and product making, chemical and mechanical properties, heat treatment, hydraulic testing and non-destructive tests. When correlation with test certificates is not possible, testing shall be carried out as per relevant material standard. To guard against cracks in ferrous material less than 6mm thick, identification marks shall be made either by engraving or painting but in no case by hard stamping.

3.2.2 It shall be ensured that material used for an application is suitable for duty conditions specified in the code and it conforms to the specifications and standards listed in the relevant code.

3.2.3 Plates/pipes etc. shall be checked for rust, pitting etc. and shall be cleaned by recommended procedure like sand blasting, shot blasting, wire brushing, grinding etc., to even out pitting, rust, scale etc. However, it must be ensured that the minimum thickness meets the code requirements.

3.2.4 Thick plates shall be tested ultrasonically to ensure freedom from laminations.

### 3.3 Material preparation

3.3.1 Material shall be prepared to size and shape by thermal cutting or shearing or machining or grinding. It shall be ensured that the cutting process does not lead to hardening or cracking of the edges.

3.3.2 Preheating requirements as stipulated in the code shall be observed during thermal cutting.

3.3.3 Notches etc., shall be removed as recommended in the relevant code.

3.3.4 The edges shall be free of slag, scale and detrimental discolouration of material caused by thermal cutting.

3.3.5 Prepared edges, when in doubt, may be checked by PT (liquid penetrant test) to ensure soundness of material.

### 3.4 Forming and Fit up

3.4.1 Preliminary rolling shall be checked for flat spots, dents etc. Rolls and plates shall be free from foreign matter before rolling.

3.4.2 Fit up, mismatch, ovality, circumference etc., shall be as per the relevant code/drawing.

3.4.3 Tack welding shall be done by qualified welders only and the size of the tack shall be as per the code.

3.4.4 Rerolling of pipes may be done to achieve dimensions as per the code. Sometimes when it is difficult to achieve dimensional tolerance after welding, rerolling may be done followed by NDT as per the code.

3.4.5 Wherever bending is involved, it shall be ensured that the bend radius, ovality and thinning are as per code requirements and heat treatment is done if so required in the code.

### 3.5 Welding

3.5.1 Before start of welding, it shall be ensured that the relevant weld procedure and welder qualification tests are in accordance with the stipulated code requirements, otherwise, qualification test shall be done.

3.5.2 Welding electrodes shall be of approved make.

3.5.3 Tacks shall completely fuse with the weld and parent metal during welding.

3.5.4 Start-on and end-off pieces of minimum 50 mm length shall be provided for longitudinal seams.

3.5.5 Root Run shall be checked with PT and back chipped to sound metal when required by code/ when in doubt. Full root penetration must be ensured wherever required.

3.5.6 All butt welds shall be preferably checked on both sides with PT after the completion of the weld.

3.5.7 Wherever low hydrogen electrodes are being used, only baked electrodes shall be used. For baking and holding temperature for electrodes, guide lines may be taken from AWS spec/manufacturer. After baking, the electrode shall be stored in a holding oven at a lower temperature, Low hydrogen electrodes shall preferably not be stored along-with the other electrodes in the holding oven. Repeated re-baking of electrodes shall be avoided.

3.5.8 Welding sequence shall be so as to minimise distortion. Before starting next run, slag, spatters etc. shall be properly cleaned to ensure sound welding.

3.5.9 Reinforcement of butt welds shall be controlled during completion of welding in accordance with the applicable code.

3.5.10 Size and shape of fillet welds shall also be controlled as per the code during completion of welding.

3.5.11 Any reinforcement of welds must blend smoothly into base metal surfaces with transition areas free from undercut, under flush etc.

3.5.12 The completed weldment shall be checked by NDT methods like PT/MT/RT/UT, whenever, required by code. The testing and acceptance norms shall be as per code.

The most commonly used NDT standards for welds are ASME Sec. V, ASME Sec. VIII Div. 1 BS-2600, IS-2595 IS-2825 etc. These give both the procedure as well as the acceptance standards.

3.5.13 Each joint shall be marked with welder number as per code requirements.

3.5.14 Stress relieving charts shall be checked to ensure that heat treatment has been done properly. Wherever possible, thermocouples shall be attached directly to the job. For long length assemblies, more number of thermocouples shall be attached to monitor temperature gradients.

3.5.15 The completed assembly shall be checked hydraulically as per the code. It shall be ensured that pressure gauges are of correct range, and accuracy and are calibrated. The test pressure and duration shall be as per code. At least two pressure gauges shall be used. Also it shall be ensured that proper supports are put during hydraulic testing.

### 3.6 Cleaning and Marking

3.6.1 The inside and outside surfaces of the completed assembly shall be cleaned by sand blasting/acid pickling as per specifications like BS-4232.

3.6.2 Dimensions like ovality, circumference, length, level, alignment, squareness, edge preparation, orientation of nozzles, flanges, stubs, their dimensions etc. shall be checked.

3.6.3 Match marking for pipe to pipe and pipe to support assembly shall be checked. Markings to identify the system/sub-system/spool/component in addition to material markings shall be available.

### 3.7 Painting

3.7.1 It shall be ensured that primers and paints are of reputed and approved makes and manufacturers test certificates are furnished with each batch.

3.7.2 Painting shall be done immediately after surface preparation to avoid rust formation.

3.7.3 Surface finish, shade and thickness of painting shall be checked.

### 3.8 Documentation

3.8.1 It shall be ensured that proper certificates/inspection reports/records are available for all stages of check.

3.8.2 Details as in 3.8.1 shall be summarized in the form of check sheets and history cards for materials, processes etc.