

Chapter 5. Welding Inspection Operations

Chapter Four outlined some prerequisites of a welding inspector in order to suggest the type of individual needed to carry out the various responsibilities of that position. This chapter deals with some of the more essential operations involved in the weld inspection process. It should be kept in mind, however, that welding inspectors can have a very diversified range of responsibilities, dependent largely upon the specification, code, or standard to which they are working and the particular manufacturing or fabrication industry with which they are engaged. No one type of inspector is being considered here, but rather an all-inclusive category of processes typical to the overall inspection operation.

Welding inspection operations will, for most types of fabrication, follow the general order of the fabrication procedure. The following outline is a general list of responsibilities that might be encountered in the overall weld inspection process:

- (1) Knowledge of drawings, specifications, and manufacturing instructions
- (2) Verification of the manufacturer's approved quality assurance program
- (3) Verification of welder and inspector qualifications
- (4) Verification of approved procedures for qualifying welders and inspection personnel
- (5) Verification that approved welding and inspection procedures are being used
- (6) Selection of production test samples
- (7) Evaluation of test results
- (8) Preparation of test reports and storage of records

Knowledge of Drawings, Specifications, Manufacturing Instructions

All weld inspectors would be well advised to obtain a working knowledge of the product being manufactured, specifically those components or subassemblies which they will inspect. Detailed knowledge of drawing requirements, detailed specification requirements, and manufacturing instructions would be essential. Also helpful would be a knowledge of the material to be used in the welded structure, since certain metals often require special treatment for satisfactory welding. Welding and related procedures should contain information which subsequently incorporates all of the specified variables for performing the fabrication operation. Manufacturing instructions authorize the use of particular procedures for various phases of component fabrication.

Situations arising during the course of manufacturing that require deviations from drawing or detailed specification requirements may be necessary. The weld inspector should be alert to any changes made, to assure consistent compliance with all other procedures and fabrication requirements. It is the inspector's responsibility to ensure that any deviation complies with the requirements of all criteria set forth for the contract. Deviations beyond the level of the inspector's expertise or jurisdiction should be referred to the appropriate technical activity for resolution. In some instances, the acceptance or rejection of a large welded structure may be involved, and it will

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be his duty, after careful study, to determine whether the deviation can be accepted in accordance with drawings and specification requirements. Deviations from drawings usually must be referred to the design agency for approval.

It is not always possible to write an all-inclusive specification that contains all the detailed information needed to provide an answer for any question that might arise. Those parts of the specification, where requirements are not fully defined and where doubt exists as to the correct interpretation of the intent, should be interpreted only by the appropriate technical personnel who are authorized to provide such interpretation.

Quality Assurance Program

The welding inspector should be aware of the manufacturer's quality assurance program. Depending upon the type of job and the manufacturer, the quality assurance program provides the administrative steps needed to inspect and control the quality of the completed product. A quality assurance program may include control over a manufacturer's procedures, including final approval and control of procedure revisions or procedures and job order applicabilities. Other functions might include the administration of the manufacturer's instrument calibration program. Measuring instruments play a vital part in the inspection process and their periodic calibration is often essential.

The quality assurance personnel will evaluate any discrepancy reports or findings presented to them by the weld inspector. The inspector should be familiar with rules, procedures, and methods for handling and presenting the manufacturer with such discrepancy findings. The quality assurance group may supervise or serve as an arbitrator or may initiate engineering evaluations or request waivers for departures from specification requirements.

Welding Procedure and Welder and Welding Operator Qualifications

One universal principle involved in specifications and codes for the fabrication of weld-

ments is the requirement that the fabricator must provide written welding procedure specifications that will be followed in producing weldments under that particular specification or code. The welding procedure must be capable of producing welded joints to certain acceptance criteria in accordance with the requirements of the particular specification or code involved. Chapter 10 of this text describes the elements of a welding procedure specification and explains the reasons for its use.

Prior to the start of production welding, the fabricator must ensure that only qualified welders and welding operators will be used. It may be desirable, depending upon the contract, to have a procedure detailing qualification methods. Some contracts may require it and also that the procedure be approved. The welding inspector should ensure (1) that only approved welding procedures are used on the applicable contract, and (2) that welders and welding operators are qualified. The contract should specify how this may be accomplished.

Additionally, the welding inspector should be alert to changes in any welding procedure in excess of the limits prescribed by the welding procedure. Changes or deviations in excess of the procedural requirements should be brought to the attention of the proper personnel. Revisions should be qualified by tests where required, and, if necessary, welders and welding operators should then be requalified in accordance with the new procedural requirements. If procedure or performance requalification is required, the revised procedure(s) should not be applied to production work until the changes have been approved for use.

Usually, most contractual requirements applying to the fabrication of weldments will stipulate that all welders and welding operators be qualified in accordance with prescribed procedures, and the specific procedure for such qualification is prescribed by the detailed specification or code requirements. Chapter 12 and Table 10.1 in Chapter 10 contain sample qualification requirements and examples where welders may be working out of their qualifications.

Welding specifications or codes do not normally require requalification of procedures, welders, or welding operators for each new

contract or change of design, unless the new contract creates new or additional welding requirements. The objective of welding procedure qualification tests is to determine the mechanical properties of the welded joint. The objective of performance qualification is to determine the ability of an individual to deposit sound weld metal with a previously qualified welding procedure.

Inspection Personnel and Procedure Qualifications

As with welder and welding operator qualifications, inspection personnel should also be qualified prior to the start of production inspection of production welds. The fabricator must ensure that only qualified personnel are used to inspect or perform inspection operations. It may be desirable or a requirement, depending upon the contract, to have a procedure detailing qualification methods. Some contracts may require the procedure to be approved. The welding inspector, depending upon his duties, should ensure that only qualified inspection personnel are used.

Application of Welding and Allied Procedures

Although welders and inspection personnel are qualified in accordance with approved procedures, verification is nonetheless necessary to provide added assurance that those procedures are applied properly and competently. To a large extent, the quality of welding and the quality of inspection depend upon the application of the correct procedures. As his duty requires, the welding inspector should verify that those procedures specifically approved or agreed upon for this job are being used. The inspector may find it to his advantage to prepare a checklist for each procedure to guide him in performing his duties. Various recognized inspection methods and tests are described in Chapters 13 through 16.

In general, inspection processes should be performed in sequence with the manufacturing operations, as established by the fabricator. There are good reasons for doing this, some of which are:

(1) Interference between inspection and production is kept to a minimum.

(2) Inspection operations required at a certain stage of fabrication (such as when performance of the next manufacturing step would make inspection of the preceding one impossible) can be completed.

(3) In-process inspection permits earlier correction of deficiencies, improves economics, and speeds delivery.

The following sequence of welding and inspection operations is offered as a general guide to overall welding and inspection operations. It should be understood, of course, that the actual operations and the order in which they are applied will depend upon the type of weldment, the method of manufacture, and the requirements of the governing contract.

Inspection Procedure

Prior to welding

Material identification

Chemical analysis

Mechanical properties

Base metal discontinuities

Laminations and cracks

Surface irregularities

Flatness

Joint geometry (fit-up)

Edge preparation (including root face and beveling)

Dimensions

Cleanliness

Root opening

Tacking

Backing (where required)

Special setups used for assembly and fabrication (only to see that uniform practices are employed)

Jigging and bracing

Prestressing or precambering

During welding

Preheat and interpass temperatures

Controls

Measurement methods

Filler Metal

Identification

Control

Handling

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- Root Pass
 - Contour
 - Soundness
- Root preparation prior to welding
 - second side
- Cleaning between passes
- Appearance of passes (sometimes in comparison with workmanship standard)
- In-process NDT inspection as required or specified
- Conformance to approved welding procedure
- After welding
 - Postheat treatment requirements
- Acceptance inspection
 - Method of cleaning for inspection
- Nondestructive testing
 - Visual inspection
 - Surface contour and finish of welds
 - Conformity of welds with drawings
 - Magnetic particle and liquid penetrant tests
 - Radiography
 - Ultrasonic tests
 - Proof testing
 - Other suitable methods
- Destructive testing
 - Chemical
 - Mechanical
 - Metallographic
- Repairs
 - Marking for acceptance or rejection
 - Inspection after repair

Selection of Production Test Samples

In many types of welded assemblies, certain inspections of the finished product may be performed on samples selected by the inspector from the production line. These samples may be selected at random, or in accordance with an established sequence. In either case, the selection and the witnessing of the testing of these samples are among the important duties of the inspector. In some cases, selection of samples is left to the judgment and discretion of the inspector, rather than prescribed by specifica-

tion or code. In such cases, the number of samples should not be more than is needed to reasonably determine conformance to the required standards. It is common practice for most contracts to mandate a specific sampling plan and, further, to require that for each unsatisfactory sample additional sampling be performed until satisfactory workmanship standards are demonstrated.

Certain tests or treatments may be prescribed for the samples selected by the inspector. These may include radiography, hydrostatic tests, trepanning, metallurgical examination, mechanical testing to destruction, or other detailed examinations. The inspector must determine that such work, as prescribed, is properly carried out. Various sampling, testing, and inspecting methods are described in Chapters 13 through 16.

Evaluation of Test Results

In the majority of cases it will be impractical for the inspector to perform or witness all tests made in connection with some weldments. Where his job requires, however, he should witness or observe sufficient test processes to satisfy himself that the tests are being performed in the proper manner and that the results are accurate. Evaluation and final disposition of test results will usually require the inspector to carefully consider the attributes of the entire process.

From time to time the welding inspector will review test or inspection results that do not meet the required standards for acceptance in every detail. The final disposition or decision will require careful judgment as to whether the product meets the intent of the specification requirements. In such cases, the results of the test must carefully be evaluated. In some instances, such as inadvertent inspection of work not intended to be or not required to be inspected, or when the work has borderline acceptability, an engineering judgment must be made as to the acceptability of the product. Engineering judgments should only be performed where the specification or contract allows and only when sufficient information is available from which to exercise sound judgment.

Preparation of Records and Reports

Any work performed under a specification or code that requires inspection or tests will also require records. However, whether required or not, the inspector should keep adequate records.

It is also the inspector's duty to check all records for completeness and accuracy in accordance with specified requirements and to make certain that they are available when needed.

Any records that require the fabricator's signature should be prepared by the fabricator rather than the inspector.

Records should be in as much detail as necessary. It is desirable that the inspector comment on the general character of the work, how well it stayed within prescribed tolerances, difficulties that occurred, and any defects. Any repair should be explained. Copies of these records should go to all persons entitled to receive them, and the inspector should keep a copy in his own file.