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Visual Inspection Workshop

Reference Manual

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INTRODUCTION

Rationale

Inspection is traditionally considered a post-processing activity. A machine component may be turned to finished form and size—then inspected for conformance to the applicable drawing or specification. A garment is inspected after sewing and all the buttons and other features are in place. In these and similar instances, *visual inspection* is carried out after the production activities have been completed.

In the case of weldments, experience has shown that post-processing inspection, even when supplemented with nondestructive examination (NDE), gives no guarantee of suitability for intended service. However, consistent results over a considerable period of time have demonstrated the effectiveness of a preplanned sequence of visual inspections. If carried out at specific stages of weldment production, such programs give a high degree of assurance of meeting quality expectations—frequently without recourse to NDE.

With welding, the factors influencing quality may manifest themselves at any stage of the production operation. In many instances, quality is compromised even before welding commences. In most such circumstances, suitably timed visual inspection would have revealed the shortcoming at a stage when corrective action would be simple to implement and inexpensive to carry out.

Weld and weldment quality are determined by:

- Weldment and joint design
- Materials used in construction
- Welding procedures
- Manner of weld application
- Inspection program

Visual welding inspection provides the basis for the effective control of these determinants.

Workshop Aims

The aims of this workshop are to:

- Provide a basic understanding of the circumstances under which weld and weldment quality, or both, may be compromised.
- Offer a program of weld inspection that gives a high degree of assurance of meeting weld quality requirements for most fabricated products.
- Show how to develop and implement specific quality plans to meet all normal requirements for weld and weldment quality.

- Demonstrate and practice the techniques of visual inspection required to carry out effective weld quality control.

Quality

The term *quality* is widely used and applied. However, many times, the general concept of quality is misunderstood.

Quality is conformance to the applicable specification.

The required level of quality for a product or service is typically determined by the designer, based on suitability for service over the intended life span. All product variables must be specified in a manner that is capable of being measured. Dimensions are readily verified. Attributes such as surface finish, if significant, must be specified in terms allowing for precise determination or measurement.

In carrying out an inspection, the inspector's task is to compare the *actual* with the *required* or specified product dimensions. Appearance alone is rarely the determinant of product quality.

Terms and Definitions

Certain important terms are used in the inspection of welding that may or may not apply in other industries. These include:

- ***Discontinuity***—any interruption in the uniformity of an object.
- ***Defect***—a discontinuity that does not meet the required product specification.

In general, a discontinuity is described as any interruption in the uniform nature of an item. Therefore, a bump in a highway could be considered to be a type of discontinuity because it interrupts the smooth, uniform surface of the pavement. In welding, the types of discontinuities with which we are concerned are such things as cracks, porosity, undercut, incomplete fusion, etc.

Knowledge of these discontinuities is important to the welding inspector for a number of reasons. First, the inspector will be asked to visually inspect welds to determine the presence of any of these discontinuities. If any are discovered, the welding inspector must then be capable of describing their nature, location, and extent. This information will be required to determine whether or not that discontinuity requires repair, as described in the applicable job specifications.

If additional treatment is deemed necessary, the welding inspector must be capable of accurately describing the discontinuity to the extent that it can be satisfactorily corrected by production personnel.

Before describing these discontinuities, it is extremely important to understand the difference between a discontinuity and a defect. Too often, people mistakenly use the two terms interchangeably. As a welding inspector, you should strive to realize the distinction between the terms *discontinuity* and *defect*.

While a *discontinuity is* some feature which introduces an irregularity in an otherwise uniform structure, a *defect* is a specific discontinuity which can impair the suitability of that structure for its intended purpose. That is, a defect is a discontinuity of a certain type, and one which occurs in an amount great enough to render that particular object or structure unsuitable for its intended service based on criteria in the applicable code.

In order to determine if a particular discontinuity is actually a defect, there must be some standard which defines the acceptable limits of that discontinuity. When its size or concentration exceeds these limits, it is deemed a defect. We can therefore think of a defect as a "rejectable discontinuity." So, if we refer to some feature as a defect, we are implying that it is rejectable and requires some further treatment to bring it into acceptable limits to a particular code. Depending on the intended service of the part in question, an existing discontinuity may or may not be considered to be a defect. Consequently, each industry uses specific codes or standards which describe the acceptable limits for those discontinuities which could affect the successful performance of various components.

A *code* by definition is "a body of laws, as of a nation, city, etc., arranged systematically for easy reference." When a structure is built within the jurisdiction of a city or state, it must often comply with certain "building codes." Since a code consists of laws having legal status, it will always be considered mandatory. Therefore, we will see text containing words such as "shall" and "will." A specific code includes certain conditions and requirements for the item in question. Quite often it will also include descriptions of methods to determine if those conditions and requirements have been achieved.

The next document type to be covered will be the standard. The dictionary describes a *standard* as, "something established for use as a rule or basis of comparison in measuring or judging capacity, quantity, content, extent, value, quality, etc." A standard is treated as a separate document classification; however, the term standard also applies to numerous types of documents, including codes and specifications. Other types of documents considered to be standards are procedures, recommended practices, groups of graphic symbols, classifications, and definitions of terms.

Some standards are considered to be mandatory. This means the information is an absolute requirement. A mandatory standard is precise, clearly defined and suitable for adoption as part of a law or regulation. Therefore, the welding inspector must make judgments based on the content of these standards. These mandatory standards use such words as "shall" and "will" because their requirements are not a matter of choice. Codes are examples of mandatory standards because they have legal status.

There are numerous standards that provide important information, but are considered to be nonmandatory. An example of a nonmandatory standard would be a recommended practice. They are nonmandatory because they may provide other ways in which objectives can be accomplished. Nonmandatory standards include words such as "should" and "could" in place of "shall" and "will." The implication here is that the

information has been put forth to serve as a guideline for the performance of a particular task. However, it doesn't mean that something is rejectable just because it fails to comply with that guideline. Even though a standard may be considered nonmandatory, it still provides important information.

The final document classification to be discussed is the specification. This type is described as, "a detailed description of the parts of a whole: statement or enumeration of particulars, as to actual or required size, quality, performance, terms, etc." A specification is a detailed description or listing of required attributes of some item or operation. Not only are those requirements listed, but there may also be some description of how they will be measured.

Depending upon a specific need, specifications can exist in different forms. Companies often develop in-house specifications describing the necessary attributes of a material or a process used in their manufacturing operation. The specification may be used entirely within the confines of that company, or it may be sent to suppliers to detail exactly what the company wants to purchase. When these requirements are put into writing, there is more assurance that the item or service that is supplied will meet the quality expectations.

To advance the application and utilization of welding, the American Welding Society (AWS) has standardized requirements for welding inspectors. Certification of eligible persons is based on documented evidence of appropriate experience along with the achievement of a certain minimum level of competence in a 3-part examination.

Certified Welding Inspectors

An Inspector meeting AWS standards is designated a **Senior Certified Welding Inspector** (SCWI) or a **Certified Welding Inspector** (CWI). SCWIs and CWIs are employed in a wide spectrum of industry and carry out a variety of tasks. While certain inspectors will have a wide range of situations with which to deal, others work in more specific areas of inspection. However, a knowledge of all facets of welding quality is required of SCWIs and CWIs to determine how the variables interact.

Visual Inspection

Key points about the visual inspection of welding should be recognized. These include:

- No inspection program will give an absolute guarantee as to weld and weldment suitability for intended service over the life of a product. However, by structuring an appropriate *inspection plan*, commercially realistic degrees of confidence in a welded product can be achieved.

- While visual inspection is highly effective in the control and assessment of weld and weldment quality, there is one obvious limiting factor. Visual inspections are confined to exposed surfaces—so subsurface discontinuities may not be detected. This is offset by structuring welding inspection programs to examine the minimum number of surfaces that will give the required degree of assurance.

- Nondestructive testing of welds and welding is an adjunct to the visual inspection program, not a substitute for it. The four NDE methods used in connection with welding each have their own areas of best application—along with limitations. Penetrant and magnetic particle testing are surface techniques, with the latter limited to ferromagnetic materials. Radiography is directional, ultrasonic examinations require smooth surfaces for transducer contact.

Safety and Health

This document does not address all welding and health hazards. Pertinent information can be found in ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, and other safety-related documents including federal, state, and local regulations.

1. CHAPTER #1—VISUAL INSPECTION OF WELDING

1.0 Aims of Chapter #1

This manual includes an outline of the fundamental prerequisites for personnel performing visual examination of welds. Such prerequisites include physical limitations or capabilities, as well as technical knowledge, training, experience, judgment, and certification.

This manual essentially provides an introduction to visual examination of welding. These examinations fall into three categories based on the time they are performed, as follows: (1) prior to welding, (2) during welding, and (3) after welding. An extensive treatment is provided on weld surface conditions, including reference to frequently used terminologies associated with *preferred* and *nonpreferred* conditions. Visual examination may be performed by different people or organizations. Personnel performing welding examination include welders, welding supervisors, the contractor's or fabricator's welding inspector, the purchaser's examiner, or the regulatory inspector. For the purpose of simplicity, these individuals are referred to as visual inspectors in the remainder of this manual in that they perform visual inspection. Fabrication documents, contract specifications, and regulatory agencies may specify who performs final inspection.

1.1 Application

Information contained in this manual applies to the general duties and responsibilities of visual inspectors of weldments and is useful to them in carrying out their duties and responsibilities defined in particular codes or specifications. This workbook is primarily intended for those who are responsible for the final acceptance of weldments. However all welders, supervisors, technicians, and engineers who are required to routinely inspect work performed by them or under their authority will benefit from the use of this workbook. This workbook will provide general guidelines for the visual examination of weldments.

The inspector should be knowledgeable concerning each of the principles and methods of examination required on a particular weldment. It is the responsibility of those charged with the administration and supervision of inspection to make certain that the principles and methods set forth are properly understood and uniformly applied. This responsibility also includes the qualification and certification of inspectors, where such certification is required by codes, specifications, or civil laws. AWS QC1, *Standard for AWS Certification of Welding Inspectors*, and AWS B5.1, *Specification for the Qualification of Welding Inspectors*, indicates the importance AWS assigns to visual examination.

Contract documents should specify the requirements for visual examination. In the absence of such requirements, the manufacturer should be requested to establish, in writing, the extent and the methods of examination to be required.

Acceptance standards should be clearly understood by both the manufacturer and the buyer before any welding is started. This is not only to make more effective use of the