11. NONDESTRUCTIVE TESTING

Nondestructive testing includes magnetic particle testing (MT), Liquid Dye Penetrant testing (PT), Radiographic Testing (RT) and Ultrasonic Testing (UT). The purpose of nondestructive testing is to serve as a backup to Visual Inspection and to detect flaws and defects that are not visible. Nondestructive examination is not a replacement for an adequate program of Visual Inspection, and should not be used as such.

11.1 Personnel

11.1.1 Qualification

Nondestructive testing personnel shall be qualified under The American Society for Nondestructive Testing, Inc., Recommended Practice No. SNT-TC-1A, in one of the three following levels:

a) **NDT Level I** - An NDT Level I individual should be qualified to properly perform specific calibrations, specific NDT, and specific evaluations for acceptance or rejection determinations according to written instructions and to record results. The NDT Level I should receive the necessary instruction or supervision from a certified NDT Level III individual or designee.

b) **NDT Level II** - An NDT Level II individual should be qualified to set up and calibrate equipment and to interpret and evaluate results with respect to applicable codes, standards and specifications. The NDT Level II should be thoroughly familiar with the scope and limitations of the methods for which he/she is qualified and should exercise assigned responsibility for on-the-job training and guidance of trainees and NDT Level I personnel. The NDT Level II should be able to organize and report the results of NDT.

c) **NDT Level III** - An NDT Level III individual should be capable of establishing techniques and procedures; interpreting codes, standards, specifications and procedures; and designating the particular NDT methods, techniques, and procedures to be used. The NDT Level III should be responsible for the NDT operations for which he/she is qualified and assigned and should be capable of interpreting and evaluating results in terms of existing codes, standards, and specifications. The NDT Level III should have sufficient practical background in applicable materials, fabrication, and product technology to establish techniques and to assist in establishing acceptance criteria when none are otherwise available. The NDT Level III should have general familiarity with other appropriate NDT methods, as demonstrated by the ASNT Level III Basic examination or other means. The NDT Level III, in the methods in which certified, should be capable of training and examining NDT Level I and II personnel for certification in those methods.

11.1.2 Written Practice

a) The employer (Testing Agency or Fabricator/Erector) should maintain a written practice for the control and administration of NDT personnel training, examination and certification.

b) The employer's written practice should describe the responsibility of each level of certification for determining the acceptability of materials and weldments in accordance with the applicable codes, standards, specifications and procedures.

c) The employer's written practice should describe the training, experience and examination requirements for each level of certification.

11.1.3 Certification

a) Certification of all levels of NDT personnel is the responsibility of the employer.

b) Certification of NDT personnel should be based on demonstration of satisfactory qualification in accordance with Sections 6, 7 and 8 of SNT-TC-1A, as modified by the employer's written practice.

c) Personnel certifications should be maintained on file by the employer and a copy should be carried by the technician.

11.1.4 Recertification

a) All levels of NDT Personnel should be recertified periodically in accordance with one of the following criteria:

   i) Evidence of continuing satisfactory performance

   ii) Reexamination in those portions of the examinations in Section 8 deemed necessary by the employer's NDT Level III

b) Recommended maximum recertification intervals are:

   i) Levels I and II - 3 years

   ii) Level III - 5 years

c) The employer's written practice should include rules covering the duration of interrupted service that requires reexamination and recertification.

11.2 Execution

11.2.1 General

Nondestructive testing should not be used in lieu of visual inspection.

Commentary: Visual inspection and NDT should be used as a complement to one another. There are four basic testing methods beyond visual inspection which are commonly used: magnetic particle (MT), liquid penetrant (PT), radiographic *testing (RT) and ultrasonic testing (UT). The uses of the methods are described in detail in AWS B1.0, Guide for Nondestructive Inspection of Welds.*

When nondestructive testing other than visual is to be required, it should be so stated in the bid documents. This information should designate the categories of welds to be examined, the extent of examination in each category and the methods of testing.

The designer should require that the testing laboratory employing the NDT technicians be certified by the National Institute of Standards and Technology, NAVLAP program and that the technicians are qualified under ASTM E543. Additionally, the laboratory should employ a Level III NDT supervisor under the requirements of SNT-TC-1A.

The designer or his/her designated welding engineer should be familiar with the strengths and limitations of each NDT method. Incorrect selection of the methods has caused false reliance on the results. Each method has its own strengths and weaknesses. Magnetic particle and liquid penetrant testing require the least amount of training; radiographic and ultrasonic testing require a higher level of training and background. NDT technicians are not generally required to be certified welding inspectors under the QC1 requirements; however, it is highly recommended that at least one NDT technician active on the project site be so qualified.

11.2.2 Magnetic Particle Testing (MT)

MT may be used for surface and near-surface linear defect flaw detection. It is essential that for linear indications to respond to MT, they must be oriented at an angle between 45^o and 90^o, with the maximum influence occurring at 90^o to the flux field. Therefore each area tested should have the electromagnetic yoke positioned at 0^o then at 90^o.

Commentary: MT's depth limitation is less than 1/8 inch for typical flaws. The instrument consists of an electro-magnetic yoke which sets up a magnetic flux field around a weld. A very fine magnetic powder dust is applied to the area being tested. As the flux lines cross a linear defect the field is interrupted and the powder aligns with the defect. Spurious indications are sometimes encountered along areas of poor weld bead contour, undercut or overlap. The use of a white background paint to improve contrast can improve the reliability of this method.

A key use of this method is during air-arc gouging to determine if a crack has been totally removed. Root pass testing is also commonly done with MT. These tests, of course, require that the NDT technician be continually present during welding.

11.2.3 Liquid Penetrant Testing (PT)

PT may be used to locate defects which are open to the surface.

Commentary: In PT, a highly fluid, red dye penetrant is sprayed on the surface of the joint and allowed to soak into any open surface defect by gravity and capillary action. The surface is then wiped clean and a white developer with a powder consistency is applied. The red dye bleeds back out of the defect highlighting the flaw. The method is typically used on completed welds.

Due to the problems associated with additional surface preparations and the time involved with PT, it is recommended that MT be applied when ever possible. There may be situations where, because of geometrical conditions or restricted access, MT cannot be performed. PT is an allowable option keeping in mind that additional surface preparation may be necessary.

11.2.4 Radiographic Testing (RT)

RT may be specified for internal flaw detection.

Commentary: The RT procedure consists of using an X-ray or gamma ray source to expose a film similar to that used in medical applications. The most common shop and field technique uses an iridium 192 source of gamma rays on one side of the member being inspected and a film cassette on the opposite side. An exposure is made and the film developed much the way photographic negatives are produced. Areas of different film density relate to flaws in the weldment.

RT is sensitive to cracks, lack of fusion, lack of penetration, slag inclusions and porosity defects. RT is rather insensitive to lamellar type defects perpendicular to the path of radiation. It does produce a permanent film record. Due to its two dimensional capability, it gives limited information about the depth of the defect or the angular orientation of a crack. RT has limited application in WSMFs because groove welds in T-joints and the associated geometry of beam-column connections make it impractical. Additionally, the surrounding area must be cleared of personnel for radiation safety requirements. RT is a very useful tool for inspection of groove welds in butt splices in plate applications.

11.2.5 Ultrasonic Testing (UT)

UT should be specified as the main form of NDT used in support of VI for the testing of WSMFs. The bottom beam flange to column flange weld should be inspected in accordance with the requirements of AWS D1.1. The proper scanning techniques beam angle(s) and transducer should be used as specified in a written ultrasonic test procedure. The acceptance standard should be that specified in the original contract documents. If these documents are unavailable the acceptance criteria of D1.1 Chapter 8 Statically Loaded Structures should be used. The shear wave scan should be preceded by a scan for laminations in the base metal as specified in D1.1. Rejectable discontinuities should be reported on a standard format as recommended by D1.1, i.e.; length, amplitude and classification. Reflections generated from the root and backing bar area of the weld may be cause for further exploration when:

1. the operator is unable to determine if the signal is from a crack or the weld backing.

2. a reflection can be detected in the web zone but the received signal is not great enough to cause rejection.

Although different angles, transducer sizes and scanning methods may be used to further evaluate the root area, the removal of the backing bar may be just as cost effective and will always yield more positive results. After the backing has been thoroughly removed, the root should be tested with MT to detect any linear indication.

Typically, on existing buildings being inspected for damage, only the inside face of the top flange of the beam to column weld is accessible. This will require the lower portion including the root to be tested in the second leg of the ultrasonic sound path. This increases the difficulty of evaluating the root and weld backing which is difficult enough to evaluate in the first leg of sound travel. As in the bottom flange, all rejectable discontinuities should be recorded. If root defects are found or discontinuities which are difficult to interpret, it should be the engineers decision whether or not to do further exploration by UT and/or remove the steel backing. Access may become a problem at perimeter columns where one half of the top beam flange is inaccessible.

Commentary: The UT test involves sending ultrasonic frequency sound waves into a weldment. Any reflector within the weld or parent metal sends back a reflected signal to the instrument. The sent and received signals are presented on an oscilloscope for interpretation. Unlike RT, MT and PT, the interpretation of the received signal is highly dependent on the skill and training of the technician. The location and depth of the flaw can be accurately determined. The shape and type can also be interpreted to some degree by competent operators. The scanning surfaces must be clean and free from fireproofing, upset metal and weld spatter for proper transducer contact.

AWS D1.1, Section 6.19, requires that the entire area to be scanned by shear wave for weld flaw detection be first scanned by longitudinal wave to detect any lamellar defects. These defects can mask indications from the weld areas, if present, and are not favorably oriented for shear wave testing.

UT is highly sensitive to planar defects if they are favorably oriented to the sound beam. The primary testing is done by utilizing a shear wave transducer from the flange faces of the beams. The key to detection is to select the proper testing angle which will intercept the flaw perpendicular to its orientation. The amplitude of the received signal is directly related to the flaw orientation and, *hence, the rejection criteria. In the typical T-joint configuration of WSMF connections, defects in the HAZ of the prepared bevel and root area are favorably oriented to the sound path. This is not the case for the column face HAZ which is not optimally oriented. Sometimes this area can be inspected by using a longitudinal wave transducer from the back side of the column face if no continuity plates are present; however, AWS has no rejection criteria for this method.*

UT technicians are prone to skipping the lamination check when pressed for production. Recalibration of the instrument is required each time the transducer is changed.

The intent of D1.1, 6.19.6.2 is to achieve shear wave testing from both the top of the beam flange (A surface) and from the bottom of the beam flange (B surface). High production pressures sometimes force premature movement of scaffolding, allowing the UT technician access to only the top of the bottom flange (A surface). This precludes proper testing of the weld area below the beam web.

Another area of concern is back-up bar removal. Removal of backing is left as an option in D1.1 which defers to the Contract Documents. It is strongly recommended that back-up bar removal be required in the Contract Documents to enhance visual and UT inspection.

A common problem with rejects identified by UT technicians occurs during the air-arc gouging of the defect area. If too large of a carbon arc electrode is used or if too large a pass is taken, the defect can easily be gouged out without ever being observed by the welder or the UT inspector. For typical WSMF welds, a 1/4 or 3/16 inch maximum size electrode should be used and light skim passes taken. The UT technician should observe the process through a welding shield. A technician can be falsely lured into reducing his/her rejection criteria if no defect is found during gouging.