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REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

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NONDESTRUCTIVE EXAMINATION OF TUBULAR PRODUCTS

A. INTRODUCTION

General Design Criterion 1, "Quality Standards and Records," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, requires that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50, requires that measures be established to assure materials control and control of special process, and that proper testing be performed. This guide describes a method of implementing these requirements acceptable to the AEC Regulatory staff with regard to the nondestructive examination requirements for tubular products used for components of the reactor coolant pressure boundary and other safety-related systems. This guide applies to light-water-cooled reactors. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory postion.

B. DISCUSSION

The requirements for nondestructive examination of wrought seamless tubular products used for components of nuclear power plants are specified in paragraph NB-2550 of Section III, "Nuclear Power Plant Components," American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code.[1]

These code requirements cover the examination of several product forms (pipe, tubing, flanges, fittings) under a single category, "Seamless and Welded (Without Filler Metal) Tubular Products and Fittings," without specifying the examination method to be used for each product form. Instead, the code simply states that the products shall be examined by one of several methods listed.

The requirements for the specific examination methods mentioned in NB-2550 lack detail and need supplementing. In practice, examination procedures which conform to these requirements have permitted defects of unacceptable size in tubular products to go undetected because the defects were unfavorably oriented for the examination procedure applied.

To assure adequate control of quality for the products listed above, supplementary requirements have been incorporated in this guide which include the identification of specific examination methods to be used for each product form and additional requirements for specific examination methods when appropriate.

Ultrasonic Examination of Pipe and Tubing. Pipe and tubing should be examined by the ultrasonic method using the angle beam technique in both the axial and circumferential directions. The ASME Code requirements in NB-2550 supplemented by ASTM E-213, "Standard Method for Ultrasonic Inspection of Metal Pipe and Tubing for Longitudinal Discontinuities,"[2] provide a suitable basis for detecting axial defects. However, no consensus standard exists for the detection of circumferential defects (found in pipe manufactured by processes such as extrusion, swaging, and tube reducing). Therefore, supplementary requirements for this purpose are included in this guide.

The acceptance criteria for ultrasonic examination are based on a comparison of ultrasonic indications reflected from discontinuities in the product with indications from standard defects in a reference

[1] Copies may be obtained from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, New York 10017.

[2] Copies may be obtained from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

specimen. The ASME Code requires that standard defects be axial notches on the inside and outside of the reference specimen, for which optimum resolution is developed by scanning in the transverse (circumferential) direction. However, transverse scanning is not ideal for resolving defects oriented in other directions. As a consequence, when pipe or tubing is examined using transverse scanning and axial standard defects, defects of unacceptable size with unfavorable orientation may appear to be smaller than the reference standard and thus escape detection. To adequately detect circumferential defects, it is necessary to scan in the axial direction with equipment calibrated using circumferential notches.

Further, scanning should be performed in *both* axial and *both* circumferential directions for optimum detection of defects oriented in directions not normal to the surface. This four-way scanning may be accomplished by separate passes of the pipe through the examination equipment in each direction (back and forth) or by a single pass through equipment containing four complete and independent channels of instrumentation.

Eddy-Current Examination. Eddy-current examination may be used as an alternative to ultrasonic examination for thin-walled pipe and tubing. However, this method should be limited to materials with uniform magnetic properties (variability in magnetic properties may result from a variation in the degree of cold work in the material due to fabrication) and to pipe and tubing of appropriate sizes and thicknesses. Since the limiting size and thickness may be affected by such variables as coil design, frequency, material properties, and instrumentation, these limitations should be established by the ability to resolve standard notches on both outside and inside surface of the reference specimen.

Examination of Fittings. To the degree feasible, fittings should be examined using a volumetric examination method. Ultrasonic examination is preferred when applicable, but radiographic examination using appropriate techniques will also detect unacceptable defects. The use of these techniques may be limited by size, product configuration, or material condition (coarse-grained stainless steel) in which case a surface examination method (magnetic particle or liquid penetrant) should be applied.

C. REGULATORY POSITION

Nondestructive examination applied to tubular products used for components of the reactor coolant pressure boundary and other safety-related systems which are designed for pressures in excess of 275 psig or temperatures in excess of 200°F should be capable of detecting unacceptable defects regardless of defect shape, orientation, or location in the product. Accordingly, to the degree practical, the examinations should include methods that apply to the entire volume of the product and should include techniques designed to locate all types of defects. In particular, procedures for ultrasonic examination of pipe and tubing should provide a sensitivity that will detect randomly oriented defects that occasionally develop in pipe and tubing manufactured by extrusion, swaging, or tube-reducing processes. To increase the probability of detecting such defects, the examination requirements for tubular products[3] specified in the ASME Boiler and Pressure Code, Section III, "Nuclear Power Plant Components,"[1] should be supplemented as follows:

1. Required Examinations

a. Wrought seamless and welded (without filler metal) pipe and tubing should be examined over the entire volume of the material by the ultrasonic method in accordance with ASTM E-213, "Standard Method for Ultrasonic Examination of Pipe and Tubing for Longitudinal Discontinuities,"[2] and paragraphs C.2. and C.3. below. Alternatively, eddy-current methods in accordance with NB-2554, Section III, ASME Code, may be used provided the material has uniform magnetic properties and the product is limited to sizes and thicknesses for which meaningful examination results can be obtained by eddy-current methods.

b. Tubular products used for Class 1 vessel nozzles should be examined by the ultrasonic method in accordance with NB-2552 or the radiographic method in accordance with NB-2553 over the entire volume of material and by the magnetic particle method in accordance with NB-2555 or the liquid penetrant method in accordance with NB-2556 on all external surfaces and all accessible internal surfaces.

c. Wrought seamless fittings (including flanges and fittings machined from forgings and bars) should be examined by the ultrasonic method in accordance with NB-2552 or the radiographic method in accordance with NB-2553 over the entire volume of the material for which meaningful examination results can be obtained. Fittings or sections of fittings for which meaningful results cannot be obtained by these methods because of irregular geometry or size should be examined by the magnetic particle method in accordance with NB-2555 or the liquid penetrant method in accordance with NB-2556 on all external surfaces and all accessible internal surfaces.

d. Welded tubular products (with filler metal added) should be examined in accordance with NB-2560, Section III of the ASME Code. When the option for ultrasonic examination of finished welded pipe is invoked as permitted by NB-2560, the examination should also meet the requirements of ASTM E-213, "Standard Method for Ultrasonic Examination of Metal Pipe and Tubing," and paragraphs C.2. and C.3. below.

[3] Piping of 2 inch nominal pipe size or less which meet design requirements of NB-3673, Section III, ASME code exempted from the examination requirements.

2. **Ultrasonic Examination**

a. The procedure for ultrasonic examination should provide a sensitivity which will consistently detect defects that produce indications equal to or greater than the indications produced by standard defects in the reference specimen described in paragraph C.3. below and, insofar as practical, should be capable of detecting such defects regardless of orientation. Products with defects that produce indications in excess of the reference standards are unacceptable unless the defects are eliminated or repaired.

b. The techniques employed in ultrasonic examination of pipe should include angle beam scanning in *both* transverse and *both* longitudinal directions.

c. The rotation of the pipe and translation (feed helix) of the search unit assembly should be maintained constant and should be such that 100% volumetric coverage is assured in the longitudinal and transverse directions.

d. The calibration procedure for ultrasonic examinations should be conducted in both transverse and both longitudinal directions and at the speed that will be used for acceptance examination of the piping.

3. **Reference Specimen**

In addition to the axial notches or grooves required by NB-2552, Section III of the ASME Code, the reference specimen used for ultrasonic examination of piping should also contain transverse notches extending circumferentially on the inner and outer surfaces. The transverse notches should have the same dimensional requirements as the axial notches (e.g., length of approximately 1 inch or less depending on the diameter, a width not to exceed 1/16 inch, and a depth not greater than the larger of 0.004 inch or 5 percent of the nominal wall thickness). All standard notches should be separated sufficiently to preclude any interference or amplification of their respective indications.