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U.S. ATOMIC ENERGY COMMISSION

REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

REGULATORY GUIDE 1.36

NONMETALLIC THERMAL INSULATION FOR AUSTENITIC STAINLESS STEEL

A. INTRODUCTION

General Design Criterion 1, "Quality Standards and Records," of Appendix A to 10 CFR Part 50, "General Design Criteria for Nuclear Power Plants," 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 function to be performed. In addition, General Design Criteria 14 and 31 require assurance that the reactor coolant pressure boundary will have an extremely low probability of gross rupture or rapidly propagating fracture. Stress-corrosion cracking, which is promoted by certain contaminants, is one mechanism whereby such failures may be postulated. This guide describes an acceptable method for implementing these criteria with regard to the selection and use of nonmetallic thermal insulation to minimize any contamination that could promote stress-corrosion cracking in the stainless steel portions of the reactor coolant pressure boundary and other systems important to safety. 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 position.

B. DISCUSSION

Whether sensitized or not, austenitic stainless steel is subject to stress corrosion and should be protected from certain contaminants that can promote cracking. Chloride and fluoride ions are the most serious contaminants, so it is necessary to minimize the levels of these ions (and others that have the potential to cause stress-corrosion cracking) in all material that may come in contact with austenitic stainless steel.

Thermal insulation is often employed adjacent to, or in direct contact with, stainless steel piping and components. Accidental spillages and leakages of fluids through pipe fittings, valves, and equipment cannot be entirely prevented, and contaminants present in the thermal insulation may be leached by these liquids and deposited on the stainless steel surfaces. Extensive test programs by Dana[1] and Karnes[2] have demonstrated that stress-corrosion cracking of both unsensitized and sensitized austenitic stainless steel can be induced by chloride or fluoride ions leached from many representative thermal insulation materials. Karnes has further shown that leachable sodium and silicate ions at least partially inhibit the adverse effects of the chloride and fluoride ions.

Controls should be exercised to assure that nonmetallic thermal insulations employed in nuclear power plants do not contribute significantly to stress corrosion of stainless steel. A quality assurance program should be implemented at all steps from manufacturing through installation to minimize pickup of contaminants from external sources.

Each type[3] of insulation should pass an appropriate qualification test (such as those identified in C.2.a. below) to demonstrate that under conditions conservatively representing those encountered in reactor operation, the insulation does not induce excessive cracking in stressed stainless steel specimens. A further qualification test should consist of a chemical analysis to demonstrate that the leachable chloride and fluoride ion

[1] A. W. Dana, Jr., "Stress Corrosion Cracking of Insulated Austenitic Stainless Steel," ASTM Bulletin, October 1957.

[2] H. F. Karnes, "The Corrosion Potential of Wetted Thermal Insulation," presented at American Institute of Chemical Engineers 57th National Meeting, September 1965 (Conf – 650905-2).

[3] Type means material of similar composition, form, and class and of consistent quality, formulation, and manufacturing process.

concentrations are within acceptable levels and that sufficient quantities of the corrosion inhibiting ions (sodium and silicate) are present in the insulation.

The following procedures may be used in the chemical analyses[4] for chlorides and fluorides:

1. American Society for Testing and Materials (ASTM) D512 – "Tests for Chloride Ion in Industrial Water and Industrial Waste Water;" and
2. ASTM D1179 "Tests for Fluoride Ion in Industrial Water and Industrial Waste Water."

Silicates may be analyzed using ASTM E60, "Photometric Methods for Chemical Analysis of Metals," by either of the following methods:

1. ASTM E62 Molybdisilicic acid method; or
2. ASTM E120 or E146 – Molybdenum blue method.

Sodium ion concentrations may be obtained by either spectrographic or flame photometric methods.

Further, each lot[5] of insulation should be analyzed to demonstrate that chlorides and fluorides are being maintained at acceptable levels and that the composition is representative of the material employed in the qualification test. The production lot is considered representative if the levels of the principal leachable promotors (chloride and fluoride ions) and inhibitors (sodium and silicate ions) of stress-corrosion cracking are within fifty percent of the corresponding values determined for the qualification sample.

C. REGULATORY POSITION

The levels of leachable contaminants in nonmetallic insulation materials[6] that come in contact with austenitic stainless steels of the American Iron & Steel Institute (AISI) Type 3XX series used in fluid systems important to safety should be carefully controlled so that stress-corrosion cracking is not promoted. In particular, the leachable chlorides and fluorides should be held to the lowest practicable levels. Insulation for the above application should meet the following conditions:

1. All insulating materials should be manufactured, processed, packaged, shipped, stored, and installed in a manner that will limit, to the maximum extent practical, chloride and fluoride contamination from external sources.

2. Qualification Test: Each type[3] of insulating material should be qualified by the manufacturer or supplier for use by:

   a. An appropriate test to reasonably assure that the insulation formulation does not induce stress corrosion. Two acceptable tests are:

      (1) ASTM C692-71, "Standard Method for Evaluating Stress Corrosion Effect of Wicking-Type Thermal Insulations on Stainless Steel" (Dana Test). The material should be rejected if more than one of five specimens crack; and

      (2) RDT M12-1T,[7] "Test Requirements for Thermal Insulating Materials for Use on Austenitic Stainless Steel," Section 5, (Knolls Atomic Power Laboratory (KAPL) Test). The material should be rejected if more than one of four specimens crack.

   b. Chemical analysis to determine the ion concentrations of leachable chloride, fluoride, sodium, and silicate. Insulating material that is not demonstrated by the analysis to be within the acceptable region of Figure 1 of this guide should be rejected. This analysis should also be used as a comparison basis for the production test specified in C.3. below.

3. Production Test: A representative sample[8] from each production lot[5] of insulation material to be used adjacent to, or in contact with, austenitic stainless steels used in fluid systems important to safety should be chemically analyzed to determine leachable chloride, fluoride, sodium, and silicate ion concentrations as in C.2.a. above. The lot should be accepted only if:

   a. The analysis shows the material to be within the acceptable region of Figure 1; and

   b. Neither the sum of chloride plus fluoride ion concentrations nor the sum of sodium plus silicate ion concentrations determined by this analysis deviates by more than 50 percent from the values determined on the sample used to qualify the insulation in C.2. above.

4. Requalification: When a change is made in the type, nature, or quality of the ingredients, the formulation, or the manufacturing process, the insulation material should be requalified by repeating the tests described in C.2. above.

[4] Samples for chemical analysis may be prepared by the procedure described in Reactor Development & Technology (RDT) M12-1T, Para. 6.1-6.3. Copies may be obtained from RDT Standards Office, Oak Ridge National Laboratory, Building 1000, P.O. Box X, Oak Ridge, Tennessee 37830.

[5] A lot is defined as the thermal insulation material of the same composition, form, type, grade, and class produced at one plant under the same conditions over a limited time span and designated by the producer as a production lot.

[6] Thermal insulating materials include block insulation, pipe insulation, board and blanket and the cements and adhesives employed in their application.

[7] Copies may be obtained from RDT Standards Office, Oak Ridge National Laboratory, Building 1000, P.O. Box X, Oak Ridge, Tennessee 37830.

[8] A representative sample should be fully representative of the cross section of the material; that is, it should include proportionate amounts of all components including facing fabrics and finishing layers.

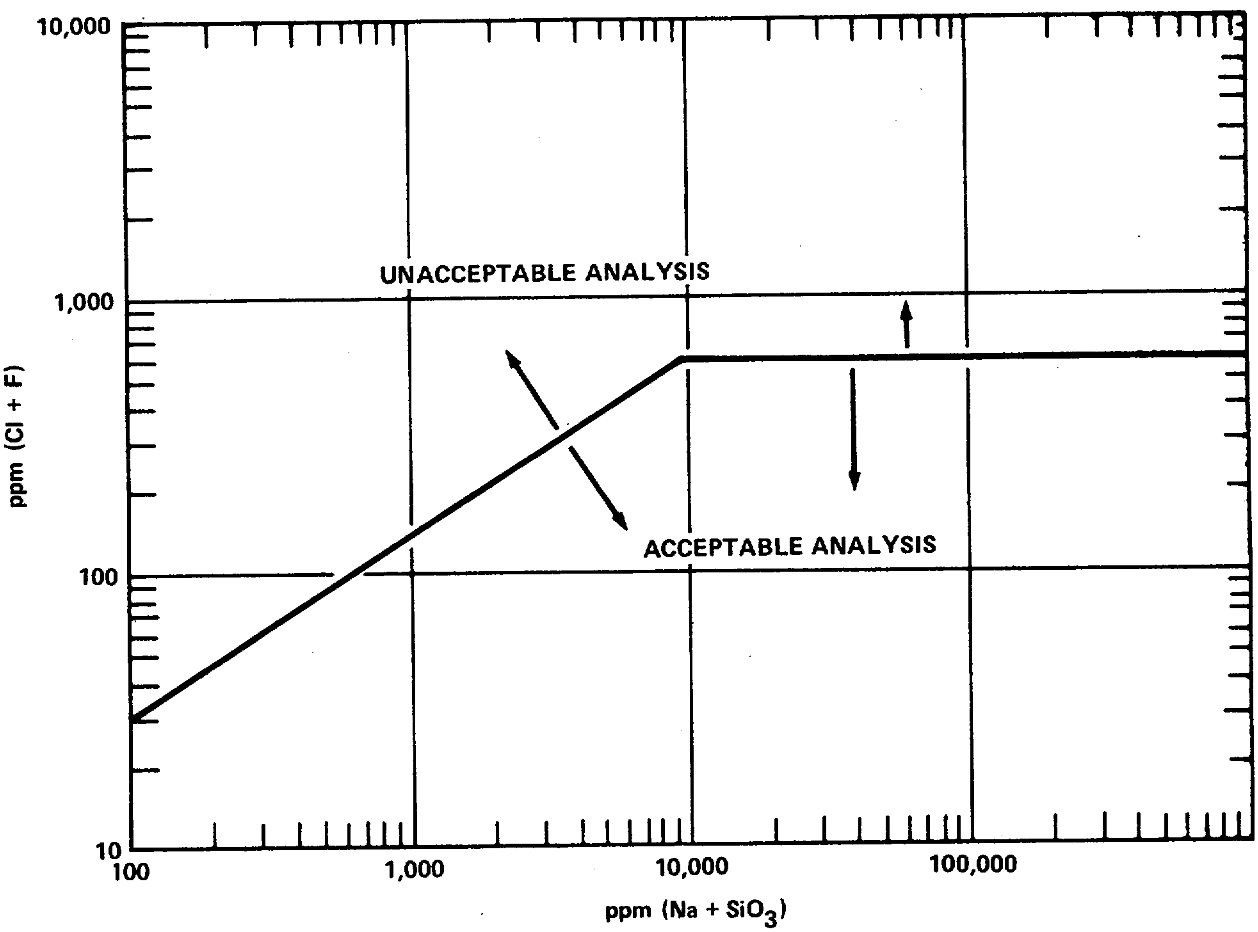

FIGURE 1

ACCEPTABILITY OF INSULATION MATERIAL BASED ON THE LEACHABLE (Cl + F) AND THE LEACHABLE ($Na + SiO_3$) ANALYSES