Topical Report Evaluation

Report Number and Title: OCF-1; Nuclear Containment Insulation System
Originating Organization: Owens-Corning Fiberglas Corporation

Summary of Topical Report

The topical report describes the design and testing of the Owens-Corning Fiberglas (OCF) Corporation's thermal insulation system (Nu'K'on) for use in the containment areas of light water nuclear power plants. Nu'K'on is a blanket insulation consisting of Fiberglas insulating wool encapsulated in Fiberglas cloth. It is reinforced with a Fiberglas scrim and sewn with Fiberglas thread. The insulation blanket will be held in place by the Velcro hook/loop fastening system. An optional stainless steel jacket that acts as a protective cover over the blankets to prevent damage from abuse during installation and regular plant maintenance, provides a means for holding the blanket in place during various postulated accidents. Non-jacketed blankets are designed with secondary holding straps attached to the blanket and wrapped completely around it.

Nu'K'on is designed to withstand the containment area environment expected during normal operations over the design life of the plant, and the predicted environment during the postulated loss of coolant accident or a main steam line break accident.

Nu'K'on is designed to insulate systems that have surface temperatures up to 675°F in an environment of 100% relative humidity, an integrated neutron flux of 10^{15} nvt and continual background level of alpha, beta, and gamma radiation on the order of 10^6 Rad for a forty (40) year design life.

The predicted environmental conditions during and following the postulated accidents are quite different from those specified above for normal operations. The expected containment pressure, temperature, spray water chemistry and gamma radiation during a postulated loss of coolant accident are 40 psig, 400°F, pH of from 4 to 11 and 10^8 Rads, respectively. As with lifetime conditions, Nu'K'on is designed to withstand the containment area environment during accident conditions. In addition, Owens-Corning Fiberglas Corporation has indicated that the insulation system would meet all applicable NRC regulations, standard review plans, and branch technical positions.

Staff Evaluation

Owens-Corning Fiberglas Corporation has conducted tests and evaluation programs for its nuclear containment insulation system (Nu'K'on) that address six potential concerns. These concerns are:

1. Release of airborne particles leading to a radiation health hazard in service;

2. Stress corrosion cracking of the austenitic stainless steel surfaces that comes in contact with the insulation;

3. Deterioration of the thermal properties during normal operation, complicating operation and control of the plant;

4. Presenting a fire hazard in the containment area that could interfere with safe operation of the plant;

5. Interference with the emergency spray system in the event of a Loss-of-Coolant Accident; and

6. Blocking of pressure relief ports in the event of an accident.

Each part of Owens-Corning Fiberglas' considerations is evaluated separately below.

1. Airborne Contaminants

A neutron activation test was performed by the Battelle Columbus Laboratories for Owens-Corning Fiberglas on Nu'K'on insulation to determine if airborne particles released from the insulation system leads to a radiation health hazard in service. This activation test lasted for 6.5 minutes in a fast neutron flux of 2.6×10^{12} n/cm^2-sec. and thermal flux of 3.2×10^{12} n/cm^2-sec. This test served to indicate that, at the dose rates expected in the nuclear plant, the neutron activation products will decay at a sufficient rate so that health hazards will not exist with any of the insulation's materials.

2. Stress Corrosion Cracking of the Austenitic Stainless Steel

With respect to the acceptability for use in light water cooled nuclear plants, the only criteria that the Nuclear Regulatory Commission has for evaluation of thermal insulation are found in Regulatory Guide 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steel," issued February 23, 1973. This guide deals solely with the potential problem of stress corrosion cracking of austenitic stainless steel. The test data and information in the topical report indicate that a representative insulation system sample was tested and did comply with the basic requirements of Regulatory Guide 1.36, namely, the Qualification Test of Position C.2. On this basis, we consider the Nu'k'on system qualified for use in light water cooled nuclear power plants.

To meet the Qualification Test requirements of Regulatory Guide 1.36, it was sufficient that a representative blanket of the final Nu'k'on total system pass an appropriate stress corrosion cracking test and comply with the Regulatory Guide Figure 1 chemical analysis limitations regarding leachable chloride, fluoride, sodium, and silicate. Two acceptable stress corrosion tests are given in Regulatory Guide 1.36, namely ASTM C692-71 and RDT M12-1T. The Owens-Corning Fiberglas Technical Center report, dated March 21, 1978, appended to Topical Report OCF-1, shows that the representative Nu'k'on blanket passed both of the two acceptable stress corrosion tests in addition to meeting the chemical analysis requirements.

The topical report includes test data and information in excess of the qualification requirements of Regulatory Guide 1.36. Appended to Topical Report OCF-1 are two Owens-Corning Fiberglas Technical Center reports dated August 13, 1974, and February 18, 1976, detailing that another Nu'k'on blanket had passed the ASTM C692-71 stress corrosion test and that insulating Fiberglas wool, individually, had passed the chemical analysis test. In addition, Topical Report OCF-1 states that the exterior Fiberglas cloth of the Nu'k'on system has been tested independently by the manufacturers and certified in compliance with Mil-I-24244. This certification passed a stress corrosion test essentially the same as RDT M12-1T and meets the Regulatory Guide Figure 1 limitations on leachable chloride, sodium and silicate.

3. Deterioration of the Thermal Properties During Normal Operation

Tests were performed by Owens-Corning Fiberglas on the insulation blanket's thermal properties by monitoring the energy input to heating elements within a test pipe. The insulation blanket was then examined visually and compressive strength tests were conducted to determine if there had been any unusual change in the physical arrangement of the fibers or any physical degradation. The results of these tests indicated that blanket integrity is not adversely affected and will not deteriorate by conditions found during lifetime operations at the plant.

4. Fire Hazards

Owens-Corning Fiberglas performed a fire test according to ASTM E-84 to measure flame spread, smoke developed, and fuel contributed. Additional tests to measure the combustibility of the major insulation component were performed in accordance with the U. S. Coast Guard specification USCG 164.009.

The results of these tests indicated that Nu'K'on system will not present an additional fire hazard when used in the containment areas of light water power reactors.

5. Interference With Emergency Spray Systems

The tests performed by Owens-Corning Fiberglas at its Product Testing Laboratory to assess the Nu'K'on insulation system's potential for interference with containment spray systems in a LOCA were divided into three progressive stages of severity. The first test considered the potential for interference of intact blankets with containment sump water flow to the spray system. The second test considered the effects of torn blankets on this flow, and the last test considered severe damage to the blankets where blanket wool, scrim, and cloth were ingested into the spray system. In all three

cases, no loss of water flow rate or spray nozzle pressure was noted in the test apparatus designed to simulate the containment spray system's operating conditions. In the final test stage, ingestion of the blanket material results in a complete separation of blanket fibers forming a slurry containing about 0.4 pounds of glass fiber per gallon. Owens-Corning Fiberglas has indicated that this is a conservative concentration of fibers in the spray coolant relative to the insulation materials and spray water present in a containment structure. A continuous six-hour recirculation test of this mixture demonstrated no loss of spray flow rate or recirculating pump head. The apparatus used in these tests consisted of an open top tank draining to the suction of a recirculation pump which fed two nuclear containment spray nozzles located about 12 inches apart and 18 inches over the open tank. A wire rack was used to support the intact and torn blankets to simulate containment sump strainers in the first two tests, and manual feed to the tank sump of torn blanket material was used in the third test.

Owens-Corning Fiberglas has conducted additional tests to answer the staff's concerns regarding the possible adherence to high temperature surfaces of fibers contained in a coolant stream. Such a condition may exist in the core in the later stages of a LOCA when core cooling water make-up may be drawn from the containment sump. Core cladding temperatures will be at or near saturation temperatures consistent with containment pressure in the post-LOCA long-term

cooling phase; however, high cladding temperatures well above coolant temperatures at full power operation are characteristically encountered before that stage, and the time at which core cooling water sources are taken from the containment sump would be a decisive consideration if a sensitivity for adherence to hot surfaces exists for the blanket fiber material.

In this regard three tests were performed using a slurry of chopped Nu'K'on blanket fibers in distilled water. In the first test a rod heated to 2200°F was quickly quenched in the Nu'K'on slurry. In the second test, stainless steel strips were put into a suspended slurry, the strip temperature was increased to yield nucleate boiling conditions and continued for three hours. Test Number 3 was the same as in Test Number 2 except that the temperature was raised to yield film boiling conditions. These tests provide qualitative indications that Nu'K'on blanket fibers suspended in a slurry will not adhere to a stainless steel rod which is heated to 2200°F and that slight fiber adherence will occur when rods are submerged into a slurry of Nu'K'on fibers and raised to either film boiling or nucleate boiling temperatures.

However, the fiber deposits which occur on rods heated to film or nucleate boiling temperatures will not accumulate in sufficient thickness or quantity to measurably change either the flow of coolant or the heat transfer characteristics of the rods.

Another staff concern regarding LOCA safety analyses would be the intact blanket sink rate characteristics in low velocity streams as functions of blanket and water temperatures for determination of the probability of blanket entrainment with the water flow toward the containment sump strainers.

Owens-Corning Fiberglas has conducted a blanket float characteristics test in an open-top steel drum at two different temperatures of still water (75°F and 120°F). The outcome of the tests indicated that Nu'K'on blanket will not readily sink and will float on the water. However, if the blanket is forced by wringing action to absorb water, or is exposed to a hot surface (700°F) and immersed while hot, the blankets will sink readily at a rate of 2-1/2 inches per second if the blanket were lying horizontally and at a rate of 4 inches per second if it were lying vertically. The test results also show that the blanket behavior is similar for immersion in both 75°F and 120°F water.

These tests provide an adequate qualitative indication of the negligible degree of interference with containment spray systems to be anticipated from detached intact or damaged blankets deposited in the containment sumps following pipe ruptures. As relatively few blankets out of the total containment inventory would be available for such interaction, the interference tests performed by Owens-Corning Fiberglas conservatively bound the probable containment sump blockage and sump ingestion of blanket material that might occur.

6. Interference With Containment Relief Ports

The potential for interference with air and steam flow between containment structure compartments in a LOCA was considered subjectively by Owens-Corning Fiberglas. Because the blanket construction materials are porous and have been used as air filters, air or steam flow through detached blankets lodged in relief ports would not be expected to be retarded sufficiently to develop excessive pressure differentials between compartments. Lifetime exposure of the blankets to fast neutron flux has shown no loss in flexibility or porosity for the blankets, so that air or steam flow characteristics would not be plant life dependent. As relief port designs and dimensions are plant dependent, Owens-Corning Fiberglas did not consider a generalized analysis of relief port interference in a LOCA, but did conclude from its qualitative consideration that the Nu'K'on insulation blankets would not restrict the safe flow of air in the pressure relief ports.

In addition, Owens-Corning Fiberglas Corporation has conducted specific pressure drop analysis for Nu'K'on blanket that correlate friction factors versus Reynold Numbers that could be used in the design and evaluation of pressure relief vent openings on a plant-by-plant basis.

Finally, because of the various sizes and configurations for the jacketing material, and since there is no simple analysis to determine the forces required to push it through various sizes of vent openings, Owens-Corning Fiberglas Corporation recommended that the jacketing design not include jacketing in or near the vicinity of any vent openings. If a utility wishes to use metallic jacketing, an analysis should be performed to assure that adverse flow restrictions will not occur.

Regulatory Position

Based on the results of the quantitative and qualitative tests performed by or for Owens-Corning Fiberglas, we conclude that the Owens-Corning Fiberglas Corporation's nuclear containment insulation system (Nu'k'on) is capable of retarding heat loss from piping and equipment in containment areas and that the overall integrity of the blanket will not be adversely affected by the conditions found during the lifetime of the plant.

We also conclude that during a loss-of-coolant accident, the Owens-Corning Fiberglas insulation system is not expected to interfere with the operation of the emergency recirculation cooling system. Although the topical report does not explicitly address the Nu'K'on insulation system's potential for interference with the emergency core cooling system (ECCS), we conclude that the Owens-Corning Fiberglas insulation system is not expected to interfere with the operation of the ECCS. This conclusion is based on the factors that the ECCS pumps take suction from the same sump as the containment spray system during the recirculation phase; and that the amount of fibers contained in the recirculation coolant will not significantly adhere to fuel rods and change either the flow of coolant or the heat transfer characteristics of the fuel rod.

The potential for jacketed insulation, in the vicinity of a postulated pipe break, to be stripped from piping and components and the potential for these loose insulation pieces to partially or completely clog pressure relief ports in concrete shield walls are beyond the scope of this topical report. This issue should be reviewed on a plant-by-plant basis. However, Owens-Corning Fiberglas has provided correlation for friction factors versus Reynolds Numbers that will facilitate the analysis of pressure relief vent openings on a plant-by-plant basis.

Finally, should Regulatory criteria or rules change, such that our conclusions concerning this topical report are invalidated, you will be notified and given the opportunity to revise and resubmit the report for reevaluation should you so desire.