

February 24, 2000

MEMORANDUM TO: Samuel J. Collins, Director
Office of Nuclear Reactor Regulation

FROM: Ashok C. Thadani, Director /RA/
Office of Nuclear Regulatory Research

SUBJECT: USER NEED REQUEST ON THE ACCEPTABILITY OF THE
ARRHENIUS METHODOLOGY FOR ENVIRONMENTAL
QUALIFICATION (EQ) FOR LOCA AND POST-LOCA ENVIRONMENTS

In a memorandum dated November 25, 1997, NRR requested RES to perform appropriate research and provide independent confirmation of the applicability of Arrhenius methodology to meet the environmental qualification (EQ) requirements for LOCA and post-LOCA environments. RES was requested to support the NRR reviews of licensees' requests for (1) power uprate amendments, (2) reevaluation of qualified life of electric equipment due to plant modifications and changes, and (3) license renewal technical reports on EQ.

My response memorandum to you, dated July 13, 1998, noted that RES would initiate a two-phase research approach to address the subject issue. Our response also stated that based upon the results of the Phase 1 research program, a determination would be made if a Phase 2 study is warranted.

As part of Phase 1, RES convened an expert panel to independently assess the use of Arrhenius methodology and the need for additional research. The panel members were Dr. Kenneth Gillen of Sandia National Laboratories, Dr. Salvatore Carfagno, a consultant (formerly with Franklin Research Institute), and Dr. Montgomery Shaw of the University of Connecticut. The panel members provided their independent reports on the use of Arrhenius methodology. We also had an opportunity to review a technical report submitted by the Nuclear Utility Group on Environmental Qualification (NUGEQ) outlining the industry's views on the subject matter. Members of the RES technical staff also reviewed the plant specific calculations (Monticello and Hatch nuclear power plants) provided by the licensees, that justified the use of Arrhenius methodology.

Based on the overall Phase 1 research effort, the following conclusions are drawn:

1. The Arrhenius methodology has been studied extensively over the past few decades and has been shown to be a valid means of modeling temperature effects and for evaluating thermal degradation of polymers, with some limitations. These limitations include: (i) Arrhenius methodology is applicable only if the thermal degradation of the polymer involved is dominated by a single reaction within the temperature range of interest; Arrhenius extrapolation between different transition regions should be avoided;

Contact: S. Aggarwal, MEB/DET/RES, at 415-6005

Samuel J. Collins

(ii) there may be significant uncertainties in the activation energy used (i.e., activation energies measured in air are used to model accident environments, and these may be different from those in steam environment); (iii) oxygen diffusion limitations are not accounted for in the Arrhenius model; and (iv) moisture effects are not accounted for in the Arrhenius model.

2. Arrhenius methodology can be used to evaluate the effects of varying temperature conditions provided that it is based on the principle of cumulative damage to the polymers involved.

3. There is a general agreement that an adequate technical basis exists to justify the application of the Arrhenius methodology for integrated time-temperature equivalent analysis as used in recent licensee submittals. In spite of its limitations, the Arrhenius methodology is applicable for analyzing the effects of small deviations in time-temperature profiles to meet EQ requirements for LOCA and post-LOCA environments.

These conclusions are based on (1) the review of individual panel member reports, (2) the NUGEQ report, (3) the discussions with technical experts (from both NRR and RES), and (4) the discussions at a public meeting held on June 29, 1999, to discuss the Arrhenius methodology. Attached are the following supporting documents:

1. Dr. Gillen's report dated March 1, 1999.
2. Dr. Carfagno's report dated August 6, 1999.
3. Dr. Shaw's report, dated June 15, 1999.
4. NUGEQ report dated January 1999.
5. Dr. Shaw's review comments, dated March 1, 1999, on the NUGEQ report.

The consultants' reports identify a broad range of limitations with the overall EQ process and suggest several topics for future research. These topics include A Study of Risk Significance of LOCA Simulation as a Function of Time After the Start of LOCA, and An Investigation of Moisture Effects on Equipment Operability.

It is beyond the current scope of the user need to implement these types of long-range research programs to alleviate concerns with the overall EQ process. However, in a separate forum, RES staff will discuss these recommendations with cognizant NRR staff and determine whether further research is warranted.

From reviews of the licensees' submittals, we note that deviations in the actual vs. required temperature profiles are relatively minor with respect to the overall conservatism that is inherent in the EQ methodology and in the margins that it provides to account for thermal effects. Typically, EQ test temperatures are much more severe than the plant-specific accident profiles. Also, in their analyses the licensees have avoided time-temperature extrapolation among different transition regions of the material properties and activation energies involved.

Samuel J. Collins

RES in consultation with the NRR staff has concluded that the use of Arrhenius methodology is acceptable for the reviews of licensee requests for (1) power uprate amendments, (2) reevaluation of qualified life of electric equipment due to plant modifications and changes, and (3) license renewal technical reports on EQ. The staff has also concluded that a Phase 2 study, involving tests and evaluation of samples of naturally aged and artificially aged insulating materials and cables under LOCA and post-LOCA conditions, is not warranted because the technical basis is sufficiently complete.

By transmittal of this memorandum and attachments, RES considers that the requested information in the NRR memorandum of November 25, 1997 has been provided and the User Need should be considered as closed.

Attachments: As stated

Samuel J. Collins

DOCUMENT NAME:

B. Sheron J. Strosnider J. Calvo D. Thatcher P. Shemanski F. Miraglia C. Paperiello
S. Aggarwal M. Mayfield, A.Thadani MEB r/f DET r/f

OFFICE	RES/DET/MEB	RES/DET/MEB	RES/DET	D/RES
NAME	S Aggarwal*	E. Hackett*	M. Mayfield*	A C.Thadani
DATE	12 /16 /99	2 /23 /00	02/23/00	2/23/00

OFFICIAL RECORD COPY

RES File Code: RES-1B

Accession number ML003686908