August 5, 2003

MEMORANDUM TO: Kathy Halvey Gibson, Acting Chief
Special Projects and Inspection Branch
Division of Fuel Cycle Safety
and Safeguards
Office of Nuclear Material Safety
and Safeguards

Thru: Brian W. Smith, Acting Chief **/RA/**
Special Projects Section
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FROM: David Brown, Health Physicist **/RA/**
Special Projects Section
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SUBJECT: JULY 22-23, 2003, IN-OFFICE REVIEW SUMMARY: DUKE COGEMA STONE & WEBSTER CONSTRUCTION AUTHORIZATION REQUEST SUPPORTING DOCUMENTS FOR THE HAN EXPLOSION DESIGN BASIS

On July 22-23, 2003, U.S. Nuclear Regulatory Commission (NRC) staff (Brian Smith, David Brown, and Alex Murray) conducted an in-office review at Duke Cogema Stone & Webster (DCS) headquarters in Charlotte, NC. The purpose of the visit was to review calculations that support DCS's proposed design bases for the prevention of hydroxylamine nitrate (HAN) explosions in the aqueous polishing process. By letter dated May 30, 2003, DCS had proposed specific design basis values for solution temperature and concentrations of HAN, nitric acid, ionic strength, hydrazoic acid, and hydrazine that would prevent a HAN explosion.

The principal focus of this in-office review was to: (1) review the supporting documentation for the five non-linear differential equations and associated chemical reaction rate constants that DCS has proposed to describe the HAN-nitric acid system, and from which DCS derived the May 30, 2003, design basis values; and (2) to compare computer models developed by both DCS and NRC to solve the complex system of equations. The NRC developed model was based on the equations presented in the May 30, 2003, letter.

During the meeting, the staff was provided a copy of a draft DCS calculation and supporting references for review. The approximately 100-page calculation that the staff reviewed had not

been design verified, which would normally indicate the completion of the DCS quality assurance review. However, the originator had signed the cover page on the first day of the staff's visit (July 22, 2003), indicating the calculation was nearing completion. Staff also learned that, after submitting the May 30, 2003, letter, DCS had revised the mathematical model describing the plutonium-HAN-nitric acid system. DCS staff explained that changes to the proposed May 30, 2003, design basis values would be submitted to NRC, once the model was finalized. Staff also reviewed technical literature referenced by DCS in the draft calculation. The staff did not have findings associated with the paper review of the calculation. However, staff will continue to review the literature to evaluate the system of equations and constants assembled by DCS.

To compare computer models, NRC staff first adjusted the NRC model to account for the changes in the draft DCS calculation. Then, both DCS and NRC staff ran identical input cases and compared results. The results obtained for each data input set included whether initial chemical concentrations and temperatures represented either stable or unstable conditions, and, for unstable systems, the elapsed time until the excursion occurred. Good agreement was observed across a representative range of input values.

One finding relative to the draft calculation and the associated new computer model is that it no longer predicts a stable system for the experiment cited in the May 30, 2003, letter. In that experiment, a mixture of 10 M nitric acid and 0.0167 M HAN at a temperature of 70 C was stabilized by 0.0005 M hydrazine. Using the May 30, 2003, model, DCS had reported stability at 0.002 M hydrazine. However, NRC had not found stability at these low hydrazine concentrations, using either the May 30 model or the July 22, 2003, model. DCS confirmed that the July 22, 2003, model also predicts instability.

According to DCS staff, the inability of the current mathematical model to accurately predict the experimental results at low HAN concentrations is related to the reaction parameters for dinitrogen tetraoxide production. An assumption in the model relating to the back reaction of dinitrogen tetraoxide production is conservative at low HAN concentrations. DCS explained that the back reaction rate constant will be studied in future experiments in order to refine the model.

Staff developed several questions as a result of the visit, which were communicated to DCS during a telephone call on July 24, 2003.

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cc: P. Hastings, DCS
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