UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ALTERNATIVE TESTING METHOD FOR CABLE VAULT

TOTAL FLOODING CO_2 FIRE SUPPRESSION SYSTEM

VERMONT YANKEE NUCLEAR POWER CORPORATION

VERMONT YANKEE NUCLEAR POWER STATION

DOCKET NO. 50-271

INTRODUCTION

At the time the total flooding carbon dioxide (CO_2) fire suppression system was installed in the Vermont Yankee cable vault, the licensee interpreted NFPA (National Fire Protection Association) 12, "Standard on Carbon Dioxide Extinguishing Systems" as not requiring a full discharge test prior to declaring the system operational and placing it in service. The staff discovered this deficiency during the Region I Inspection No. 50-271/89-04 performed March 20-23, 1989. The Inspection Report is dated May 18, 1989. After several telephone conferences with the staff, the licensee declared the system inoperable and initiated a once-per-hour fire watch for the cable vault.

During a meeting on October 25, 1989, the licensee proposed an alternative testing method based upon a test described in the 1989 edition of NFPA 12A, "Standard on Halon 1301 Fire Extinguishing Systems." The staff agreed that this alternative test method might be acceptable and that we would review any procedures, results and conclusions from such testing that the licensee might wish to submit. By letter dated January 16, 1990, the licensee submitted such a report for our review.

EVALUATION

During the period October 31-November 2, 1989, the licensee conducted the alternate tests, mentioned above, of their cable vault. Prior to conduct of the test, a rigorous engineering evaluation of the as-installed configuration of the CO_2 system was conducted. This evaluation considered:

- Piping size, lay-out, run length, etc., to assure ability to deliver the necessary volume of CO_2 liquid to the enclosure.

- Nozzles installed to assure proper nozzle selection and installation orientation to assure that CO_2 is discharged in the proper pattern to obtain satisfactory concentration and piping.

- Original design calculations used to determine requirements for total CO_2 volume required and discharge times.

- SER for TS Amendment No. 43, which provides the functional requirement that a minimum concentration of 50 percent CO_2 in air must be maintained for a minimum of 10 minutes.

The alternative test conducted is based on the methodology provided by NFPA 12A, "Standard on Halon 1301 Fire Extinguishing Systems," 1989 Edition, Appendix B, "Enclosure Integrity Procedure", and the National Fire Protection Research Foundation (NFPRF) document "Enclosure Integrity Procedure for Halon Total Flooding Fire Suppression Systems," January 10, 1989. NFPA 12A, Appendix B, is derived from this NFPRF document. Some aspects of the test are based on NFPA 12.

The alternative test is further based on the nearly identical densities of a 6 percent Halon 1301/air mixture and a 50 percent CO_2/air mixture. In addition to the above, a standard tracer gas dilution test (ASTM E 741-80) was included to determine the air exchange rate for the cable vault.

The major issues addressed by the alternative test are:

(1) Ability of the enclosure to withstand the pressures generated during a full discharge of CO_2.

(2) Distribution of CO_2 within the enclosure.

(3) Ability of the enclosure to maintain the required concentration of CO_2 over the required time period.

The NFPA 12A, Appendix B, "Enclosure Integrity Procedure" quantifies the leakage area within the enclosure based on the door fan test. NFPA 12 provides the methodology for calculating the maximum pressure during full discharge in consideration of the leakage area within the enclosure. The calculated maximum pressure, based on this methodology, was well within the limit established by NFPA 12 for light building construction.

The "Enclosure Integrity Procedure" includes a model for predicting the height of a descending air-to-CO_2/air mixture interface with respect to time. Movement of the interface is the result of air inflow to the enclosure and CO_2/air outflow due to the greater density of the CO_2/air mixture. This model assumes a reasonably static environment with no mechanical mixing. However, mixing is provided in the cable vault by the RPS MG set rotating assemblies, various leakage paths, and convection due to the temperature differentials between the cold CO_2 and the warm concrete walls of the enclosure. The presence of mixing was supported by pressure measurements within the enclosure, which indicated a variety of differential pressures and, therefore, air flows across the enclosure boundaries. Thus, a standard tracer gas dilution test using SF_6, was conducted to determine the actual air exchange rate for the cable vault under normal conditions. The results of this test verified the assumption that the degree of mixing in the enclosure more closely approximates a well-mixed model than a static model. In consideration of this and NFPA 12, Figure A-2-1(A), which is a graphical means for determining the percentage of CO_2 received within an enclosure, a concentration of 65 percent CO_2 was calculated to occur at the end of the 3-minute discharge period.

The "Enclosure Integrity Procedure" can be further used to model the ability of an enclosure to maintain CO_2 concentrations, assuming a descending interface between the CO_2/air mixture and the air above it. Calculations based on this model predict a 50 percent or more CO_2 concentration at levels up to 7 feet above the floor for a period of 25 minutes. Calculations assuming a well-mixed model and the air exchange rate obtained by the tracer gas dilution test predict an evenly distributed concentration of 50 percent CO_2 or greater will be maintained for a period of approximately 15 minutes. A "worst case" analysis would consider a combination of the above effects, as follows. The NFPRF document cited above refers to the ASHRAE 1981 Fundamentals Handbook, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Chapter 22, "Natural Ventilation and Infiltration," which provides a method for calculating the total leakage flow through enclosures caused by various sources, acting together, when the flow caused by each source, acting alone, is known. This method was used to calculate the total air exchange to the cable spreading room during the time when CO_2 is present. Based on this, the length of time it would take was calculated for the average concentration of CO_2 to drop from the expected initial concentration of 65% to the minimum specified concentration of 50%. The calculated duration of the minimum concentration is between 11 and 12 minutes, which is in excess of the minimum time period of 10 minutes specified as acceptable.

We have reviewed the analytical and testing methodologies used in the licensees alternative test, as described above, and find that they are consistent with the industry standards identified and, therefore, are acceptable.

3.0 CONCLUSION

Based upon the above evaluation and the staff's review of the test report and supporting technical information, we agree with the licensee's conclusions of reasonable assurance that the CO_2 system as installed in the cable vault will function properly and that a minimum concentration of 50% CO_2 will be maintained for at least 10 minutes in accordance with the original design requirements. Therefore, we consider the fan Pressurization Test to be an acceptable alternative to a full discharge test of this system providing no substantive changes are made to the CO_2 system or the enclosure and the periodic maintenance committed to by the licensee continue to provide proper operation of the system.

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