ALTERNATE TESTING FOR CO_2 FULL DISCHARGE TEST BY PRESSURE BUILD AND TRACER GAS DILUTION TESTING

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* Based on the results of this test, the Cable Vault CO_2 system is declared operable. As a compensatory measure, a once-per-every-two hour fire watch will continue until otherwise terminated by the Plant Mgr or Ops Supt.

* On November 15, 1989, Alex Klein reviewed this package and gave his verbal approval. His summary report (and subsequent signature) will follow.

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Summary

ESD completed the prescribed testing and achieved the following results:

1. Per the pressure build section of "Cable Vault Enclosure Integrity Test", the calculated maximum pressure (with the exhaust damper open for 200 seconds) is 3.45 inches of H2O with an equivalent leakage area of 250 sq inches. This compares very favorably with NFPA 12, Table 2-6.2.3 (Ref. 3) for light construction strength of 5 inches H2O.

2. Per the SF6 section of the "Cable Vault Enclosure Integrity Test", ESD found that the air inleakages into the Cable Vault were significant enough such that the descending interface model could not be used.

3. Per the SF6 section of "Cable Vault Enclosure Integrity Test", ESD found the air exchange rate was 640 scfm. This exchange rate, coupled with RPS-MG fans and CO2-wall temperature gradients provided enough mixing to approach a "stirred mixed tank" model as compared to the "descending interface" model. The stirred mixed tank model showed that a total room CO2 concentration of 50% (with no interface) could be maintained for 14 minutes and 50 seconds. Additionally, the descending interface model was calculated for information and comparison purposes. It showed that a CO2 concentration of 50% could be maintained for 25 minutes.

ESD noted that different models required different CO2 distributions. ESD utilized NFPA 12 to provide the CO2 distribution information for the mixed tank model. (Note that this standard is based on NFPA experience).

4. Based on the above and attached information, ESD has evaluated that the Cable Vault CO2 system can perform its intended function and should be declared operable. An attached 50.59 safety evaluation shows that plant configuration is maintained and supported by the alternate test.

Additionally, ESD has collected the required technical and quality documentation to support the above results (See attachments).

Introduction

This report summarizes the pressure build/SF6 testing that VY performed on the Cable Vault Room to determine the pressure buildup and CO2 distribution after a CO2 injection. VY sought this information to help provide additional technical basis for considering the Cable Vault CO2 system operable. VY declared the system inoperable after a June 89 VY/NRC telecon. During the telecon the NRC informed VY that as the "Authority Having Jurisdiction", the NRC considered the 1985 NFPA 12 functional testing mandatory for VY. After subsequent discussions, a NRC to VY letter (Ref 11) informed VY that either a functional test or suitable alternative (as agreed to by the NRC) should be used to address this issue. VY proposed alternate testing to the NRC at an October 25,1989 meeting in lieu of performing a CO2 full discharge test (Note: VY management evaluated the CO2 full discharge test as a small but potential increased risk for a scram). VY wrote, PORC reviewed and Plant Manager approved the alternate test procedure (see enclosure tab).

At the October 25,1989 meeting, VY presented both the test method and the acceptance criteria. The acceptance criteria were:

1. Per NRC-VY discussions, that the peak pressure would be determined and verified acceptable.

2. Per engineering practice, that the alternate test method (" descending interface " model) required verification. Although not specifically mentioned at the meeting, VY-ESD had already specified SF6 leakage testing for this verification per ASTM E741-80.

3. Per SER for Technical Specification Amendment 43, that the testing demonstrate that the Cable Vault CO2 system be able to sustain a 50% CO2 concentration for a hold time of 10 minutes. Additionally VY stated that the 50% CO2 "descending interface" will not descend to less than a critical height of 7 feet after 10 minutes.

Technical Evaluation

I. Standards Used for Developing VY Test Procedure

A) Background

VY's test procedure provided a method to determine that the Cable Vault Total Flooding Carbon Dioxide extinguishing system would function properly. The functional criteria for the system are specified by the Safety Evaluation Report for Technical Specifications, Ammendment No. 43. The functional criteria specified are a CO2 concentration of 50 percent maintained for a period of 10 minutes.

At the time of installation, the system was tested to the criteria of the National Fire Protection Association (NFPA) Standard for CO2 systems (NFPA-12, 1977). The standard of record at that time did not require a full discharge test to demonstrate operability. Recently, the NRC, claiming the powers of the Authority Having Jurisdiction, has interpreted that a full discharge test is required to prove the adequacy of the CO2 system (ref. 9).

In the NRC response to the VY response to the notice of violation, the NRC stated that they would entertain an alternate to the full discharge test if a conclusive test method could be designed (ref. 11).

B) Pressure Build Test - NFPA-12

The 1989 Edition of NFPA 12A, the standard on Halon 1301 Fire Extinguishing Systems includes an Enclosure Integrity Procedure in Appendix B. This test was developed by a research team for the subcommittee of the NFPA 12A committee. The subcommittee was charged with the task of developing an acceptable alternative to full discharge testing of Halon 1301 gaseous fire suppression systems. Appendix B to the Standard is the result of the efforts of the research team and the subcommittee. This alternative test was presented to the NFPA 12A committee and approved. The test was then added to the draft of the new edition of the code. This draft was then reviewed by the membership of the NFPA and approved by them for inclusion in the 1989 edition of the code.

In that the gas densities for Halon 1301 at a 6 percent concentration and CO2 at a 50 percent concentration are nearly identical, the Enclosure Integrity Procedure can be readily applied to CO2 Total Flooding systems. (A 6% Halon concentration has a density of 0.0935 lbs. per cubic foot, while a 50% CO2 concentration has a density of 0.0945 lbs. per cubic foot.) With this in mind a test procedure was developed to utilize Appendix B of NFPA 12A for the determination of operability of the Cable Vault CO2 system.

C) Tracer Gas Dilution Test - ASTM E 741-80

To further ensure that the results of the Enclosure Integrity procedure are valid, a standard ASTM tracer gas dilution test was included. This test provided a standard method for determining the air exchange rate within the Cable Vault. Utilizing the results of this test and a standard calculation for the decay over time, a determination of concentration and hold time was possible.

II. Major Test Parameters

Three major issues were addressed by the procedure with regards to system operability:

A) Ability of the enclosure to withstand the pressures generated during a discharge of CO_2.

NFPA 12, section 2-6.2 addresses the issue of Pressure Relief Venting. In this section guidance is provided with respect to the required free vent area for CO_2 systems. The calculation incorporates CO_2 discharge rates and the allowable strength of the enclosure. The CO_2 discharge rate is specified by the original system design. The values utilized for allowable strength are based on general construction practices. Due to the nature of the doors in the room, the values for light building construction were utilized in determining the minimum acceptable free vent area for this system. The actual calculations for the determination of free vent area are included in the Calculations section of this report. The value determined by this calculation is a free vent area of 130 square inches. This is the minimum amount of leakage area required for this enclosure to guarentee that room integrity is maintained during discharge.

The Enclosure Integrity Procedure quantifies leakage area within the enclosure. The leakage area is identified as an Equivalent Leakage Area (ELA) and is provided in units of square inches. The Enclosure Integrity procedure measured an ELA of 250 square inches. Of this leakage area, 56 percent was identified as that vent area provided by the exhaust damper. This is a best possible configuration in that the vent path is high in the enclosure, thus venting excess air during discharge.

A comparison of the calculated Free Vent area as opposed to the measured Equivalent Leakage Area clearly shows an acceptable amount of free vent area. This ensures that the integrity of the room will be maintained during a discharge of CO_2.

Further calculations were conducted to determine the maximum pressure which would be experienced during a discharge. The data for these calculations was gathered as a portion of the Enclosure Integrity procedure. The predicted maximum pressure experienced during a CO_2 discharge is 3.45 1/7 inches of water. This value is well within the limit of 5 inches of water established by NFPA 12 for light building construction.

B) Distribution of CO_2 within the enclosure.

ESD conducted a review of the original design criteria and calculations the system. This review revealed that the system had been designed lizing accepted industry standards and practices. The placement and sizing of nozzles and distribution piping was consistent with NFPA 12 recommendations and requirements. To further verify the acceptibility of the system, an as built review of the system was conducted. This review further verified the acceptability of the system.

The Enclosure Integrity procedure includes a model for predicting the height of the descending air to CO_2 interface with respect to time. The model assumes leakage within the enclosure which is equally distributed between the floor and ceiling levels. It also assumes a reasonably static environment with no mechanical mixing. Differential pressures across enclosure boundaries are assumed to be negligible. The model provides a conservative prediction of the CO_2 concentration and maximum hold time for a specific enclosure.

The results provided by the Enclosure Integrity procedure for the Cable Vault, predict a 50 percent concentration at a level 7 feet above the floor for a period of 25 minutes.

Although the leakage paths within the Cable Vault have been determined to be well distributed, other parameters such as mixing (which occurrs within the room) and differential pressures (between the Cable Vault and surrounding rooms) required further evaluation.

Mixing of the CO_2 and air in the Cable Vault is provided 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 enclosure.

Pressure measurements were made relative to the pressure within the enclosure. These measurements indicated a variety of differential pressures across the enclosure boundaries. This information further reinforced the need for the tracer gas dilution test.

Due to the potential for mixing, and the differential pressures noted, the assumptions made for the Enclosure Integrity procedure became less valid. It appears that the conditions within the Cable Vault more closely approximate a "mixed tank" model. With this in mind, a standard tracer gas dilution test (utilizing Sulfur Hexafluoride (SF_6)) was conducted to determine the actual air exchange rate for the Cable Vault. The results of this test verified the assumption that the room more closely approximates a "mixed tank" model. The air exchange rate was determined to be 640 scfm with the Cable Vault in a CO_2 discharge configuration. Utilizing a standard calculation for the decay over time, it was determined that a 50 percent concentration of CO_2 will be maintained for a period of 13 minutes following discharge.

An additional 1 minute and fifty seconds of hold time is developed between the establishment of a 50 percent concentration and the end of the discharge period. Therefore, the 50 percent concentration will be maintained for a total of 14 minutes and 50 seconds.

The additional 1 minute and 50 seconds assumes that a concentration of 65 percent is reached at the end of the discharge period.

Support for this assumption is developed using NFPA 12, Fig. A-2-1(A). This figure provides a graphical means for determining the percentage of CO2 received within the enclosure. The injection factor is determined by dividing the protected ~~[illegible]~~ Volume by the available CO2. In this case the injection factor is [illegible]5 cubic feet per lb. of CO2.

Three curves are provided on the graph. The lowest curve represents no efflux, the middle curve represents free efflux, and the top curve represents perfect efflux. Perfect efflux would be the situation where all of the air was evacuated, to be replaced with a homogeneous mixture of CO2 and air. This would be accomplished with mechanical assistance. The free efflux situation would be an enclosure with normal leakage paths and no additional means for venting air or CO2. The situation in the Cable Vault, based on the delayed closure of the exhaust damper, is assumed to fall between these two curves. Assuming a conservative value for the efflux achieved, midway between free efflux and perfect efflux, provides a concentration of 65 percent of CO2 received at the end of discharge.

C) Ability of the enclosure to maintain the required concentration of gas over time.

The Enclosure Integrity procedure allowed for the quantification of Equivalent Leakage Area. This not only demonstrated the ability of the enclosure to withstand the anticipated pressure incursion, but also provided data which supports the ability of the room to maintain the concentration. If we were to assume a descending interface model for this enclosure, a "worst case" assumption, then a concentration of 50 percent CO_2 could be expected for 25 minutes at a critical height of 7 feet above the floor.

The Tracer Gas dilution method for measuring air exchange provided an actual measurement for the air exchange rate within the Cable Vault. This air exchange rate, in conjunction with a standard decay rate calculation, provides the prediction of the maximum hold time at 50 percent concentration. The use of the tracer gas dilution assumes a "best case" scenario for the CO_2 discharge. In this case a 50 percent concentration of CO_2 is predicted for 14 minutes and 50 seconds evenly distributed throughout the room.

III. Conclusion

The evaluation of the test results and data gathered as a result of the Test Procedure indicates that the Cable Vault Total Flooding CO_2 system will perform as designed. The system will inject a concentration of 65 percent CO_2 and the enclosure will maintain a concentration of 50 percent for a minimum period of 14 minutes and 50 seconds. The peak pressure incursion will be approximately 3.45 inches of water. These results provide assurance that system design, licensing criteria, and regulatory requirements are satisfied.

50.59 Safety Evaluation

The purpose of this safety evaluation is to ensure that the attached pressure build/SF6 testing provides assurance that the Cable Vault CO2 system will operate as designed and that no unreviewed safety question exists. When evaluating this alternate testing ,it is helpful to examine the design basis of the CO2 full discharge test which achieves 2 purposes:

- With adequate sensing devices, the test can provide CO2 distribution concentrations. Placement of these sensors are based on engineering judgement.

- The test can provide peak pressure buildup within the enclosure. Typically, this test is performed on a functional basis versus quantifiable basis ,ie if inadequate venting exists , this test will fail the enclosure instead of measuring peak enclosure pressures.

VY considers that the pressure build/SF6 method meets these design criteria as compared to the CO2 full discharge test based on the following:

- CO2 distribution is determined by combining a very sensative bulk concentration test (ie tracer gas) with accepted bulk venting (ie NFPA 12) bracketed by 2 conservative/standard distribution models (ie "descending interface/plug flow" model and "back-mix,stirred tank" model as described in Reference 14). The net result is that the actual CO2 concentration is between a model that predicts 50% CO2 concentration for 25 minutes and a model that predicts 50% concentration for 14 minutes 50 seconds both of which exceed the minimum requirement of 50% concentration for 10 minutes.

- The pressure build test as supported by NFPA 12A App B provides an approved method for determining pressure buildup within a room. This is achieved by determining an equivalent leakage area (ie equivalent resistance to flow) which can be accurately extrapolated to actual test conditions without risk of equipment damage. In this way, both room integrity and room venting needs can be determined. The net result is a non destructive test that provides more information than the CO2 full discharge test.

Based on the above ,the following 50.59 statements can be made per VYAPF 6002.01:

a. This test does not increase the probability of occurrence of an accident reviously evaluated in the FSAR. The CO2 full discharge test is not specifically described in the FSAR or SER to TS ammendment 43 but is referenced via NFPA 12 - 1985 edition as a required test. The intent of the CO2 full discharge test is met by the pressure build/SF6 testing. In fact, the pressure build/SF6 test did not physically challenge/alter the Cable Vault Structure which further ensures that the system would perform its intended function when called upon .

1.b. This test did not increase the consequences of any of the accidents as described in the FSAR for the same reasons described in 1.a.

1.c. This test did not create the possibility of an accident not bounded by those specified in the FSAR as described in 1.a.

2. This test did not increase the probability that a piece of equipment necessary for Nuclear Safety would malfunction. The Cable Vault automatic total flooding CO2 suppression system is a non-safety class system. The CO2 system provides fire protection for safety class electrical cable and equipment and is designated as a Vital fire protection system. The pressure build/SF6 test provided additional assurance that the system would perform as intended without challenging the Cable Vault room or equipment. It assured that the CO2 distribution, pressure build profile, and Cable Vault venting area were appropiate for the system.

3. This test did not increase the consequences of any malfunction of equipment necessary for Nuclear Safety because it did not physically challenge any equipment in the Cable Vault above any anticipated normal environment ie there is reasonable assurrance that all cable vault equipment is in the same condition after the test as it was before the test (excepting normal wear).

4. This test did not create the possibility of an equipment malfunction not anticipated in the accidents specified in the FSAR as described in "3." above.

5. This action does not reduce the margin of safety defined in the basis of any Technical Specification. The pressure build/SF6 test assures that the Cable Vault CO2 system will perform its intended function while providing additional engineering information to ensure that the margin of safety is maintained.

Based on the above analysis, there is no unreviewed safety question.

It should also be noted that additional assurance of CO2 Cable Vault system performance is provided by a) a supplemental 2 hour fire watch of the Cable Vault Room that will be provided during the initial review of this report by the NRC and b) second shot capability available from the switchgear rooms.