J Costello

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NUCLEAR REGULATORY COMMISSION
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MEMORANDUM FOR: Distribution

FROM: J. F. Costello, MSEB

SUBJECT SMALL STEEL CONTAINMENT MODEL TEST

Model SC-3, the last in a sequence of small models of steel containments, was tested to failure on December 2, 1983. A quick look report has been prepared by Sandia National Laboratories and is provided in the enclosure.

James F. Costello
Mechanical/Structural Engineering Branch
Division of Engineering Technology

Enclosure:
Quick Look Report

Quick-Look Report

Test of Model SC-3

Model Description

SC-3 was a small steel containment model with representations of three penetrations - an equipment hatch and two personnel locks. The equipment-hatch representation included a sleeve welded into the shell and a dished (inward) cover plate welded to the sleeve. The personnel-lock representations consisted simply of sleeves with flat cover plates welded on the inside and outside. Except for the penetration representations, model SC-3 was the same in configuration as model SC-1, the baseline model.

First Pressurization

The model was internally pressurized in a step-wise fashion using nitrogen gas on November 30, 1983. Pressure steps of 20 and 40 psig were specified. Model behavior was interpreted during the test to be elastic. Shortly after the next step to 50 psig, one of the theodolite operators observed a slow outward movement of the cover of the equipment-hatch representation. One-half minute after pressurization, the dished cover on the hatch snap-through buckled. The model continued to hold pressure and data was recorded. Per our test plans, the model was depressurized to zero pressure.

Modifications to the Model

To permit further pressurization of the model without fear of a tear in the now severely distorted cover plate, the model was modified. Holes were drilled in the buckled cover plate and the cover was forced inward slightly. A thick (0.104 inch) flat plate was cut and fitted over the equipment hatch representation and welded to the outer edges of the sleeve.

Second Pressurization

On December 2, 1983, the modified model was pressurized. Steps of 20, 40, 60, 70 and 75 psig were specified. On the next step to 80 psig, the model required a longer time to stabilize, probably because of some membrane yielding. Gross membrane yielding was apparent after the next step to 85 psig. Steps to 90, 95 and 100 psig were taken with about 15 minutes required at each level for model stabilization. Paint was noted to begin to peel from the area adjacent to the meridional seam of the cylinder at 100 psig.

The peeling of paint spread and continued throughout the remainder of the test. During the pressure steps to 105, 110 and 115 psig, stabilization of the model required progressively longer times. At 120 psig, stabilization was particularly slow. After 25 minutes the model was still observed to be growing but at a very slow and decreasing rate. Theodolite readings were initiated despite the slight continued growth. At 30 minutes after pressurization to 120 psig, while theodolite readings were being taken, the model failed completely. Based upon the observation of a gas cloud initially to the south side of the model and the location of debris after the test, we believe that failure initiated on the side of the model with the two close penetrations (the equipment hatch and personnel lock representations). The large number of pieces suggests that the entire model was close to rupture when the failure initiated.

Data Acquisition

Strain measurements and displacements (from LVDTs) were recorded after stabilization at each pressure step up to 115 psig. Because the model was still growing slightly at failure, a full set of data had not been recorded before failure at 120 psig. In general the strain and displacements away from the penetrations show a trend very similar to those recorded during the test of model SC-1 (clean shell). At 115 psig the maximum free field displacements and strains were over two inches and 10 per cent respectively. At 120 psig strains of about 15 per cent were noted during the test.

Pressure and temperature measurements and leakage rate calculations were made during a 30-minute hold at 100 psig. The measurements were successfully recorded but the leakage rate calculations appear to be unrealistically high based upon a first examination. The recorded data will be used to diagnose and correct errors in the calculations.

The acoustic emission system for locating leaks appeared to function correctly during pressure steps up to 100 psig. The system located micro cracking (perhaps in paint) at areas at which strains larger than free field were expected. Because no leakage occurred, we could not check the system's ability to locate leaks, per se. Unfortunately the dedicated computer for the system crashed during the hold at 100 psig. Because the computer was located close to the model, the system could not be recovered during the test.

Post-Test Examination

The pressure pulse and/or debris from the failure of the model caused the wooden overhead structure to be destroyed. Pieces of

the model and instrumentation were scattered over a wide area. Although most of the debris was found within a 60-feet radius of the test fixture, two pieces were located about 130 and 220 feet away. A piece found about 40 feet away included the modified equipment-hatch and the nearby personnel-lock representation. Based upon the crinkled form of part of the piece, the final shaping may have occurred when a larger piece hit a structure after failure. The personnel-lock representation on the other side of the model separated from most of the shell and was found under the destroyed overhead structure. Again, whether the separation occurred during or after the failure is not clear. In conclusion, the sequence of failure can not be determined from the post-test inspection. However, the initial running crack probably started on the side of the model with the equipment-hatch and personnel-lock representations.

Continuing Education

Data reduction for the test is continuing. At first examination most of the strain and displacement channels operated successfully through most of the test. However, some strain gages were lost at large strain levels. We are rechecking our strain gage application procedures prior to gage applications on the large steel model.

The leakage rate software is being examined and will be corrected prior to testing the large steel model.

The computer for the acoustic emission system is being upgraded Adding the ability to restart the system from a remote terminal will be investigated and accomplished if feasible.

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