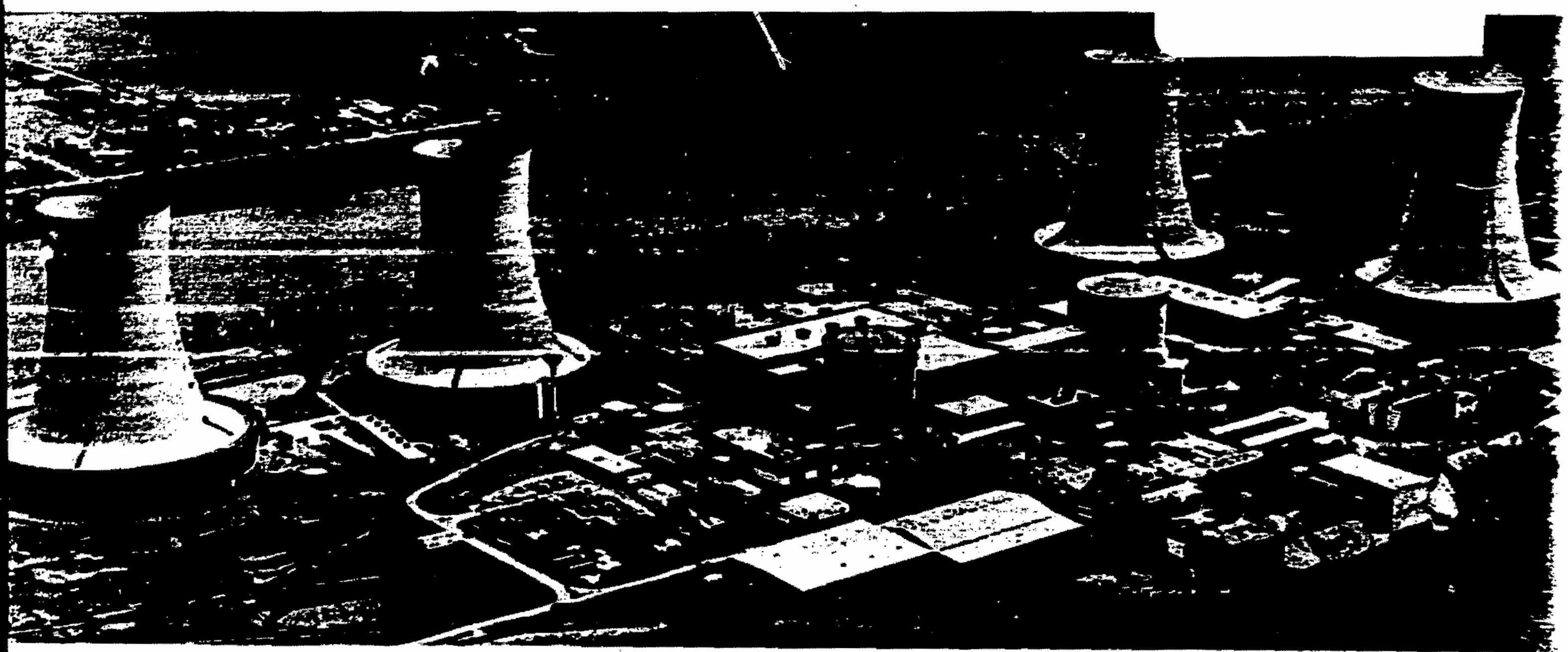
GEND-INF--029-Vol.3

DE93 009111



This is an informal report intended for use as a preliminary or working document

GEND

General Public Utilities • Electric Power Research Institute • U.S. Nuclear Regulatory Commission • U.S. Department of Energy

EXAMINATION AND EVALUATION OF TMI-2 TRANSMITTERS

CF-1-PT4 AND CF-2-LT4

Merlin E. Yancey
Rolf C. Strahm

Prepared for the
U.S. Department of Energy
Idaho Operations Office
Under DOE Contract No. DE-AC07-76ID01570

GEND-INF-029
Vol. III

Examination and Evaluation of TMI-2 Transmitters CF-1-PT4 and CF-2-LT4

Merlin E. Yancey
Rolf C. Strahm

Published January 1985

EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

Prepared for the
U.S. Department of Energy
Idaho Operations Office
Under DOE Contract No. DE-AC07-76ID01570

ABSTRACT

This report summarizes the results from the examination of core flood transmitters CF-1-PT4 and CF-2-LT4, removed from the Three Mile Island Unit Two (TMI-2) reactor building. Both of the transmitters were operational, although minor changes had occurred in their operating characteristics since the accident in 1979. A summary of findings relative to the moisture problems associated with several of the previously examined core flood instruments is also presented.

ACKNOWLEDGMENTS

The authors express appreciation to N. H. Ellis, R. E. Thurman, and R. L. Rowe for performing tests at the Contaminated Component Test Facility, and to M. R. Dinsel for his observations in the TMI-2 reactor building.

CONTENTS

EXAMINATION AND EVALUATION OF TMI-2 TRANSMITTERS CF-1-PT4 AND CF-2-LT4

INTRODUCTION

This report discusses the examination and evaluation of pressure transmitter CF-1-PT4 and level transmitter CF-2-LT4, removed from the Three Mile Island Unit 2 (TMI-2) reactor building March 25, 1984 and evaluated by EG&G Idaho, Inc. at the Idaho National Engineering Laboratory (INEL). Both transmitters were examined in their as-received condition and no attempts were made to decontaminate the units.

Both the Foxboro transmitter, CF-1-PT4, and the Bailey transmitter, CF-2-LT4, were operational. There was no apparent physical or functional degradation of these units due to water damage, which had occurred in three previously examined Bailey transmitters.[1,2]

This report is a continuation of work that was initiated shortly after the TMI-2 accident to determine its effect on the instrumentation in the reactor building. Two Foxboro pressure transmitters and three Bailey level transmitters were previously removed and evaluated.

GENERAL

The transmitters were examined in their as-received condition to determine their operational status, and if necessary, isolate any failure modes. The examination included a visual inspection and a functional check of each unit.

In situ testing of both of these units was performed by the Technology for Energy Corporation (TEC) during September 1980. Based on those tests, the examiners concluded that both of these units were operational.[3,4] Because of extensive water damage to the three previously examined Bailey transmitters, it was not possible to determine the extent of any radiation damage to those units. Since the Bailey unit, CF-2-LT4, appeared to be functional after the accident, the unit was removed for examination along with the Foxboro unit, CF-1-PT4. In addition to these transmitters, some of the conduit and the junction box associated with the units were removed in an effort to understand more about how and where the water could have gained entry to the conduits and transmitter housings of the previously examined transmitters.

CHARACTERIZATION

General Instrument Condition

Tests were performed by EG&G Idaho on similar Foxboro and Bailey transmitters which had electronic amplifiers identical to those installed at TMI to determine the effects of irradiation on the performance of these types of transmitters.[5] The performances of the transmitters were monitored during the actual irradiation. Both types of transmitters remained operational at radiation levels of up to 1×10^7 rads. Dose rates varied from 1.0×10^4 to 3.6×10^5 rads/h; the Bailey transmitters showed the greater change due to irradiation.

Moisture Damage

A fourth Bailey transmitter, CF-2-LT4, was still operational when it was evaluated at the INEL. According to information reported in GEND-001,[6] all four of these transmitters had standard NEMA-4 housings, which were not qualified for steam or spray environment although they were specified for use in nuclear power plants. GEND-001 indicates that special sealing procedures were used on these units to upgrade their resistance to water damage, but the exact nature of this upgrade could not be determined.

Photographs of several of the core flood transmitter installations at TMI-2 were taken during reactor building entries 92 and 342, and a general visual inspection by EG&G Idaho personnel was made of the Core Flood Tank B area during entry 499 (November 30, 1984).[7] Figure 1 shows the installations of transmitters CF-1-PT4 and CF-2-LT4 and their common junction box prior to their removal from the reactor building. This installation is typical of the core flood transmitter installations, in that a flexible conduit runs a short distance from each of the transmitters to a junction box where an in-line splice is made. A rigid conduit then connects the junction box (Figure 2) to the cable tray area, as shown in Figure 3.

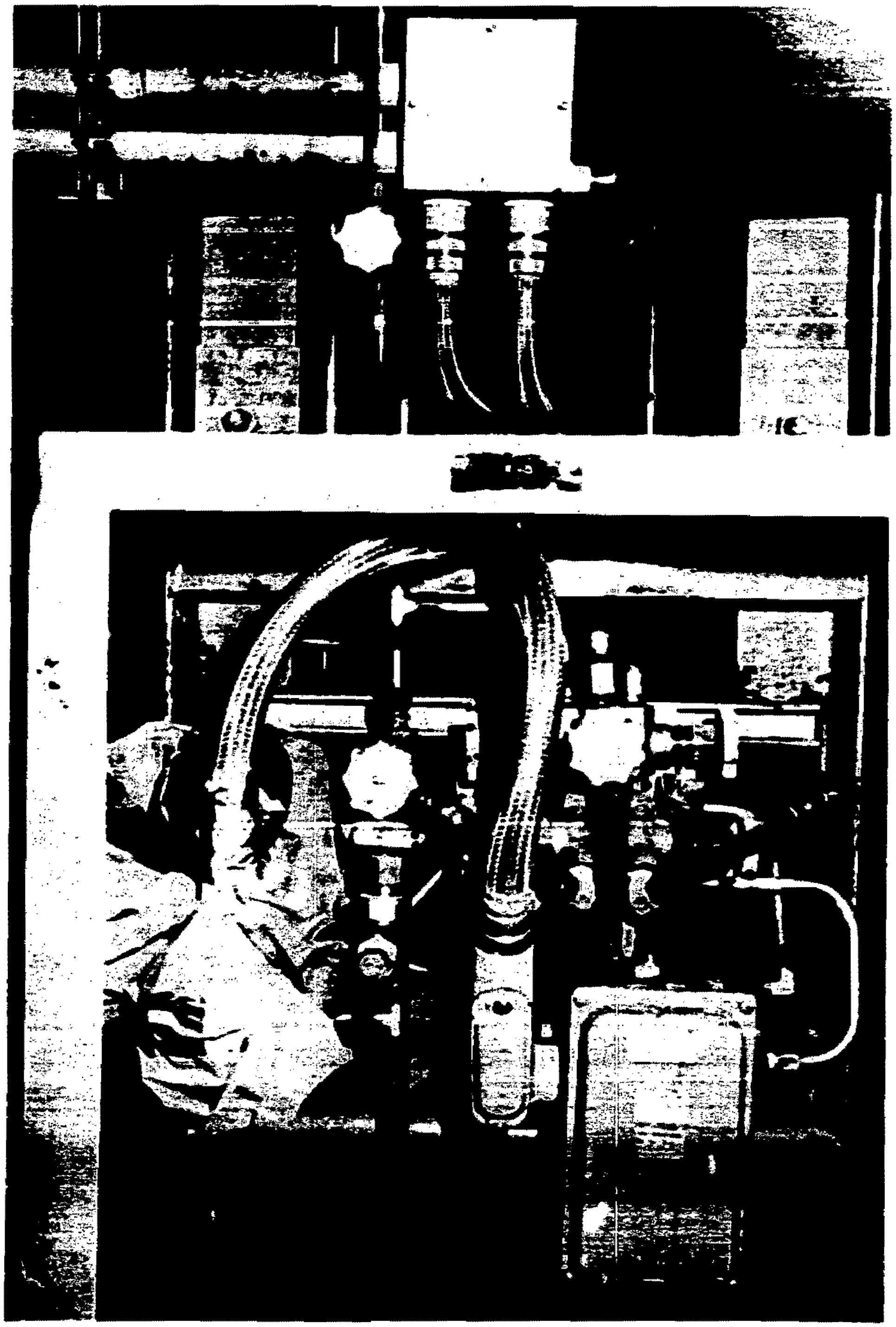


Figure 1. Core flood instruments CF-1-PT4 and CF-2-LT4 prior to removal (entry 342-7).

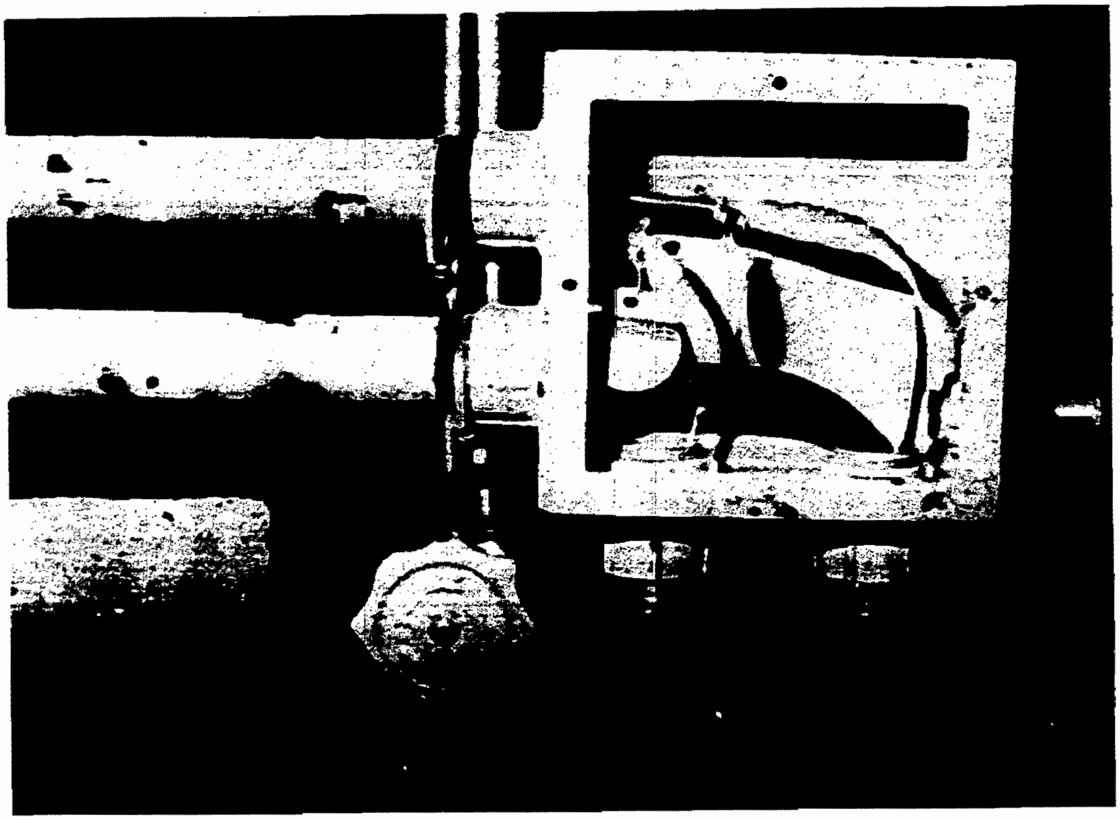


Figure 2. Junction box associated with CF-1-PT4 and CF-2-LT4 (entry 342-8).

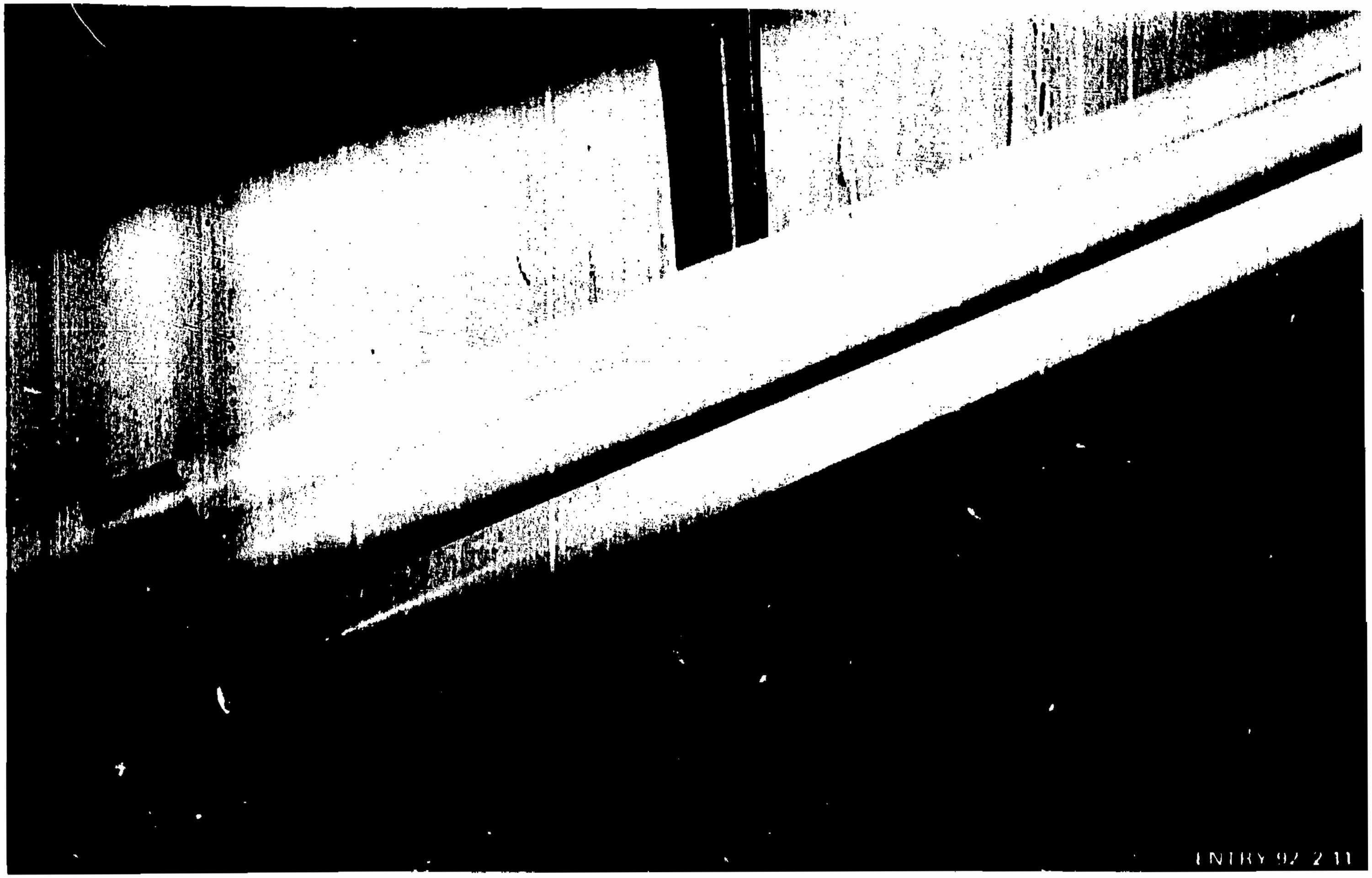


Figure 3. Conduits IT2746C (CF-2-LT1) and IT2750C (CF-2-LT2) terminating at the cable tray (entry 92 2-11).

In another installation involving CF-1-PT3 and CF-2-LT3, it was noted that the flexible conduits each entered separate Condulet conduit outlet bodies (Figure 4). The flexible conduits from CF-2-LT2 and CF-1-PT2 were also connected to a common junction box as shown in Figure 5; however, several differences were noted in the area of the junction boxes. The rigid conduit associated with the junction box shown in Figure 2 enters the box from the side, while the conduit enters the junction box shown in Figure 5 from the top. If water or condensate were to enter the conduits, the installation where the conduit entered the junction box from the side may have trapped a small amount of moisture in the junction box. The universal drains or breathers (Crouse-Hinds ECD15) were mounted on the junction boxes differently. In one case, an ECD15 was mounted as a drain, while in the other case the ECD15 was mounted on the side of the box, presumably as a breather. According to the product data sheet,[8] "ECD drains and breathers are installed in enclosures or conduit systems to provide ventilation to minimize condensation and (to) drain accumulated condensate," and "At least one breather should be used with each drain." It should be noted that the installation shown in Figure 2 did not have a breather installed on the junction box.

Observations from entry 499 indicated that the locations of the transmitters and junction boxes were in an area where they were protected from direct water spray from the reactor building spray system. It was also noted that the cabling in the cable trays and the ends of the conduits where they terminated at the cable trays were in an area where the water from the reactor building spray system could have direct contact with them.

The junction box, fittings, and flexible conduits associated with CF-1-PT4 and CF-2-LT4 were examined in the Contaminated Component Test Facility at the INEL. The flexible conduit and fittings connecting the junction box to the transmitters were designed to be water tight; laboratory examination of these items indicated that they maintained their seal. An examination of the in-line splices indicated that adequate sealing had prevented moisture from entering the area of the electrical splices. The cover associated with the junction box had a gasket which would improve the seal; however, the seal was not water tight.

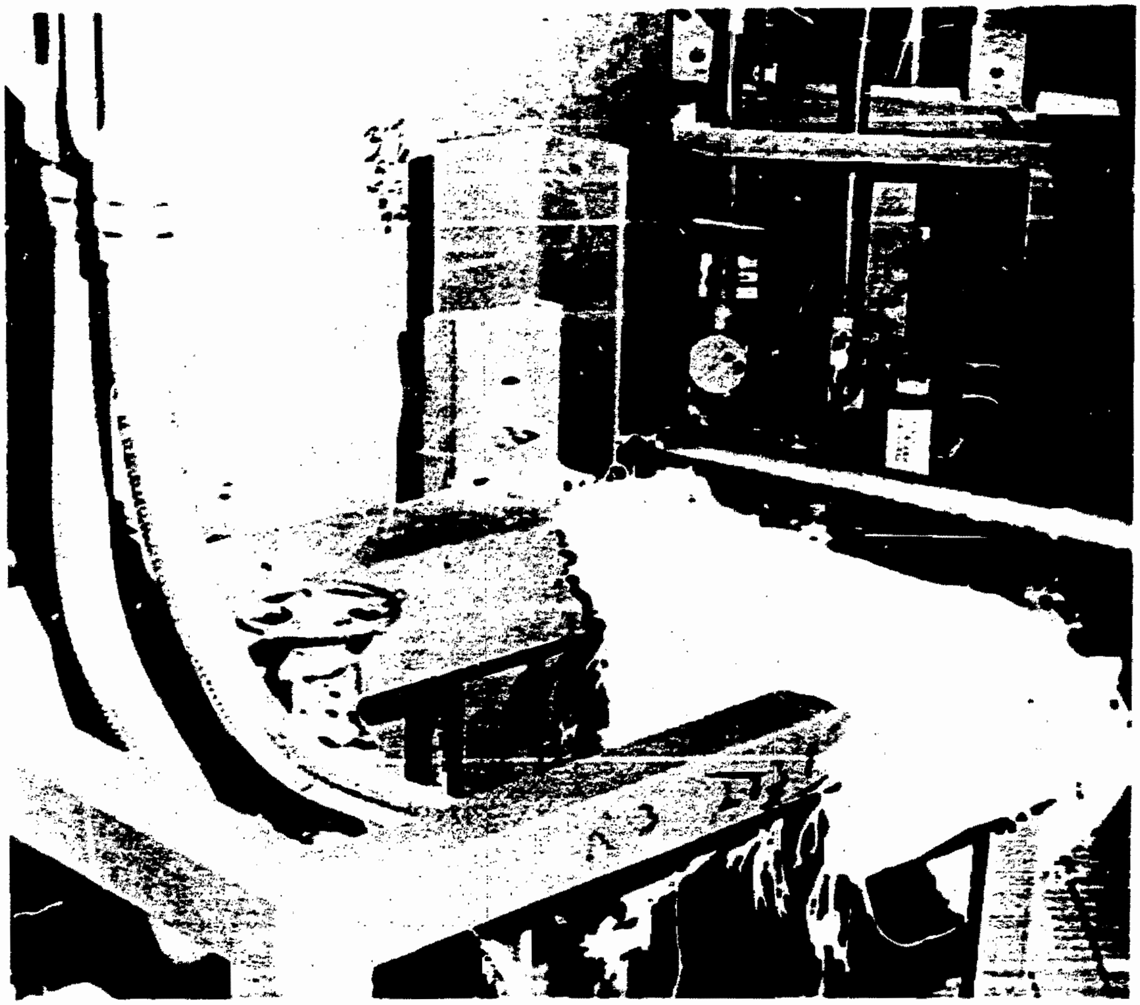


Figure 4. Condulet conduit outlet bodies associated with CF-1-PT3 and CF-2-LT3.

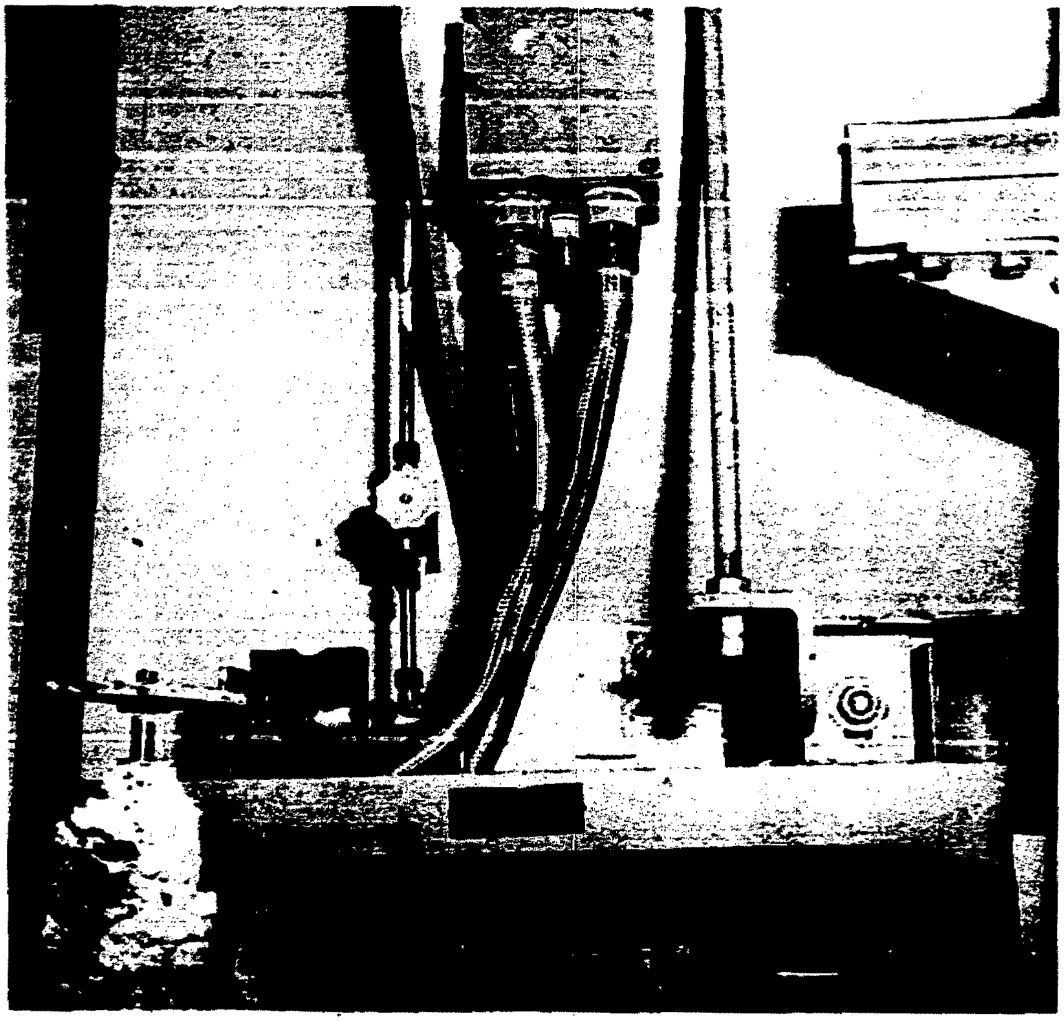


Figure 5. Junction box associated with CF-1-PT2 and CF-2-LT2 (entry 92 2-4).

An inspection of this junction box showed no internal moisture damage or mineral deposits, suggesting that the ends of the rigid conduit for these transmitters at the cable tray were more protected from moisture than were the other three installations, or, the breather installed in this junction box provided some ventilation which minimized condensation.

The internal conditions of the other junction boxes associated with the core flood instruments were not documented with photographs or written descriptions. Two of the other installations appeared to have no means of ventilation in their conduit systems and may have been subjected to higher levels of condensation, resulting in water damage to the transmitters.

Foxboro E11GM

Pressure transmitter CF-1-PT4, shown in Figure 6, was one of two transmitters used to measure the pressure in Core Flood Tank 8. The following is a summary of its characteristics:

Manufacturer	Foxboro Company
Model	E11GM-HSAD1
Serial number	2517278
Calibration range	0 to 800 psig
Output	10 to 50 mA
Power supply voltage	63 to 95 V dc
Capsule and body	316SS

The transmitter was located at the 324 ft elevation, well above the high water mark in the building.

From initial visual examination at the INEL, it appears that the transmitter was in good condition except for some minor corrosion and rust on the exterior. The interior of the transmitter, including the sensor/electronic module assembly, was free from corrosion and radioactive contamination. The circular junction box showed no signs of corrosion; however, some mineral deposits were apparent, indicating that moisture had

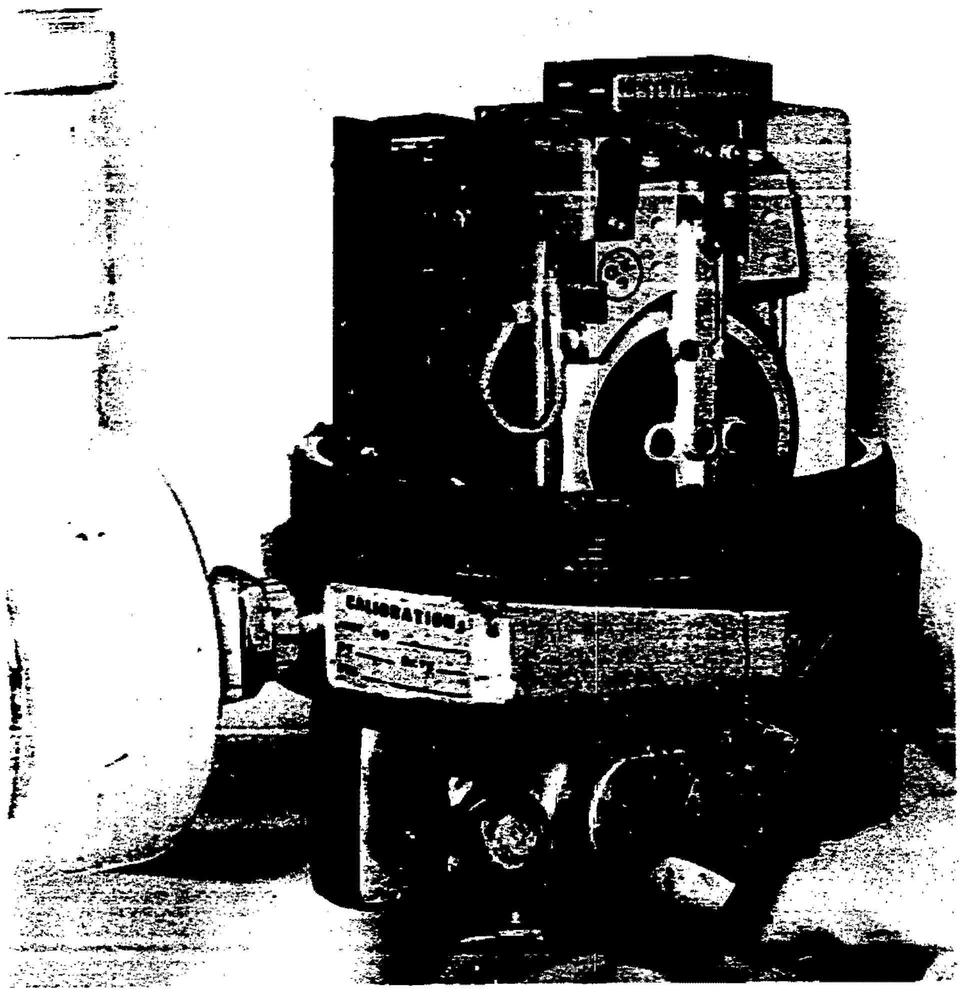


Figure 6. Foxboro E11GM transmitter CF-1-PT4.

been in the junction box at some time. Radiation measurements indicated that the interior of the junction box was radioactively contaminated. Since the junction box seal appeared to be in good condition, it is likely that the water entered the junction box through the conduit. A seal located between the transmitter and the circular junction box prevented moisture from entering the transmitter itself.

The nature of the tests performed by TEC revealed that the unit was operational, but the calibration characteristic of the unit could not be verified. An as-received calibration was performed on the transmitter at the INEL and compared with the last calibration prior to the accident. Three calibration runs, including increasing and decreasing pressure, were performed on the transmitter. From the data obtained during these calibration runs, the transmitter appeared to have good repeatability.

For comparison purposes, a set of six data points in 20% increments corresponding to data points of the preaccident calibration was selected from the first calibration run. The sets of data were subjected to a least squares fit linear regression to identify changes occurring between calibrations. The correlation coefficient (r) for each set of data was also computed. A correlation coefficient of 1.0 represents perfect correlation between the data points and the best fit straight line.

The best fit straight line for the 1977 calibration data is represented by:

$$I = 0.049780\ P + 9.98952\ \text{mA}$$

where I denoted the transmitter's output current and P equals the applied input pressure; the correlation coefficient was 0.9999994. The 1984 calibration data had a correlation coefficient of 0.9999970 and was represented by:

$$I = 0.0498857\ P + 9.451714\ \text{mA}.$$

The linearity for both sets of calibration data was better than 0.125%. The percentage change in both the zero and span occurring during the 81-month calibration interval was calculated. The zero shifted 1.34% of span, whereas a 0.2% increase occurred in the transmitter's sensitivity to pressure.

Bailey BY8231X-A

Transmitter CF-1-LT4 was used to measure the water level in Core Flood Tank B and was also located at the 324 ft elevation. The following is a summary of its characteristics:

Manufacturer	Bailey Meter Company
Model	BY8231X-A
Serial number	721886
Calibration range	0 to 166.99 in. H_2O
Output	-10 to +10 V dc
Power	118 V ac 60 Hz

An initial visual examination of this transmitter indicated a heavy layer of rust on the unit's assembly nuts, while the remainder of the exterior surfaces had only minor or no indications of rusting. The interior of the transmitter, including the housing and the electronics, was free of corrosion and rusting (Figure 7). There was no evidence of moisture in the housing, in contrast to the other core flood level transmitters, CF-2-LT1, CF-2-LT2, and CF-2-LT3, which had extensive interior corrosion due to intrusion of water during the accident. An inspection of the transmitter housing and the conduit fittings connected to the housing indicated that no special installation or sealing procedures were used on this transmitter or on the other core flood level transmitters.

Measurements were taken to determine the extent of radioactive contamination on the interior surfaces of the transmitter. These measurements showed the contamination level was considerably higher in the area of the electronics than inside the conduit fitting. It is probable that the interior of the transmitter housing became contaminated at the

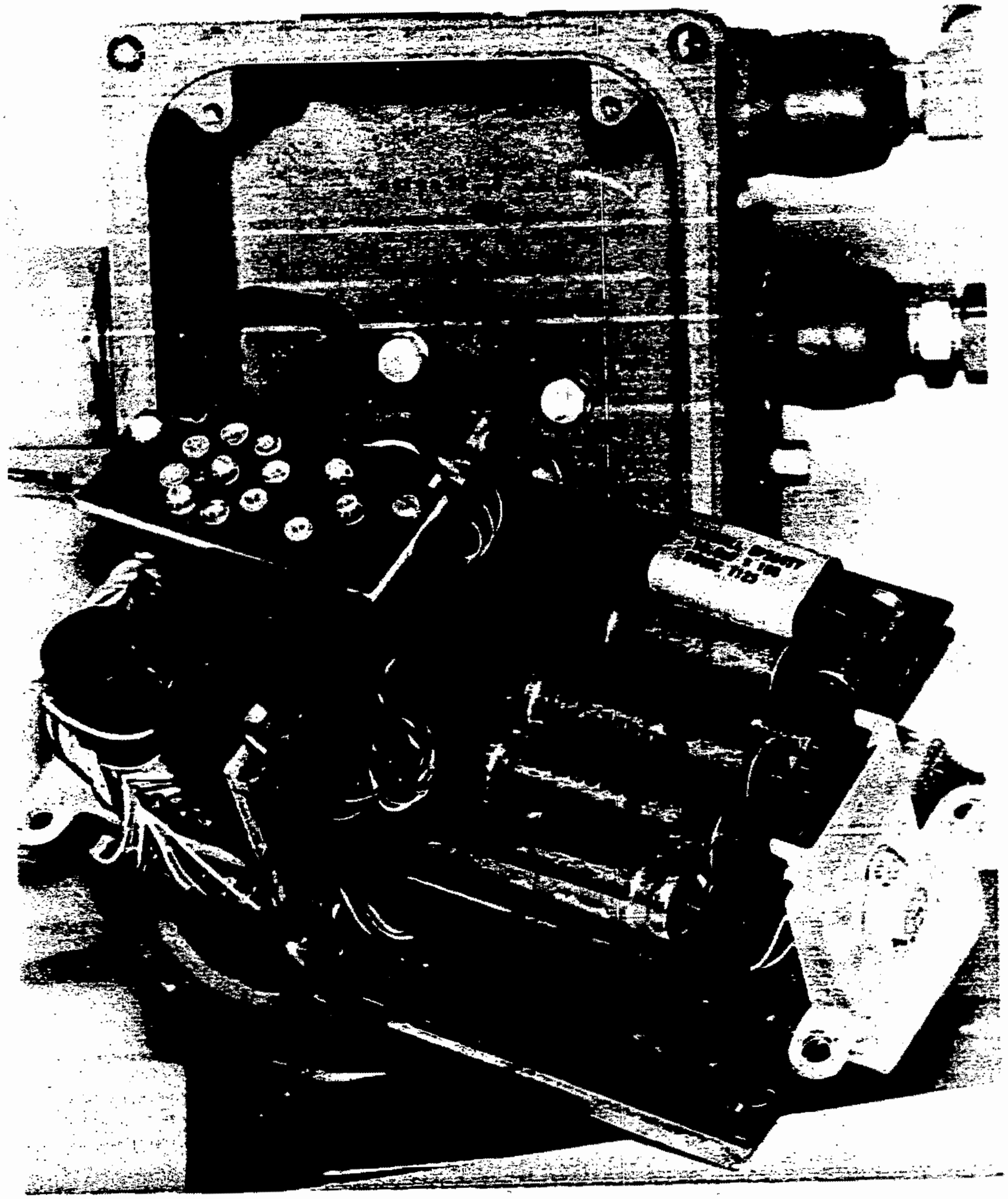


Figure 7. Bailey BY8231X-A transmitter CF-2-LT4.

time the unit was removed from the reactor building, since the cover on the housing was removed at that time.

A transmitter calibration was performed on CF-2-LT4 in its as-received condition, and compared with the last set of calibration data taken on this unit prior to the accident. Three calibration runs, which included increasing and decreasing pressure between 0 to 166.99 in. H_2O, were performed on the transmitter. A slight shift in zero was observed after completing each descending portion of the calibration runs. A least squares fit linear regression was performed on the six data points from the pre-accident calibration yielding a best fit straight line represented by the equation:

$$V = 0.11976\ P - 10.007237\ V$$

where V denotes the transmitter's output voltage and P equals the applied pressure in inches of water. The coefficient of fit for this data was 0.9999995. The postaccident data from the first calibration cycle of this transmitter can be represented by the linear equation:

$$V = 0.12167\ P - 10.58645\ V.$$

The correlation coefficient for this data was 0.999947. An analysis of the pre-and postaccident data indicated that a zero shift of 2.9% of span had occurred during the time interval, while the gain had increased by 1.59%. A zero shift of approximately 0.4% of span occurred between each of the calibration cycles, while the gain increased an average of 0.5%.

CONCLUSIONS

Laboratory examination revealed that both of these transmitters remained in operational condition following the accident. In summary, the three Foxboro transmitters evaluated appeared to still be in good operating condition, while only one of the four Bailey transmitters remained operational.

Data obtained from this examination and the earlier radiation testing show that the only failures of the Bailey transmitters resulted from moisture inside the transmitter housings. Review of the data also indicates that water damage similar to that occurring in the Bailey transmitters might have occurred in the Foxboro transmitters had it not been for the sealing around the transmitter leads where they exited the transmitter housing.

A review of the core flood installations revealed two possible sources of moisture in the transmitter housings:

1. Water from the reactor building spray system or the condensate (rain) from the humid environmental conditions in the reactor building had direct access to the cables in the cable trays and to the ends of the conduits.

2. The humid atmosphere in the reactor building, combined with the lack of adequate ventilation in some of the conduit, caused condensate to form on the inner walls of the conduits and drain into the transmitter housings. The conduits associated with CF-1-PT4 and CF-2-LT4 appeared to have a breather in the system and showed little evidence of moisture.

Both of the transmitters appeared to be in operational condition. The results of the above testing indicated that minor changes did occur to both of the transmitters as a result of the accident.

Based on the evaluation of these transmitters and the irradiation testing, the failures of Bailey transmitters CF-2-LT1, CF-2-LT2, and CF-2-LT3 were determined to be the result of the moisture in the transmitter housing rather than the result of the radiation levels in the reactor building.

RECOMMENDATIONS

This investigation has shown that the transmitters are capable of surviving a loss of coolant accident and that the conduit and cabling are an important part of the installation. In the investigation, it was noted that proper installation of the conduit, junction boxes, and cabling associated with the transmitter are essential for protecting the transmitters from intrusion of water or moisture.

Greater care should be given to the design and installation of the conduit and cabling systems associated with the transmitters in the reactor building to ensure that proper drains and adequate ventilation of the conduit/junction box system are provided.

Consideration should also be given by the manufacturer of the transmitters to providing a seal around electrical leads as they exit the transmitter housing, similar to the sealing technique used by Foxboro on their transmitters.

REFERENCES

1. Strahm, R. C. and Yancey, M. E., TMI-2 Pressure Transmitter Examination Program Year-End Report: Examination and Evaluation of Pressure Transmitters CF-1-PT3 and CF-2-LT3, GEND-INF-029, February 1983.

2. Yancey, M. E. and Strahm, R. C., TMI-2 Pressure Transmitter Examination of CF-1-PT1, CF-2-LT1, and CF-2-LT2, GEND-INF-029 Vol. II, April 1984.

3. Jones, J. E., Smith, J. T., and Mathis, M. V., Field Measurements and Interpretation of TMI-2 Instrumentation: CF-1-PT4, GEND-INF-017 Vol. II, November 1981.

4. Jones, J. E., Smith, J. T., and Mathis, M. V., Field Measurements and Interpretation of TMI-2 Instrumentation: CF-2-LT4, GEND-INF-017 Vol. IV, January 1982.

5. Yancey, M. E., Irradiation Test Report--Foxboro E11GM, Bailey BY3X31A, and Flame Retardant Ethylene Propylene Instrumentation Cable, GEND-INF-058, August 1984.

6. TMI-2 Information and Examination Program Planning Report, GEND-001, June 1980.

7. Dinsel, M. R. ltr. to M. E. Yancey, "Entry #499--Core Flood Tank Inspection," MRD-24-84, December 13, 1984.

8. Electrical Construction Materials, Crouse-Hinds catalog 4700, Syracuse, NY, October 1983.