THREE MILE ISLAND NUCLEAR STATION

UNIT II

SUPPLEMENTARY STARTUP REPORT

June 15, 1979

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5.2 NUCLEAR INSTRUMENTATION CALIBRATION AT POWER

5.2.1 PURPOSE

The purpose of the Nuclear Instrumentation Calibration At Power Test was to calibrate the power range nuclear instrumentation to the thermal power as determined by a heat balance and to the axial imbalance as determined by the incore monitoring system. Additional purposes during the Power Escalation Program were as follows:

(a) To adjust the high power level trip setpoint when required by the power escalation procedure.

(b) To verify that at least one decade overlap exists between the intermediate and power range nuclear instrumentation.

Three acceptance criteria are specified for nuclear instrumentation calibration at power as listed below.

(1) The power range nuclear instrumentation indicates the power level within 2.0% FP of the heat balance.

(2) The power range nuclear instrumentation indicates the axial imbalance to with ± 3.5% offset of the desired relationship between the incore and out-of-core detector systems (ie. 1.18 x Incore Monitoring System). This criteria does not apply below 40% FP.

(3) The high power level trip bistable is set to trip at the desired value within a tolerance of ± 0.50% FP.

5.2.2 TEST METHOD

The power range instrumentation has four linear channels, (NI-5, NI-6, NI-7, NI-8) originating in four detector assemblies, each of which contains two uncompensated ion chambers. These ion chambers are positioned to represent the top and bottom halves of the core. The individual currents from the chambers are fed into individual linear amplifiers. The sum of the top and bottom neutron signals is the total reactor power. The difference between the top and bottom neutron signal multiplied by a gain factor is the power imbalance of the core. The outputs are directly proportional to reactor power and cover the range of 0 to 125% FP for the total power and -62.5 to +62.5% FP for the power imbalance. Each channel supplies power level information to the reactor protection system (RPS) and to the integrated control system (ICS). The gain of each linear amplifier is adjustable, providing a means for calibrating the outputs against a thermal heat balance and an incore axial imbalance measurement. The location of the out-of-core detectors relative to the reactor core is shown in Figure 5.2-1.

As required during power escalation, the top and bottom linear amplifier gains were adjusted to maintain power range nuclear instrumentation channel power indication within ± 2% of the power calculated by a heat balance. During top and bottom linear amplifier gain adjustment, the ratio of their gains was maintained constant as long as the indicated axial imbalance was within 3.5% offset of the desired relationship; if not, their gains were adjusted to correct offset and heat balance mismatch at the same time.

252 081

Data was also taken to verify overlap between the intermediate and power range channels. The required overlap was a minimum of one decade between these two nuclear instrumentation ranges.

After all required testing was completed and approved at a major test plateau, the power escalation procedure then directed the high flux trip bistable setpoint to be re-adjusted. The major settings during power escalation are given below:

Test Plateau (%FP)	Bistable Setpoint (%FP)
15	50.00
40	50.00
75	85.00
98	102.75*

The verification of the trip setpoint was then performed by placing each channel in the test mode and slowly increasing a test power signal until each bistable tripped. The difference between the actual power at which the bistable tripped and the setpoint trip power was the trip error recorded during each adjustment.

5.2.3 TEST RESULTS

The power range nuclear instrumentation measures the reactor core neutron leakage flux. This leakage flux is directly effected by variations in reactor coolant boron concentrations, reactor coolant temperature, control rod configuration and xenon buildup or burnout. As system conditions were changed, an increase or decrease in nuclear power range indication could occur with resultant channel calibration becoming necessary. Calibration of this system was generally not necessary as part of the power escalation program for the following reasons:

a. The reactor core is designed for "unrodded" operation i.e. control rod groups 1-5 fully withdrawn and group 6/7 between 85% to 95% withdrawn during most tests.

b. The normal mode for power level changes was by boration/deboration rather than extensive rod movement.

c. All testing commenced with essentially zero imbalance, thus control rod group 8 operated in a relatively narrow band.

d. The reactor coolant temperature was maintained at 582 $\pm$ 1 degree F.

e. Since power escalation was generally on the order of 3% per hour or less, xenon pertubations were minimal.

*Note: The test plateau and the overpower trip setpoints were reduced 2% FP to account for the reduced RCS flow being measured.

250 003

f. Once a specified power level plateau had been completed, the computer calculated heat balance was certified for use up to and including that power level. Thus, any interruption in the test program for a problem or recalibration of instrumentation based upon the normal 8 hour shift surveillance would occur outside the test program. This is in keeping with Technical Specification requirements complied with by Metropolitan Edison Company.

The result of items (a) through (f) above was that recalibration of nuclear instrumentation channels was minimized insofar as the test program was concerned.

Each time it was necessary to calibrate the power range nuclear instrumentation as part of the power escalation or surveillance program, the ± 2.0% FP of the heat balance and ± 3.5% offset of the desired axial offset was met without any difficulties. Table 5.2-1 is a summary of the data taken at different power levels as part of the Nuclear Instrumentation Calibration At Power Test. In all cases, the nuclear instrumentation was maintained within its calibration tolerances.

Early in the power escalation test program some difficulties were experienced in the performance of the power range detectors. These problems and their solutions are briefly discussed below.

(1) Power range NI-5 had a low noise level on the signal and was replaced.

(2) Power range NI-7 had a bad connector on the signal wire and was replaced.

(3) Power range NI-8 initially had noise spikes present. This was resolved by connecting a loose ground wire.

After these modifications were made no further problems were experienced for the remainder of the test program.

The high flux level trip bistable was adjusted to 50, 85 and 102.75% FP prior to escalation of power to 15/40, 75 and 98% FP, respectively. Acceptance criteria of adjusting the setpoint to the above values within ± 0.50% FP was met each time without difficulty. The maximum trip error recorded was -0.25% FP when setting the high flux trip to 50% FP.

The actual overlap measured during the startup program exceeded the one decade overlap requirement. The overlap between the intermediate and power range channels covers the total span of the power range. Figure 5.2-2 shows the overlap of all three nuclear instrumentation channels.

5.2.4 CONCLUSIONS

The power range channels were maintained to within 2.0% FP and to within 3.5% offset of the desired relationship during the startup program. Total power was determined by a thermal heat balance, and out-of-core axial offset was determined using the incore monitoring system multiplied by a factor of 1.18. When calibration was required by either the power escalation or surveillance program the aforementioned acceptance criteria was met in all instances.

252 083

The high flux level trip bistable was adjusted prior to each power level escalation to its respective trip setpoint. Verification of trip setpoint in all cases indicated that the maximum error in the setting is well within the acceptance criteria.

252 084

SUMMARY OF NUCLEAR INSTRUMENTATION CALIBRATION
AT POWER RESULTS PERFORMED DURING POWER ESCALATION

Heat Balance Power (%FP)	Incore Offset (%)	Power Before and After Calib., % FP				Offset Before and After Calib. %			
		NI-5	NI-6	NI-7	NI-8	NI-5	NI-6	NI-7	NI-8
15.0	----	17.5	15.8	14.4	15.4	----	----	----	----
15.0	----	15.9	15.4	14.6	14.7	----	----	----	----
40.0	+3.31	40.4	40.0	40.2	40.1	+2.08	+0.23	+0.77	+1.77
40.0	+3.31	40.4	40.0	40.2	40.1	+2.08	+0.23	+0.77	+1.77
40.6	-1.49	40.4	40.5	40.4	40.4	-0.45	-0.67	-0.02	-0.05
40.6	-1.49	40.4	40.5	40.4	40.4	-0.45	-0.67	-0.02	-0.05
74.2	-2.09	72.9	72.8	72.8	72.9	-1.88	-2.45	-1.54	-3.05
74.2	-2.09	72.9	72.8	72.8	72.9	-1.88	-2.45	-1.54	-3.05
92.0	-1.45	90.1	90.3	90.2	90.3	-0.10	-0.52	-0.28	-0.07
92.0	-1.45	90.1	90.3	90.2	90.3	-0.10	-0.52	-0.28	-0.07
96.9	-3.87	96.6	96.5	95.5	95.5	-4.46	-4.53	-4.19	-4.05
96.9	-3.87	96.6	96.5	95.5	95.5	-4.46	-4.53	-4.19	-4.05

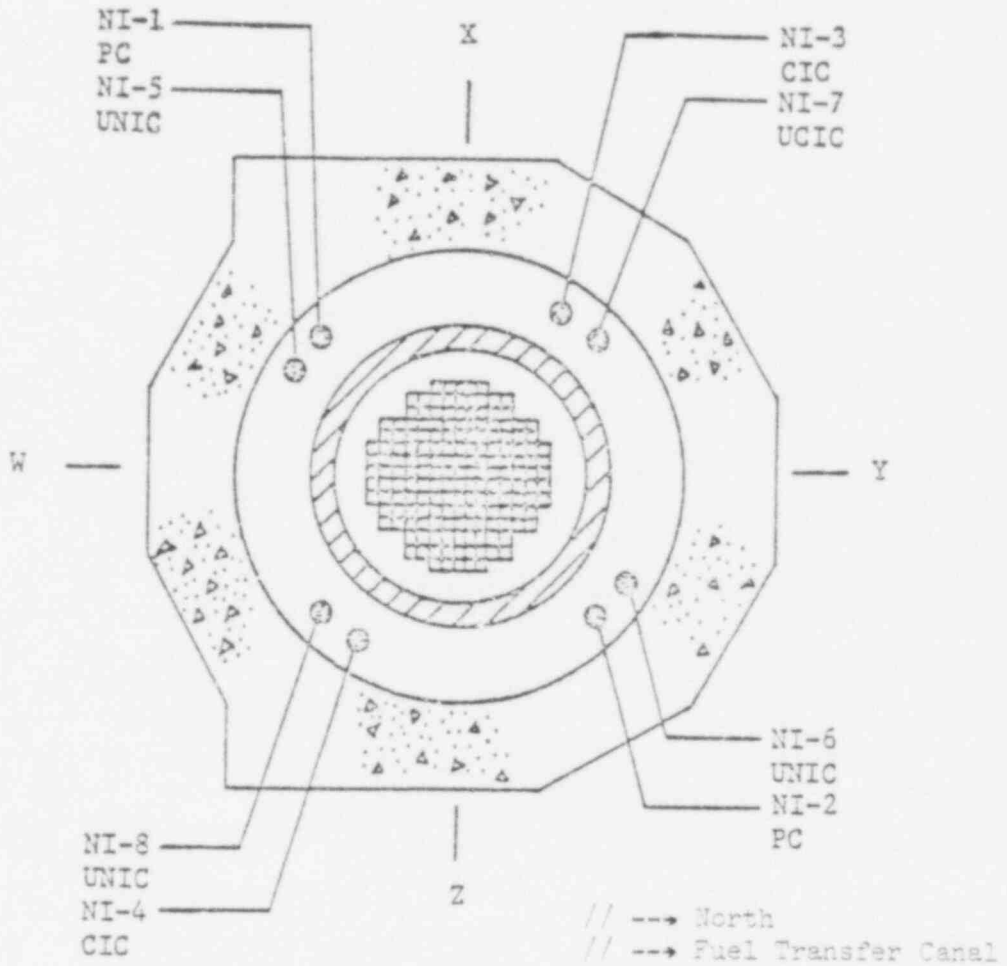
Table 5.2-1

Note: The desired out-of-core offset is equal to 1.18 times the incore offset --- see Section 5.4 Power Imbalance Detector Correlation Test.

Note: During the performance of this test, no nuclear instrumentation calibrations were required from 40 to 98% full power.

Note: The first line in each pair of data sets is the as found (before) calibration parameters and the second line represents the as-left (after) parameters.

Nuclear Instrumentation Detector Location



PC - Proportional Counter ---------- Source Range Detector

CIC - Compensated Ion Chamber ---------- Intermediate Range Detector

UNIC - Uncompensated Ion Chamber --------- Power Range Detector

252

Figure 5.2-1

Nuclear Instrumentation Flux Ranges

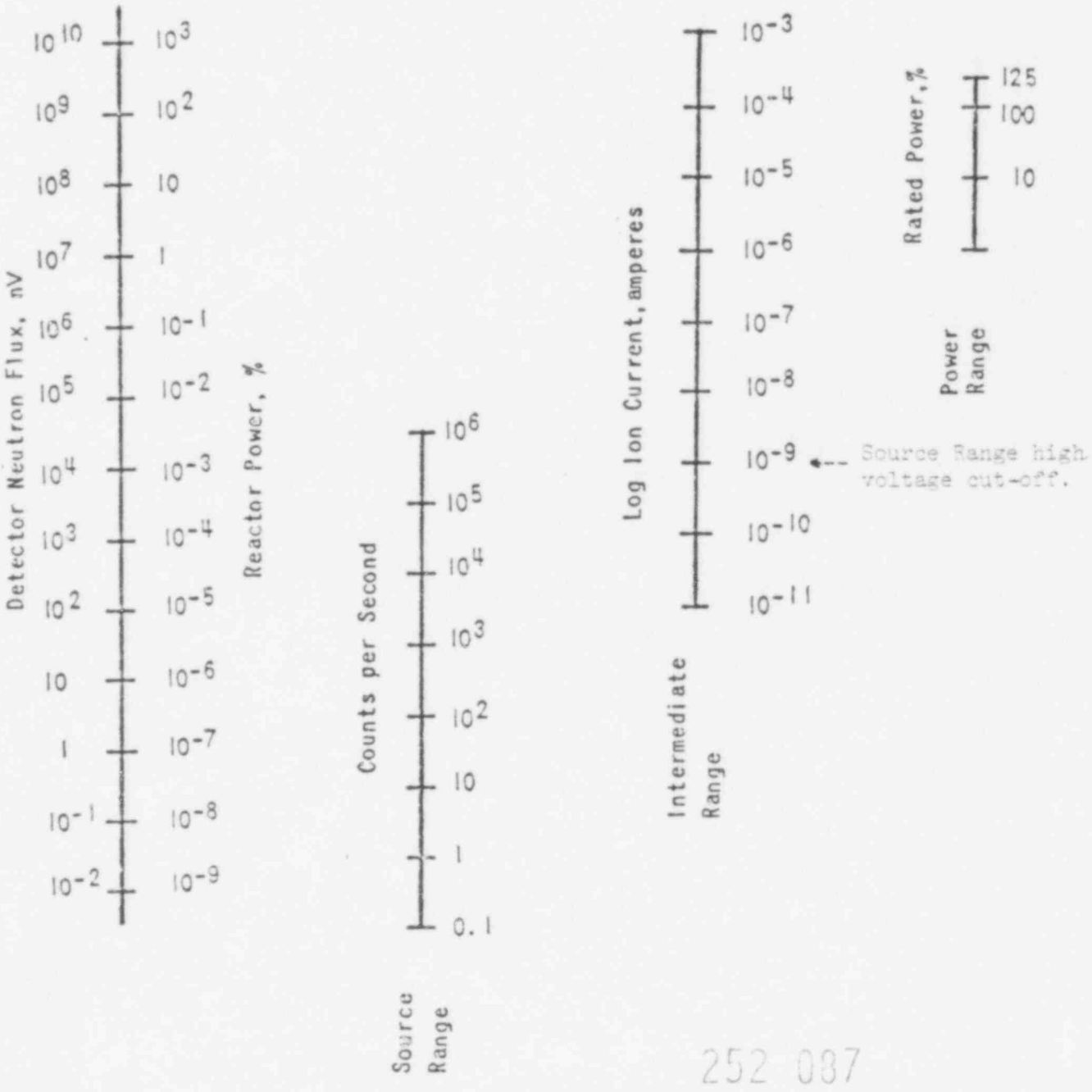


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Figure 5.2-2

5.8 PSEUDO CONTROL ROD EJECTION TEST

5.8.1 PURPOSE

The purpose of the Pseudo Control Rod Ejection Test is to verify the safety analysis relating to the accidental ejection of a control rod normally inserted in the core during power operation. This would be accomplished by measuring the rod worth and associated core power distribution as the pseudo control rod was withdrawn from the core. Verification that satisfactory values of minimum DNBR, maximum linear heat rate (MLHR), maximum Nuclear Heat Flux Hot Channel Factor (F_Q), and maximum Nuclear Enthalpy Rise Hot Channel Factor ($F^N_{\Delta H}$) are obtained when the most reactive control rod is fully withdrawn from the core. Additional test objectives are the verification that the reactivity worth of the most reactive control rod is within design limits and the demonstration of asymmetric rod alarm in response to a rod asymmetry condition.

5.8.2 TEST METHOD

The test would be conducted at 40% FP with equilibrium xenon established in the core. Control rod groups 1 through 5 were positioned at 100% withdrawn, group 6/7 at 85% withdrawn and group 8 as needed to maintain core axial imbalance at 0 $\pm$ 2%. All Integrated Control System (ICS) Stations would be in automatic, except the Diamond Control System Station which would be in the manual sequence mode of operation.

Control rod 7-3 (core location E-11) was calculated to be the most reactive control rod in a rod ejection accident at power. Control rod 7-3 would be withdrawn to 100% by performing a rod swap with control rod group 6/7. Differential reactivity worth measurements using the fast insert/withdrawal technique would be performed on group 6/7 with control rod 7-3 positioned at 85% and 100% withdrawn. A differential reactivity worth measurement using the fast insert/withdrawal technique would also be performed on rod 7-3 at the same positions. The total reactivity worth of rod 7-3 from 85% to 100% withdrawn would then be obtained by integrating the differential worth data measured on the control rods. Core power distribution measurements would be taken with control rod 7-3 positioned at 100% withdrawn.

The asymmetric rod alarm and fault verification would be conducted by obtaining a control rod map from the plant computer when the asymmetric rod alarm and fault conditions occurred as rod 7-3 was withdrawn from the core.

5.8.3 TEST RESULTS

Prior to this test being conducted, an evaluation was made regarding test results obtained at SMUD during performance of this test. The SMUD and TMI-2 reactor cores are almost exactly identical and use the same computational techniques for predicted values.

The major difference between SMUD and TMI-2 are:

a. Slightly lower fuel enrichment at TMI-2.

b. Slightly higher fuel density at TMI-2.

252 088

c. Four demonstration Gadolinium fuel assemblies at TMI-2.

The Pseudo Ejected Rod Test conducted during Zero Power Physics Test, TP 710/1, at TMI-2 yielded a worth of 0.59% delta k/k for control rod group 5 at 68% withdrawn. The measured value includes a 5% uncertainty for possible measurement errors. The predicted worth with control rod group 5 at 68% withdrawn was 0.55% delta k/k.

The acceptance criteria for the Pseudo Ejected Rod at power is less than 0.65% delta k/k. Since the regulating control rod banks will be essentially fully withdrawn during any power operation. the predicted worth is less than 0.035% delta k/k.

The measured worth of the Pseudo Ejected Rod at SMUD was 0.021% delta k/k. These units are generically similar and the differences listed above would only serve to reduce the expected measured worth of this rod. Since the SMUD measured worth is approximately 5% of the allowable worth, this does not constitute a safety hazard or unreviewed safety question.

On 19 May 1978 Mr. J. G. Herbein of Metropolitan Edison Company submitted a request to Mr. S. A. Varga of the Nuclear Regulatory Commission for the deletion of this test. The letter was serialized as GQL 0970 and cited the above information as justification for the request. This test was subsequently deleted from the test program.

5.8.4 CONCLUSIONS

Deleting the Pseudo Ejected Control Rod test resulted in a savings of at least 24 hours test time while still providing assurance the public health and safety would not be effected based upon test results obtained at SMUD, a generically similar unit.

252 089