50-237

Commonwealth Edison Company

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November 1, 1971

RECEIVED NOV 3 1971 U.S. ATOMIC ENERGY COMMISSION Regulatory Mail Section

Dr. Peter A. Morris, Director
Division of Reactor Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Subject: Hydraulic Shock to the Shutdown Cooling System at Dresden Unit 2

Dear Dr. Morris:

The purpose of this letter is to report to you an incident which occurred at Dresden Unit 2 on September 28, 1971. On that date, while testing the isolation valves for the shutdown cooling system, a hydraulic shock or water hammer was experienced. A complete report of this occurrence is attached.

Following an inspection the Station Review Board and Nuclear Review Board determined that the reactor could be returned to power and that no formal report of the incident was necessary. Region III Compliance was notified prior to startup of the unit.

The attached report is being sent to you for your information knowing of your interest in matters such as the above.

Very truly yours,

Wayne L. Stiede

Wayne L. Stiede
Nuclear Licensing Administrator

cc: Mr. Boyce H. Grier, Region III



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COPY SENT REGION

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DRESDEN UNIT 2
INCIDENT NO.U2-71-46

# HYDRAULIC SHOCK TO SHUTDOWN COOLING SYSTEM

## Summary

At 2058 on 9-28-71, while at a load of 384 MWe and while surveillance testing was in progress on the timing of the shutdown cooling system isolation valves, a vibrational shock was felt in the control room. Simultaneously, there were indications of effects on the reactor system, including a vibration alarm on "A" recirculation pump. The pump was shut down and on the following morning a review was made of the situation. At this time, it was concluded that an inspection of the shutdown cooling system components and related system inside the drywell would be prudent.

The unit was taken off system at 1703 on 9-29-71 and the reactor placed in the cold shutdown condition, drywell de-inerted and cooled for inspection. The visual inspection of the drywell revealed about 8' of morror insulation dislocated immediately upstream of penetration X-111B and downstream of the shutdown cooling isolation valve MO2-1001-1B. Subsequent magnetic particle inspection of the two elbow welds in this location and stress analysis indicated no distress of this piping or related "A" recirculation piping. "A" recirculation pump was subsequently operated at 28% (minimum) speed and vibrational measurements were taken. The results of these measurments were satisfactory. The review of the events and inspections by GE and CE (SRB and NRB) concluded that no damage had been sustained by the primary system or the shutdown cooling system inside or outside the drywell and that the reactor could be safely returned to service.

A review of the sequence of testing isolation valves could not explain all of the indicated effects; however, it was concluded that a water hammer must have occurred as a result of the testing. It was further concluded that the testing of these valves should be conducted in the future only with the reactor cooled down to normal shutdown system operating temperatures.

Plant startup was authorized after concurrence by the NRB; however, the NRB did require that all seven shutdown cooling system valves be closed electrically and then checked for proper seating. This was done and proper seating did occur on electrical operation. AEC Region III Compliance was informed of our intent to restart and after a discussion of the findings with them, they had no objection.

Conditions Prior to the Incident

| | |
|---|---|
| Reactor Power, MWt | 1262 |
| Unit Load, MWe | 384 |
| Feedwater Flow $10^6$ lbs/hr | 4.57 |
| Vessel Water Level, In. | 30.9 |
| Total Core Flow, $10^6$ lbs/hr | 49.1 |
| "A" Recirculation Flow ($10^3$ GPM) | 20.8 |
| "B" Recirculation Flow ($10^3$ GPM) | 20.8 |

Valve timing surveillance involved seven valves: the MO isolation valves inside the drywell MO-2-1001-1A and 1B which are located close to their respective line (2-1001-16A and B) connections to recirculating pump suction piping for pumps "B" and "A" respectively, shutdown pump suction valves MO-2-1001-2A, 2B, and 2C which are isolation valves located outside the drywell, and the shutdown heat exchanger outlet isolation valves MO-2-1001-5A and 5B which are located outside the drywell. The sequence of testing (open and then close) was as follows:

1. All valves verified closed prior to start at approximately 2045 on 9-28-71. The high temperature interlock was moved up to permit valve movement.

2. 1A Open - Timed

3. 1A Closed - Red lite remained on with green lite

4. 1A Open - Approximately same time as Item 2 to open verifying valve closure in step 2 and limit switch problems

5. 1A Closed - Red lite remained on with green lite

6. 1B, 5A, 5B, 2A, 2B and 2C opened and closed in sequence to obtain timing.

7. Open 1A - Took approximately same time as in Item 2 for full open indication.

8. Close 1A - Felt vibrational shock in control room immediately following switch closure actuations (2058 on 9-28-71)

15 minutes lapsed time

Valve red light remain on?

Investigation and Action Immediately Following the Incident

Recorder computer and annunciator indications were as follows:

1. RPS channel "A" trip
2. 2/6 x $10^3$ gpm spike up on "A" Recirculating Pump flow
3. 5 psi spike up on Condensate Demineralizer $\Delta$ P
4. 8 x $10^5$ lbs/hr spike up on total feedwater flow
5. 3-inch spike down on Reactor Water Level
6. High vibration alarm on "A" Recirculating Pump (alarm set at 3 mils)
7. 0.5 psi spike up on Core $\Delta$ P
8. 2% spike up on APRM
9. Reactor low water level sensor "C" trip and reset after 8 cycles

No other recorders or indications reflected a change at the time of the disturbance.

Following is an account of the actions related to the operation of the shutdown cooling system isolation valves subsequent to the vibrational shock.

1. $350^{\circ}$ interlock at (normal) setting.

2. Checked valve operation which was prevented by the interlock.

3. Set $350^{\circ}$ interlock up

4. Reset isolation trip

5. Opened valve 1A. Full open indicated by red lite.

6. Closed valve 1A. Red and green lites indicated valve closed limit switch was not made up.

7. Startup engineer and operator proceeded to MCC-28-1 and held in the closing contactor on valve 1A for two seconds. The valve 1A then indicated fully closed (green lite on, red lite off). RPS channel "A" tripped and after resetting of this channel, a review of normal operations of all reactor systems was made. In addition, an audit of the existing status of nearby rooms was made. A request was made to the load dispatcher to drop load to comply with the operating procedure requirements for shutdown of "A" recirculating pump following vibration alarm.

   At 2120, the speeds on "A" and "B" recirculating pumps were reduced to minimum speed to attempt to reset the "A" recirculating pump high vibration alarm. The alarm could not be reset and at 2158, the pump was shut down. At approximately 2330, the alarm was reset when it was realized a separate reset button had to be actuated to reset the trip signal prior to resetting the alarm. It was therefore likely (in view of later pump vibration measurements) that the alarm could have been reset prior to pump shutdown.

   The following items were checked immediately in an attempt to determine the cause of the shock:

   (a) Communicated with the construction department on possible blasting. None had occurred. (A later blast near the 138 KV yard tripped 138 KV line 1207 but no vibration was felt in the control room).

(b) Transformers (no observable distress).

(c) Auxiliary electric room (no observable distress).

(d) Turbine trackway (crane movement was reported, but no movement was in progress at the time and there was no observable distress).

(e) Shutdown cooling heat exchanger room and pump room. No damage was noted, however, the "B" pump inlet and discharge piping was warm to the touch, whereas "A" and "C" were at ambient temperature. It was also noted that "A" pump discharge pressure was 175 psig and slowly decreasing, "B" pump discharge pressure was 0, and "C" pump discharge pressure was 50 psig and steady. (At a later date, an operator reported that the "A" and "C" pressures had previously been somewhat lower than these reported values.)

Investigation for Possible Damage

On 9-29-71, a thorough visual inspection was made of the shutdown cooling system piping, equipment, piping supports, insulation and connections to LPCI piping and drywell penetrations (which were also leak tested). These inspections showed no visible distress with the exception of the 2A heat exchanger. The holddown bolts of this heat exchanger were bent to the south and a small corner segment of the concrete support (~6" x 4" x 3") was cracked but was still in place. The crack did not appear to communicate with the holddown bolts.

On 9-30-71, a thorough visual inspection was made of piping and equipment inside the drywell. No abnormalities were noted except for an 8' section (3 pieces) of mirror insulation which had become loosened from the pipe. The impressions on the insulation plus scoring of the pipe at the support saddle showed that abnormal movement of this section had occurred in the amount of 5/8". No permanent set was observable in the piping. The 1A valve was operated to determine by visual observation valve movement and limit switch operation. The valve was closed seven times. The red position indicating light (closed light) was cleared only 3 out of the 7 times. The valve was fully seated in all cases. This was verified by attempting to manually "pull up" on the valve operator.

On 10-1-71, the two welds at the elbow in line 2-1001-16B were magnetic particle inspected and no defects found.

The "A" recirculation pump was operated at 28% speed and vibration data were taken. This data was the same as that taken during the preoperational tests. The highest vibration noted was only 0.6 mils which compared favorably with the preoperational data. (The motor maximum vibration was only 0.7 mils.)

The station maintenance crew checked the 1A valve operation and limitorque operator. It was concluded that the valve motor was being tripped on high torque because of valve seating prior to engaging the closed limit switch. The 2B valve, which could not be opened when attempting to place the shutdown system in operation on 9-30-71, was repaired after inspection showed mechanical problems in the limitorque operator.

Sargent & Lundy Engineers calculated the stresses in the shutdown loop piping. The movement indicated by the inspection of the piping was used as input to this analysis. The highest stress calculated was 16,715 psi, well within the yield strength of the material. The calculational results of the stress analysis were discussed with General Electric engineers. Based on this discussion, General Electric concluded that no stresses of concern could be developed within the recirculation system piping or its connections. General Electric made a detailed calculation using as input the data supplied by Sargent & Lundy. The magnitude of stresses at areas of interest at the connection to the recirculation piping were determined. It was concluded from the analysis that no significant stresses occurred and that further examination of the recirculation piping was not justified.

does this mean below code yield values?

On 10-2-71, the results of the visual observations and the stress calculations were presented by the Review Committee which consisted of Phil Barrow (GE), N. A. Kershaw (CE), R. Mazza (S&L), and C. B. Zitek (CE). Other contributing and interested parties to this review included G. L. Redman, G. Wagner, and O. W. Dodd (CE), and R. J. Ascherl (GE). The review committee concluded that the plant could safely be returned to service and that no further inspections were required.

The SRB reviewed the results of the visual observations and stress analysis. Following their review, the SRB concurred with the findings of the review committee and recommended that the NRB review this matter.

On 10-2-71, the NRB concurred with the SRB that the plant could be returned to operation, but requested that a full closure

of all shutdown cooling system isolation valves be performed to verify all valves operated properly.

In addition to the above check, each heat exchanger was placed in service to check for possible leakage. Leakage was checked by monitoring the water level in the head tank of the RBCCW system. No change in level was noted and therefore no leakage exists.

Hypothesis for Water Hammer

The last use of the shutdown cooling system was on July 22, 1971. It has been the normal practice following operation to leave the reactor coolant side of the heat exchangers full of water.

Reviewing the valve operating sequence, it can be hypothesized that between 7-27-71 and 9-38-71 the "B" heat exchanger partially drained due to valve leakage. Since the -1 and -2 valves (see attached figure) remained closed during this period, it is assumed that the header was initially full and became pressurized when the 1A and 1B valves were opened. The opening of 5A and 5B valves had no effect since the LPCI check valves were closed. The opening of the 2A,B & C valves allowed the pressure in the header to be impressed on the A & C heat exchangers. (Pump discharge pressures were noted at 175 and 59 psi respectively, after the incident, whereas B was at 0 psig, and pumps A & C had previously been noted to be at pressures lower than 175 and 50 respectively.) Since the "B" heat exchanger was partially drained, the pressure did not increase, but some flow passed through the pump (warming of the lines were noted following the incident) and into the partially drained heat exchanger.

The 2B valve is in a vertical section of piping and when fully opened might have allowed an air bubble to form in the suction header assuming the header had been sufficiently depressurized. However, it is more likely that the header was still partially pressurized (since "C" shutdown pump increased to 50 psi and suction valve was opened after "B"), and that partial venting of the header to the void in the "B" heat exchanger allowed some hot water in the header to flash to steam as the pressure was dropped to 50 psi. This flashing resulted in a steam bubble in the header which was collapsed when the 1A valve was opened. Opening Valve 1A allowed water to rush in the header toward the 1B valve (close to the "A" recirculating water pump) resulting in a mild thrust at that

end of the pipe (verified by the dislocated insulation). This would account for the "A" recirculation pump high vibration.

The above hypothesis is born out by the visual observations. The fact that bent holddown bolts were found in the "A" heat exchanger foundation cannot be logically related to the known facts as being caused by the valve surveillance testing, and it is concluded that the bolts were bent prior to the incident. No vibrational shock occurred at any time during the first complete testing sequence. It is therefore concluded that "A" heat exchanger s uffered no shock whatever at the time in question, and that the bent bolts could have been related more logically to fit-up problems during construction. In addition, when the 1A valve was open, at the time of the occurrence, the 2A, B, and C valves were fully closed. Therefore, no flow or pressure could have been impressed on the heat exchanger at the exact time of the vibrational shock.

It is difficult to comprehend any mechanism for transmitting a rather mild thrust of the header in the drywell all the way to the control room. No one can recall feeling any shock when a hydraulic surge severely damaged the Unit 2 HPCI steam piping which was located outside the drywell.

It is possible that the "A" recirculation pump vibration alarm had come up when the 1A valve was opened, but with the diversion of operator attention while operating the valve to check opening and closing indications and timing, it was not immediately recognized prior to the shock felt a few seconds later.

The fact remains that a large shock was felt in the control room and in other plant areas. Several transmitter (listed below) were checked to determine their sensitivity to vibration with the conclusion that vibration of the transmitters themselves could not have induced the recorded spikes.

"A" Reciculation loop flow
Core $\Delta$P
Reactor Level
Feedwater Flow
Condensate Demineralizer $\Delta$P

It is difficult to explain why the disturbances were in the "A" recirculation loop, or in fact, how such an apparently small surge of water flow in the header could actually result in the "A"

recirculation pump flow spikes, core flow spikes and low water level and flux spike indications. (The feedwater flow would properly spike in response to the G-MAC reactor level drop.)

At the present time, there is no satisfactory explanation of the recorded disturbances and shock felt in the control room, although the movement of the shutdown system header with resultant dislocation of some of the mirror insulation may be explained by the information accumulated.

STRAINER
GRAB SAMPLE

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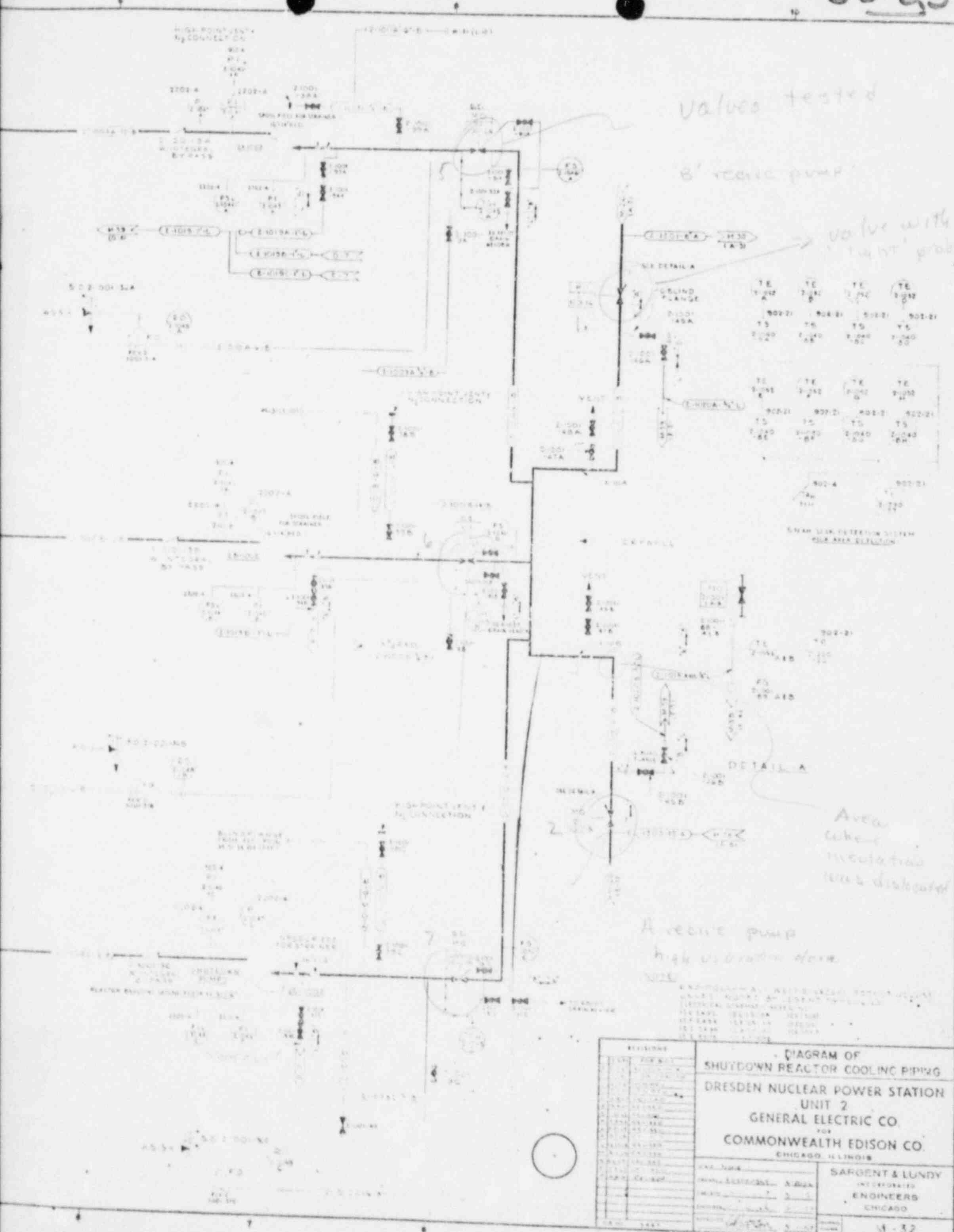

Valves tested
8' recirc pump
valve with
DETAIL A
BLIND FLANGE
VENT
HIGH POINT VENT & N2 CONNECTION
A recirc pump high vibration alarm
Area
NOTES
DIAGRAM OF SHUTDOWN REACTOR COOLING PIPING
DRESDEN NUCLEAR POWER STATION UNIT 2
GENERAL ELECTRIC CO.
FOR
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS
SARGENT & LUNDY
INCORPORATED
ENGINEERS
CHICAGO
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