Attachment #1

GPU Service

April 16, 1979

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FROM: R. L. Long

PRELIMINARY SEQUENCE OF EVENTS
TMI 2 ACCIDENT OF MARCH 28, 1979

Attached is a Preliminary Sequence of Events spanning the first approximately twenty hours following the TMI-2 accident which was initiated at 4:00 a.m. on March 28, 1979.

For this chronology of events, a reference clock was established with the time of the turbine trip, 0400:37, defined as time zero. The time of each event in the sequence is given as the number of hours, minutes and seconds relative to 0400:37, followed in parenthesis by the real time using a 24-hour clock. For example, 1:52:43 p.m. on March 28 would be written "9:52:06 (1352:43)." Depending upon the accuracy of the source of data for each event, the times appear alone or with the notation "approximate."

The sequence has been reconstructed from various information and data sources, including control room logs, strip chart recorders, alarm printouts and reactimeter printouts. Please note, however, that the alarm printer was out of service from 01:13:27 (0513:59) to 02:47:31 (0648:08) and during the course of the accident was running well behind the actual time of events. Efforts to annotate this chronology and to develop graphs of various plant parameters as a function of time are underway. This additional information will be provided as soon as it is available and we will keep you informed of our progress.

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-00:05:00
(0355:36)

Three Mile Island Unit Two was at 97% power with the Integrated Control System in full automatic. Rod groups one thru five were fully withdrawn, rod groups six and seven were 95% withdrawn and rod group eight was 27% withdrawn. Reactor Coolant System total flow was approximately 107.5% of design flow and the Reactor Coolant System pressure was 2155 psig. Reactor Coolant Makeup Pump B (MU-P-1B) was in service supplying makeup and Reactor Coolant Pump Seal injection flow. The Reactor Coolant System soluble boron concentration was approximately 1030 parts per million. Pressurizer Spray Valve (RC-V1) and the pressurizer heaters were in manual control while spraying the pressurizer to equalize boron concentrations between the pressurizer and the remainder of the Reactor Coolant System. Normal Reactor Coolant System letdown flow was established.

Steam Generator parameters were as shown in the following table:

	Steam Generator A	Steam Generator B
Loop Feedwater	5.7459 MPPH*	5.7003 MPPH*
Operating Level	56%	57.4%
Startup Level	158.8 inches	163.4 inches
Steam Pressure	910 psig	889.6 psig
Feedwater Temperature	462.7F	462.7F

* MPPH is Million Pounds Per Hour

Steam Generator Feedwater Pumps (FW-P-1A and FW-P-1B) were in service, Condensate Booster Pumps (CO-P-2A, CO-P-2B and CO-P-2C) were in service, and Condensate Pumps (CO-P-1A and CO-P-1B) were in service. An attempt was being made to clear a clogged resin transfer line in the standby demineralizer.

-00:00:01 (0400:36) Condensate Pump A (CO-P-1A) stopped.

-00:00:01 (0400:36) Feedwater Pumps (FW-P-1A and FW-P-1B) stopped at essentially the same time resulting in a loss of feedwater flow to both steam generators.

00:00:00 (0400:37) Main Generator was tripped followed by a turbine trip.

00:00:00 (0400:37) Three Emergency Feedwater Pumps (EF-P-1, 2A, 2B) started.

00:00:03 (0400:40) Approximate The Electromatic Relief Valve (RC-RV2) opened at the setpoint of 2255 psig.

00:00:08 (0400:45) Reactor tripped on high pressure at 2345 psi. Setpoint is 2355 psi.

00:00:08 (0400:45) Approximate The operator placed the Pressurized Spray Valve (RC-V1) and pressurizer heaters under automatic control.

00:00:13 The operator started the Reactor Coolant Makeup Pump A (MU-P-1A), opened High Pressure Injection Isolation Valve A (MU-V16A) and isolated letdown flow in anticipation of the expected pressurizer level decrease.

00:00:13 (0400:50) Approximate	The Electromatic Relief (RC-RV2) solenoid de-energized giving a non-open indication to the control room operators. The Electromatic Relief Valve (RC-RV2) should have reseated at about this time (closure setpoint of 2205 psig).
00:00:14 (0400:51)	The Emergency Feed Pumps (EF-P1, 2A and 2B) achieved normal discharge pressure.
00:00:15 (0400:52) Approximate	Water hammer in the condensate piping occurred.
00:00:30 (0401:07)	Pressurizer Safety Valve (RC-RV1B) and Electromatic Relief Valve (RC-RV2) discharge line temperature alarms printed out.
00:00:38 (0401:15) Approximate	Steam Generator A level reached the 30-inch setpoint where the Emergency Feedwater Valves (EF-V11A and EF-V11B) open. Feedwater was not admitted because Emergency Feedwater Block Valves (EF-V12A and EF-V12B) were shut.
00:00:39 (0401:16)	Reactor Coolant Makeup Pump A (MU-P-1A) was stopped.
00:00:40 (0401:17) Approximate	Steam Generator B level reached the 30-inch setpoint where the Emergency Feedwater Valves (EF-V11A and EF-V11B) open. Feedwater was not admitted because Emergency Feedwater Block Valves (EF-V12A and EF-V12B) were shut.
00:00:41 (0401:18)	Reactor Coolant Makeup Pump A (MU-P-1A) was restarted. With Reactor Coolant Makeup Pumps A and B (MU-P-1A and MU-P-1B) operating, pressurizer level rate of decrease slowed.

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00:01:00 (0401:37) Approximate	Pressurizer level started increasing. Reactor Coolant System hot leg and cold leg temperatures reached 575F. Reactor Coolant Drain Tank pressure was increasing.
00:01:00 (0401:37)	The Pressurizer Safety Valve (RC-RV1A) high discharge line temperature alarm was received.
00:01:26 (0402:03)	Reactor Coolant Drain Tank temperature normal alarm printed out.
00:01:45 (0402:22) Approximate	Steam Generators A and B have boiled dry at this time.
00:02:01 (0402:38)	Reactor Coolant Makeup Pump B (MU-P-1B) was stopped due to Engineered Safeguards actuation.
00:02:04 (0402:41)	High Pressure Injection Pump C (MU-P-1C) started automatically.
00:03:12 (0403:49) Approximate	Reactor Coolant Drain Tank Relief Valve (WDL-R1) lifted at 120 psig.
00:03:14 (0403:51)	High Pressure Injection portion of Engineered Safeguards was manually bypassed. Both Reactor Coolant Makeup Pumps A and C (MU-1P-1A and MU-P-1C) were operating.
00:03:26 (0404:03)	Reactor Coolant Drain Tank high temperature alarm received at 127.2F.
00:04:38 (0405:15)	Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.
00:04:38 (0405:15) Approximate	The operator throttled the High Pressure Injection Isolation Valves (MU-V16's).

00:04:52 (0405:29)	Intermediate Closed Cooling Pump (IC-P-1A) started.
00:04:58 (0405:35)	First alarm indication received that letdown had been secured.
00:05:06 (0405:43)	Presurizer level stopped its sharp increase at 376 inches and began to turn down. It reached a minimum of 372 inches and then started back up at 5 minutes, 21 seconds into the transient.
00:05:15 (0405:52)	Condensate Booster Pump B (CO-P-2B) tripped.
00:05:50 (0406:27) Approximate	Reactor Coolant System pressure stopped its sharp decrease and began to turn up. Minimum value reached was approximately 1350 psig.
00:05:54 (0406:31)	Pressurizer level increased beyond the range of the instrument indication.
00:06:58 (0407:35)	Letdown flow of 71.4 gallons per minute was re-established.
00:07:31 (0408:06)	Reactor Building Sump Pump A (WDL-P-2A) started.
00:08:00 (0408:37) Approximate	Emergency Feedwater Block Valves (EF-V12A and EF-V12B) were opened.
00:08:15 (0408:52)	Reactor Coolant System hot leg and cold leg temperatures began to decrease.
00:08:30 (0409:07)	Reactor Coolant System pressure began to decrease.
00:10:00 (0410:37)	Pressurizer level came on scale.

00:10:19 (0410:56) Reactor Building Sump Pump B (WDL-P-2B) started.

00:10:24 (0411:01) Reactor Coolant Makeup Pump A (MU-P-1A) tripped.

00:10:27 (0411:04) Reactor Coolant Makeup Pump A (MU-P-1A) was started.

00:10:28 (0411:05) Reactor Coolant Makeup Pump A (MU-P-1A) tripped.

00:10:40 (0411:25) Reactor Building Sump high level alarm received. Setpoint is 4.650 feet.

00:11:40 (0412:17) Reactor Coolant Makeup Pump A (MU-P-1A) was started.

00:14:50 (0415:27) The Reactor Coolant Drain Tank rupture diaphragm (WDL-U26) failed.

00:24:58 (0425:35 Relief Valve (RC-RV2) outlet temperature. The reading was 285.4F.

The operator requested computer printout of the Electromatic

00:25:00 (0425:37) Approximate Intermediate Cooling System high radiation alarm annunciator received at the Radiation Monitor Panel.

00:36:08 (0436:45) Emergency Feedwater Pump 2B (EF-P-2B) was stopped.

00:38:10 (0438:47) Reactor Building Sump Pump A (WDL-P-2A) was stopped.

-00:38:11 (0438:48) Reactor Building Sump Pump B (WDL-P-2B) was stopped.

01:10:54 (0511:31) Reactor Building air cooling coils emergency discharge alarm printed out.

01:13:29 (0514:06) Reactor Coolant Pump 2B (RC-P-2B) was stopped.

01:13:42 (0514:19) Reactor Coolant Pump 1B (RC-P-1B) was stopped.

01:13:27 (0513:59) The alarm printer became unavailable at this time and remained out of service until 02:47:31 (0648:08).

01:20:31 Operator requested printout of the Electromatic Relief Valve (RC-RV2) outlet temperature. The reading was 283.0F.

01:40:37 (0541:14) Reactor Coolant Pump 2A (RC-P-2A) was stopped.

01:40:45 (0541:22) Reactor Coolant Pump 1A (RC-P-1A) was stopped.

01:42:00 (0542:37) Approximate Operator started raising Steam Generator A level from 30 inches on the Startup Range to 50% on Operating Range. Reactor Coolant System Loops A and B cold leg temperatures both started decreasing. Reactor Coolant System pressure started decreasing.

01:54:00 (0554:37) Approximate Reactor Coolant System Loop A hot leg temperature began increasing.

02:00:00 (0600:37) Approximate Steam Generator A level reached 50% on Operating Range.

02:00:00 (0600:37) Reactor Coolant System Loop B hot leg temperature began increasing.

02:12:00 (0612:37) Reactor Coolant System Loop B hot leg temperature increased to offscale at 620F.

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02:17:53 (0618:30) Operator requested Electromatic Relief Valve (RC-R2) outlet temperature. The reading was 228.7F.

02:22:00 (0622:37) Approximate The Electromatic Relief Block Valve (RC-V2) was shut.

02:30:00 (0630:37) Operator started increasing Steam Generator B from 30 inches on Startup Range to 50% on Operating Range.

02:45:00 (0645:37) Approximate Several radiation alarms were received.

02:45:00 (0645:37) Approximate Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

02:45:00 (0645:37) Approximate Operator opened Main Steam Isolation Valves (MS-V6B and MS-V7B).

02:50:00 (0650:37) Approximate Site Emergency was declared. Notifications to offsite authorities and organizations were initiated.

02:51:57 (0652:34) Operator attempted to start Reactor Coolant Pump 2A (RC-P-2A). Pump would not start.

02:53:19 (0653:53) Operator attempted to start Reactor Coolant Pump 1B (RC-P-1B). Pump would not start.

02:54:09 (0654:46) Operator started Reactor Coolant Pump 2B (RC-P-2B).

02:54:49 (0655:26) High Pressure Injection Engineered Safeguards actuation logic reset on increasing Reactor Coolant System pressure.

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02:56:19 (0656:56) Approximate	Steam Generator B was isolated. Main Steam Isolation Valves (MS-V4B and MS-V7B) were shut.
03:00:00 (0700:37) Approximate	Reactor Coolant System pressure increased to 2130 psig.
03:03:39 (0704:16) Approximate	Steam Generator A pressure control was shifted from the Turbine Bypass Valves (MSV-25A and B and MSV-26A and B) to the Power Operated Emergency Main Steam Dump Valves (MSV-3A and B).
03:10:27 (0711:04)	Emergency Feedwater Pump 2A (EF-P-2A) was stopped.
03:12:28 (0713:05) Approximate	Electromatic Relief Block valve (RC-V2) was opened.
03:12:53 (0712:53)	Reactor Coolant Pump 2B (RC-P-2B) was stopped.
03:20:13 (0720:41)	Reactor Coolant Makeup Pump C (MU-P-IC) was started. Reactor Coolant Makeup Pumps C and A (MU-P-C and A) were operating.
03:23:23 (0724:00) Approximate	General Emergency was declared. Notifications to offsite authorities and organizations were initiated.
03:30:00 (0730:37) Approximate	Electromatic Relief Block Valve (RC-V2) was shut.
03:35:08 (0735:43)	Emergency Feedwater Pump 2A (EF-P-2A) was started.
03:37:00 (0737:37)	Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.
03:51:00 (0751:37) Approximate	Electromatic Relief Block Valve (RC-V2) was opened.

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03:55:39 (0756:16) Engineered Safeguards actuated on low RCS pressure. Setpoint is 1640 psig.

03:55:39 (0756:16) The Reactor Building high pressure isolation signal actuated and isolated the Reactor Building. The Reactor Building isolation set point is 4 psig.

03:56:04 (0756:41) Reactor Coolant Makeup Pump C (MU-P-1C) was started.

03:59:23 (0800:00) Reactor Building Emergency Cooler B was shutdown.

03:59:53 (0800:30) Reactor Building Emergency Cooler B was started.

04:06:00 (0806:37) Electromatic Relief Block Valve (RC-V2) was shut.

04:08:37 (0809:14) Reactor Coolant Pump 1A (RC-P-1A) was started.

04:09:14 (0809:51) Reactor Coolant Pump 1A (RC-P-1A) was stopped.

04:17:17 (0817:54) Reactor Coolant Makeup Pump A (MU-P-1A) was stopped.

04:17:22 (0817:59) Reactor Coolant Makeup Pump C (MU-P-1C) was stopped. No makeup pumps operating.

04:18:17 (0818:54) Operator attempted to start Reactor Coolant Makeup Pump A (MU-P-1A). The pump would not start.

04:18:30 (0819:07) Approximate Electromatic Relief Block Valve (RC-V2) was opened.

04:21:53 (0818:30) Reactor Coolant Makeup Pump B (MU-P-1B) was started.

04:26:59 (0827:36) Approximate Reactor Coolant Makeup Pump C (MU-P-1C) was started, tripped, and was restarted.

04:30:00 (0830:37) Approximate The Electromatic Relief Block Valve (RC-V2) was shut.

04:30:45 (0831:22) Condenser Vacuum Pumps 1A and 1C (VA-P-1A and VA-P-1C) were stopped and vacuum was broken.

04:30:45 (0831:22) Approximate Power Operated Emergency Main Steam Dump Valve (MS-V3A) was opened.

04:54:00 (0854:37) Approximate The Electromatic Relief Block Valve (RC-V2) was opened.

05:18:00 (0918:37) The Electromatic Relief Block Valve (RC-V2) was shut.

05:54:00 (0954:37) Approximate Operator commenced filling Steam Generator A to 99% on the Operating Range instrumentation.

07:30:00 (1130:37) Approximate Electromatic Relief Block Valve (RC-V2) and the Pressurizer Spray Valve (RC-V1) were opened.

08:11:26 (1212:03) Core Flood Tank A high level alarm was received.

08:30:00 (1230:37) Power Operated Emergency Main Steam Dump Valve (MS-V3A) was shut.

08:31:06 (1231:43) Decay Heat Removal Pumps 1A and 1B (DH-P-1A and DH-P-1B) were started.

08:54:56 (1255:33) Core Flood Tank A alarm printed out at a level of 13.13 feet.

09:04:18 (1304:55) Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

09:49:44 (1350:21) Reactor Building Isolation and Containment Spray were actuated by Engineered Safeguards. Engineered Safeguards actuation started Reactor Coolant Makeup Pump C (MU-P-1C) and Reactor Building Spray Pumps A and B (BS-P-1A and BS-P-1B).

09:49:50 (1350:27) Reactor Building Spray Valves (BS-V1A and BS-V11B) opened.

09:49:58 (1350:35) Reactor Coolant Pumps 1A and 1B (RC-P-1A and RC-P-1B) inlet air temperature high alarms annunciated and Pressurizer Safety Valves (RC-R1A and RC-R1B) discharge line temperature high alarms annunciated.

09:50:24 (1351:01) Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

09:55:30 (1356:07) Reactor Building Spray Pumps A and B (BS-P-1A and BS-P-1B) were stopped.

09:56:58 (1357:35) Decay Heat Removal Pumps A and B (DH-P-1A and DH-P-1B) were stopped.

10:24:00 (1424:37) Approximate Reactor Coolant System hot leg Loop A temperature decreased to within the instrumentation range.

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10:31:25 (1432:02) Reactor Coolant Makeup Pump C (MU-P-1C) was started. Reactor Coolant pressure was approximately 440 psig.

10:35:55 (1436:32) Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

11:06:00 (1406:37) Approximate Pressurizer level started decreasing.

11:12:00 (1512:37) Approximate Reactor Coolant System cold leg Loop A temperature started to increase from 200F to 400F. Reactor Coolant System hot leg Loop A temperature decreased from above the instrument range to 560F.

11:18:34 (1519:11) Reactor Coolant Makeup Pump C (MU-P-1C) was started.

11:24:00 (1524:37) Approximate Pressurizer level stopped decreasing at 180 inches and started increasing, going off scale during the next hour.

11:28:12 (1528:49) Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

11:32:37 (1533:14) Reactor Coolant Makeup Pump C (MU-P-1C) was started.

11:35:48 (1536:25) Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

11:36:00 (1536:37) Approximate Operator commenced filling Steam Generator B to 97% on the Operating Range instrumentation.

12:00:00 (1600:37) Approximate Steam Generator A level was 97% on the Operating Range.

12:48:00 (1648:00) Approximate Pressurizer level came on scale.

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13:08:22 (1708:59) Approximate — Normal steam generator feedwater supply was put in service.

13:13:10 (1713:47) — Condenser Vacuum Pump 1A (VA-P-1A) was started.

13:23:04 (1723:41) — Reactor Coolant Makeup Pump C (MU-P-1C) was started.

14:43:15 (1843:52) — Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

14:54:00 (1854:37) Approximate — RCS pressure reached 2350 psig.

15:24:00 (1924:37) — Reactor Coolant Pump 1A (RC-P-1A) was started.

15:24:10 (1924:47) Approximate — Reactor Coolant Pump 1A (RC-P-1A) was stopped.

16:04:00 (2008:37) — Reactor Coolant Pump 1A (RC-P-1A) was started.

22:15:00 (0215:37) Approximate — Reactor Coolant System and Steam Generator conditions were:

Reactor Coolant System pressure = 1165 psig.

Pressurizer Temperature = 551F (pressurizer heaters maintaining temperature).

Pressurizer Level = 397 inches.

Reactor Coolant System cold leg Loop A temperature = 288F

Steam Generator A steaming to the Main Condenser.

Steam Generator B isolated.

Reactor Coolant Makeup Pump B (MU-P-1B) operating to supply Reactor Coolant Pump seal injection flow.

Reactor Coolant System cold leg Loop A temperature = 256.4F.

Reactor Coolant System cold leg Loop B temperature = 252.4F.

Reactor Coolant System hot leg Loop A temperature = off scale low, i.e.,less than 520.0F.

Reactor Coolant System hot leg Loop B temperature = off scale low, i.e.,less than 520.0F.