G/712-8-4

Inter-Office Memorandum

Date January 23, 1979

GPU Service

Subject Three Mile Island Nuclear Station Unit 2 - Startup Test Program History and Delay Analysis

To Mr. R. C. Arnold

Location Parsippany TMI-2/4022

Enclosures:

(1) Summary Chronology of TMI-2 In Plant Activities; 2/8/78 through 11/16/78

(2) TMI-2 Test Program Chronology Bar Chart

(3) Power/Mode Histogram of TMI-2, 2/1/78 through 11/16/78

(4) List of Delays to TMI-2 Test Program Due to Problems Encountered (2/1/78 - 11/16/78)

(5) Test Program Critical Path Assuming Main Steam Safety Valves Function Properly - Worst Case

(6) Test Program Critical Path Assuming Main Steam Safety Valves Function Properly - Most Optimistic

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This is in response to your request for a detailed analysis of the TMI-2 Startup Test Program and delays thereto which have caused interruptions to the schedule.

The GPUSC Startup and Test Scheduling Engineer, Tom Faulkner, and I reviewed the Met-Ed TMI-2 Shift Foreman's Log and the GPUSC Startup and Test Shift Test Engineer's Log for the period 2/8/78 through 11/16/78 and developed a summary chronology, Enclosure (1), which lists the major activities as they occurred. From this chronology, a TMI-2 Test Program Chronology Bar Chart, Enclosure (2), was developed. This chart graphically displays the Test Program as it actually occurred along with problems which were encountered. (Note that the original Test Program Schedule envisioned a 120 day program. This was based on the TMI-1 Test Program experience and did provide some minimal amount of time for delays. Various conditions can be expected to cause delays during any startup program. I have attempted to select only those equipment problems which caused, or could have caused, delays in the TMI-2 Test Program.)

Enclosure (3) is a Power/Mode Histogram for your information.

On Enclosure (2) I have indicated in bold lines what I believe to be the actual critical path between 2/1/78 and 11/16/78. For clarity, I have chosen not to indicate on this critical path those problems which occurred during any test phase if they, by themselves, only amounted to a few days delay at a time. In these cases, the critical path is shown to continue along the test phase path.

Enclosure (4) is a listing of those problems shown on Enclosure (2) along with my evaluation of the period of time delay actually associated with each problem and the potential delay it, by itself, would have caused had it not been entirely or partially included under an umbrella of other problems at the same time.

Enclosures (5) and (6) project critical path scenarios predicting what I believe would have been the course of events had we not experienced the Main Steam Safety Valve problem and subsequent retrofit modification. In these cases, the inadequacy of the steam line steam hammer restraints, discovered in mid-1978, and the notification by B&W of potential loose parts (orifice rod assemblies and burnable poison rod assemblies) in the reactor internals and subsequent rectification, would have had a much more serious impact on our Test Program schedule. Enclosure (5) shows a "Worst Case" scenario and Enclosure (6) shows a "Most Optimistic" scenario. The results of these studies show that, because of problems encountered in the Test Program other than the safety valve failure, the safety valve problem itself was solely responsible for a period of delay on the order of 20 to 39 days. An explanation of these hypothetical critical paths and the actual critical path is attached to the respective enclosures.

The following persons have been consulted in performing this review:

J. J. Barton - GPUSC TMI-2 Project Manager
T. Faulkner - GPUSC Startup and Test Scheduling Engineer
A. S. Dam - B&R TMI-2 Project Manager
W. R. Cobean - B&R, Vice President
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Enclosure (1)

SUMMARY CHRONOLOGY OF

TMI-2

IN PLANT ACTIVITIES

2/8/78 THROUGH 11/16/78

		ACTIVITY	
FEB	MAR		
8		Normal preparations for fueling - Reactor Vessel filled (Received NRC Operating License)	1/3
9		MEC working on fuel transfer carriages to support fuel load	1
10			1
11	6	1st Fuel assem. in core	
12			
13			
14		Last Fuel assem. in core Commence preparations for Rx head installation	
15		Core barrel installation complete	
16		Rx head installation begins	
	7		

		ACTIVITY
FEB	0	Rx head installed, not torqued
17		Rx head bolt torquing begins
18	5	Rx head installation complete Commenced RCS fill & vent & CRDM coupling
19		Started installing incore closures Completed coupling APSR's
20		Completed torquing all incore closures Energized pressurizers for loop fill RCS filled - to be vented
21		Commenced venting CRD's & RCS instrumentation
22		Completed venting CRD's at low RCS temp./pressure Begin raising RCS temp./pressure
23		
24		Began running RCP's. Noted noise on LPRM. B&W advised secure pumps until analyzed. Pumps out of service caused slower heatup rate
25		Restarted RCP's and heated up to <200°F Commenced CRD functional testing

		ACTIVITY	
FEB 25		Completed venting CRD's at RCS temp. <200°F, >400 psig Commenced filling OTSG for secondary side hydro re-test	
26			2/3
27		Pressurized A&B OTSG's to 900 psig - Manways/Handholes satisfactory, other packing & seat leaks noted Pressurized A&B OTSG's to 950 psig, noted leaks, vented OTSG to fix leaks	1/3
28		Continued CRD Functional Testing	
MAR 1		RCP operational tests completed CRD Functional Testing Completed, Start CRD Trip Tests	
2			
3		Completed CRD Trip Tests, Raising RCS pressure for hydro	1/3
4		Commenced RCS hydro, completed inspection, noted leaks, commenced depressurization (Cooldown & drain to fix RCP Seal injection Grayloc flange leaks)	1
5		Grayloc flanges fixed, commence RCS fill	1
6		Fill & vent in progress	1

MAR		ACTIVITY	
7		Completed CRDM Venting	1
8		Discovered gland steam leaks. Secured F.W. Heating, gland steam RCS maintained <200% to fix (can't heat up) Commenced gland steam leak repair	1
9		Found caustic leaking from N_2 header in Aux. Bldg. & into bleed tanks Commenced cleanup mode. Completed gland steam leak repair	1
10		Completed cleanup of Caustic (NaOH) in RC Bleed Tanks Commence heat-up to Mode 4	2/3
11	4	Reach Mode 4, first time Rx Bldg. Personnel Access Hatch door seal failed. (Can't change mode 'till fixed) - Tested Sat. at 2230, recommenced heat-up	2/3
12		Chemistry problems with RCS for high sodium - cleaning up two make-up demineralizers	1
13	3 4	Commenced heat-up Reached Mode 3, first time RCP 2A Clutch failure, all pumps secured, plant coasting down	1
14	5	Installed anti-rotation 'I' beam on RCP 2A Lost aux. boiler, causing F.W. out of spec. Commence operating on 3 RCP's	
15	4 3	Draining OTSG due to high phosphates Commenced heat-up Noise noted in OTSG. Cooled down, depressurized, for instrumentation routing repair	1/3 1/3 1/3

		ACTIVITY	
MAR	4	Plant cooldown continues	
	5		
16			1
		(Also looked at RCP-2A during this period)	
17			1
		COMPLETED OTSG INSTRUMENTATION REPAIRS	
		Commenced fill & vent	
18		Completed venting CRD's B&W doing RCP-2A pump shaft runouts & motor checks & seal replacement	1
19			1
		Completed work on 2A & blocked it. Commenced heating & pressurizing RCS	
		Continued heat-up	
	4		
20			1
	3		
21		CRD Rod tests performed	1
		Cooled slightly to fix RCP-1A seismic restraint which bottomed out	
22			2/3
		Commenced Pressurizer Spray test @ 532°F, 1400 psig (Continuing CRD testing) Made other repairs	
23			1
		Completed group rod drop testing	
		RCP flow measurements with 3 RCP's conducted, completed.	1/3
24			
		Depressurizing & cooling down due to leaking Conax connectors	

		ACTIVITY	
MAR			
25	5		1
		Completed Conax connector replacement, tightening	
		Commenced heat-up	
26			1
	4		
	3		
27			1/3
		Started pulling rods to criticallity	
	2	**Initial Criticallity Achieved, first time**	
28		Commenced preparations for zero power physics testing	
		Start reactimeter checkout	
		Complete reactimeter checkout	
		Ran all rods out critical boron concentration test	
29	3	MEC ES testing-fuse blew on 2-1V inverter, Rx trip, ES actuation, (Pressurizer Electromatic Relief Valve Lifted) NaOH contaminated RCS	
		Commenced cleanup of RCS	1/3
30			1
		Discovered Cl^- in RCS due to NaOH contamination, commence plant cooldown	
31			1
		Cooldown, cleanup continues	
	4		
APR	5		
1		Breakdown vacuum to repair aux. steam leak in Unit 1 Satisfactorily tested repaired inverter Torqued OTSG conax connectors	1
		RCS cleanup continues	
2		Begun heating up aux. steam line from Unit 1	1
	4	Continue flushing Na^+ from MU & DH systems	

APR		ACTIVITY	
3		Discovered DH-V-186B/RC-V-149 problems preventing proper pressurizer Spray operation, thus slowing down RCS cleanup progress	1
		Started venting CRDM's, RC-V-149 problems resolved	
4		CRDM venting to clean CRDM's of Na continues	1
		Complete CRDM venting	
5		Condensate & Feedwater cleanup in process	1
		Lost one Aux. Boiler causing F.W. to cool down, delaying F.W. cleanup progress	
6			1
		Started F.W. heating again after Aux. Boiler was fixed	
7		Continuing F.W. cleanup RCS heat-up in progress	1
	3		1/3
8	1 2	Re-established prerequisites for zero power physics testing Zero Power Physics Testing (ZPPT) in progress	
9	3 2 3 2	Group 8 Rod Worth Measurements completed Preparing for Stock Rod Worth Measurements Questionable Reactimeter results discovered	
		Replaced card in reactimeter - prepare for checkout	1, 3
10		Reactimeter still uunsat. NI-3 & 4 swapped on reactimeter - prepare for checkout (Spare reactimeter rec'd on site)	1
11	3 1 2 3	New reactimeter demonstrates same unsat. characteristics Continued ZPPT while attempting to resolve reactimeter problems	1

APR			ACTIVITY	
	3		ZPPT continues	
12	2			
	3			
	2			
	3			
	2			
	3		ZPPT continues	
	2			
13	3			
	2			
	1			
	3			
	2		ZPPT continues	
	3			
14	2			
	1			
	1			
	3		Verified & rechecked reactimeter results from control room	
15	2			
	1			
	3		ZPPT continues	
	2			
	3			
	2		NI cable unction box discovered to have bad connector causing	
16	3		some unsat. reactimeter readings. Problem was corrected.	
	2			
	3		ZPPT continues	
	2			
	3			
	2			
17	3		ZPPT continues	
	2			
	3		Completed ZPPT	
	2			
	3		Begin 0-15% power escalation/testing - Rx Trip @ 2.5% power on	1/3
	2			
18	1	7	Power/Imbalance/Flow	
		9		
		15	Power escalation testing in progress	
	1	7	Rx trip when blowing down suction strainer on Condensate Pump	
	3		(tripped on high pressure)	1/3
19	2		Improper sampling procedure caused delay in recovery	
	1	10	Power Escalation Testing in progress	
		15	Completed turbine data for W	
	1	7	RPS Channel C manually tripped due to bad NI	
	1	7	Rx tripped on Hi flux, Channel D (NI-8)	
20	3			
	1		Delay in recovery due to NI-8 again	1/3
	3			
	1	15	Power Escalation in progress	

			ACTIVITY	
APR	1	15	Turbine Generator synchronized to grid for first time (105 MWe)	
21			15% Power Testing continues	
			Leakage noted at B OTSG Conax connectors	
			Performed Loss of Offsite Power Test	
22	3		Delay in recovery due to NI again	
	1			2/3
	2			
	1	15	T.G. back on line (100 MWe), Completed 0-15% Testing (W/3 RCP's)	
23		20	Begin 15-40% escalation/testing	
		30	**Rx trip on NI power spike,** rapid cooldown, M.S. relief valve excessive blowdown, **ES actuation** on low pressure, NaOH injection, bellows liners blown from M.S. relief valve discharge stacks.	1/3
	3			
	4			
24			Cooldown & investigation in progress Inspection found Conax connectors leaking - will depressurize to repair. Also found tube leaks in 3A FW heater	1
	5			
25			RCS cleanup in progress	1
26			Drained 3A FW heater for repair	1
27			RCS cleanup continuing	1
28			RCS depressurized for Conax repair, discovered oil leaks on RCP-2B Motor Began working Conax connectors Continuing to investigate bellows liner problem	1
29			RCS cleanup in progress	

		ACTIVITY	
APR	5	Preparing for RCP-2A Clutch replacement	
30		Bellows liners evaluated-all horizontals & verticals to be replaced	1
MAY			
1		Replaced Conax connectors seals where needed Moved RCP-2A clutch into R.B.	1
		Torqued all Conax connectors	
2		Continued to work M.S. relief valve discharge lines	1
3		Continued to work M.S. relief valve discharge lines	1
		Commenced F.W. heating	
4		Unit 1 Lost Aux. Boiler - couldn't maintain temp. on 1 boiler, delayed F.W. cleanup	1
		Unit 1 now at 75% - extraction steam available for F.W. heat-up	
5			1
		Completed RCP-2A motor checks, ran water	
6		Completed RCP-2A motor/pump coupling RCS fill/vent valve lineup in progress	1
		Started filling & venting RCS	
7		Filled pressurizer, started drawing bubble	1
		Started venting CRD's	
		Completed initial CRD venting	
8		Functionally tested RCP-2A sat.	1
		Found Conax connectors leaking, torqued to stop leaks	

		ACTIVITY	
MAY	5	Started second vent & flush of CRD's	
9		Found Conax connectors leaking, commenced cooldown/depressurization to repair	1
		Removed nuts from Conax connectors, applied Molykote & retorqued	
		Completed venting CRD's, commenced raising RCS pressure	
10			1
		Continued to flush CRD's at pressure	
		Completed venting CRD's	
11			1
		Discovered Purge Valve AH-V-4A could not close	
12		MEC working on repair to AH-V-4A Continuing F.W. cleanup, checking out RCP operations, etc.	1
		AH-V-4A repaired & tested	
13	4	Mode 4 prerequisites completed	1
	3		
14	4 5	RCP-2A upper oil reservoir leaked empty. Splash shield drain lines clogged, oil spill to 2S0' el. in D-ring. Started cooldown, depressurization to fix.	1
		Fixed RCP-2A backstop filter gasket, added new oil Oil cleanup in progress	
15		Oil cleanup in progress. Also fixing oil leaks on RCP-2B motor & flushing oil drain lines	1
		Oil leaks fixed, drain lines cleaned	
16	4	Found leaks reversed on four RCP oil pumps caused reverse rotation Fixed leads, commenced plant heat up	1
	3		
		Began Post F.L., pre-critical testing w/4 RCP's not previously performed	
17			

MAY	ACTIVITY	POWER
18	Completed 4 pump testing (pre-requisite to return to criticality) Commenced M.S. relief valve testing	2/3
19		1
20		1
21		1
22		1
23		1
24		1
25		1
26	Continued Support of M.S. relief valve testing Rec'd 3 & 4 letter indicating SFRA problem potential if plant is run on less than 3 RCP's.	1

		ACTIVITY	
MAY	3	Continued testing M.S. relief valves	
27	3 4 5	Discontinued valve testing and cooled down to work M.S. valves	1
28			1
29			1
30		(M.S.-R-4A is installed in M.S.-R-1A location) Commenced heat up of RCS	1
31	4 3	Started M.S. valve testing	1
JUNE		Continued M.S. valve testing	
1			1
2			1
3			1
4	4 5	Discontinued M.S. valve testing, commenced cooldown	

JUNE		ACTIVITY	
5		Plant cooled down and holding pending resolution to M.S. relief valve evalutation	1
6			1
7			1
8		Commenced cooldown for Rx Head removal in anticipation of removing ORA's & installing BPRA Holddown devices	1
9			1
10			1
11	7 6	Vessel head bolts detensioned	1
12			1
13		Rx head removed	1

	ACTIVITY	
JUNE 6	Core plenum removed	
14	preparations for incore work	1
	All 40 ORA's removed	
15		1
16	All BPRA holddown devices installed, verification in progress	1
	Commercial plenum installation	
17		1
18		1
19	(Firming up plans to modify M.S. lines for new valves)	1
20	Rx head installed, not torqued	1
21	All M.S. valves removed from steamlines	1
22	Rx vessel was overflowed without head torqued, spilled boric acid over vessel flange & O-rings- preparing to lift head & clean up	1

JUNE	ACTIVITY	DELA
23		1
24		1
25		1
26	Crouse commenced to make modifications to M.S. lines.	1
27		1
28		1
29		1
30		1
JULY		
1		

	ACTIVITY	
JULY 6	Continue modifications to M.S. lines	1
3		1
4		1
5		1
6		1
7		1
8		1
9		1
10		

		ACTIVITY	
JULY	6	Continue M.S. line modifications	
11			1
12			1
13			1
14			1
15			1
16	5	Rx Head Tensioned	1
17		(Functionally tested cable room halon system sat.)	1
18			1
19			1

JULY 5	ACTIVITY Continue M.S. line modifications	[illegible]
20		1
21		1
22		1
23		1
24		1
25		1
26		1
27		1
28		1

	ACTIVITY	
JULY 5	Continue M.S. line modifications	1
29		1
30		1
31		1
AUG. 1		1
2		1
3		1
4		1
5		1

	ACTIVITY	
AUG. 5	Continue M.S. line modifications	
7		1
8	(Conducted retest of RR-P-1B/C/D-Sat.(License condition))	1
9		1
10		1
11		1
12		1
13		1
14	Crouse begins work on new M.S. line hangers	1

AUG. 3	ACTIVITY	
16	Continue M.S. line modifications	1
17		1
18		1
19		1
20		1
21	Begin preparations for M.S. hydro	1
22		1
23		1
24	Completed M.S. safety valve modifications Began hydro of M.S. lines. Valve gags did not hold.	1

		ACTIVITY	
AUG.	5	Continued working on hydro gag problems	
25			1
26		M.S. relief valve gags re-installed for hydro. Completed Sat. commenced draining OTSG's & Steam lines.	1
27		Crouse continues M.S. line insulation & new hangers. Completed restoration of secondary after hydro Commence heat up for lift testing.	1
28	4 3		1
29		Started lifting M.S. safety with hydro set Started lifting valves with steam pressure to check blowdown	1
30		Continued safety valve testing	1
31	4 5	Completed safety valve testing & removed all gags Performed full flow & coast down tests of RCS Commenced cooldown for M.S. hanger installation (continuation)	1
SEP.		Hanger installation continues	
1			
2		Hanger installation continues	

		ACTIVITY	
SEP. 5		Hanger installation continues	
3			1
4			1
5			1
6			1
7			1
8		Cleaning up feedwater to spec.	1
9			1
		Commenced plant heat up	
10	4 3	Continue plant heat up	1
11		RC-V-1 won't open to spray pressurizer	

			ACTIVITY	
SEP.	3		Continuing cooldown	
12	4 5			1
			Begin repairing RC-V-3	
13				1
			Commenced heat up, RCS filled & vented	
	7		CRDM venting completed	
14	4			1
	3		RC-V-3 tested OK Found steam leak on 'B' E.F. recirc line - cracked fitting not isolatible	
	4		Commence cooldown to fix.	
15	5			1
16				1
	7		Repair completed, commence heat up	
	4			
	3			
17			Continue heat up to power	1
	2		Peformed reactimeter testing Sat.	
	1	10		
18		15	T.C. on line (108 MWe) Begin 15% with 4 RCP's	2/3
19			Performed 15% power testing	
	3		Performed shutdown outside control room test	
			ICS being tuned, 15% data reviewed prior to power escalation	
	1	15	Back on line (183 MWE)	
20		20	Rx trip on Hi Press due to lost cond. & F.W. pumps when blowing down cond. booster pump.	2/3
	5			
	2		Recover from trip	
	1	15	Turbine on line	

			ACTIVITY	DCLAMS
SEP.	1	15	Rx trip due to F.W. instability in startup range (Tripped on Hi pressure)	
21	2		Recover from trip	1/3
	1	10	Turbine on line	
		30	Progressed thru startup range, settled out oscillations	
		34	Reducing power for 30% Turbine trip test	
		30	30% Turbine trip test	
22		15	Manually tripped reactor to commence cooldown for work outage	
	2			
	3		Experiencing problems backflushing co-pump strainers	1/3
	4		Also fixing MSR crossover piping steam leaks (fermenite) and	
	5		leaking conax connectors and bad RTD in RCS hot leg.	
23				1
24				1
	4		Commence heat up	
	3			
	1			
	2			
25	1	10		1
		18	Discovered steam leaks in M.S. cross under piping due to vibration	
	3		Rx trip on Hi pressure due to CO pump trip when reducing load to fix leak.	
			Steam leak repaired	
	2		Recover from trip	
26	1	20	T.G. back on line	
			FW-P-1B has broken ICS controller, FW-P-1A, Hi vibration	1
			Can't escalate in power until resolved.	
		15	FW-P-1A coupled, tested Sat.	
		20		
27			Commence power escalation to 40%	
		25		1
			Keeping F.W. in spec. as power increases	
		26		
28				
		40	40% power testing commences	
			Repaired FW-P-1B controller	
29				
			40% testing in progress	

		ACTIVITY	
SEP. 30	1 40	40% testing in progress	
OCT. 1		40% testing in progress	
2		40% testing in proress	
3		40% testing in progress, unable to close condensate pump section valve for strainer backflushing.	
4		Both F.W. strings in service 40% testing in progress	
5	3	40% Rx trip test performed Commenced cooldown for work outage	
	4	Working CD pump suction valve & strainer problem	2/3
6		Inspecting main condenser	1
7		Inspecting main condenser	1
8	5	Inspecting main condenser	1

			ACTIVITY	
OCT.				
9			Commence F.W. clean up & RCS heat up	1
		4		
		3		
10			Noted leak in Conax connector	1
		4	Commenced cooldown to fix.	
		5		
11			RC-V-1 would not operate	
			Completed conax repairs	1
			Completed CROM venting, begin heat-up	
		4	Completed electrical repair of RC-V-1	
12		3		1
		2		
	1	10	Turbine on line	
		21	RC-V-1 inoperable	
13		15		
	2		Found & fixed loose connection on RC-V-1	1
	1	20	Turbine on line	
		26		
	3		Rx trip on low pressure following turbine trip	
14			Recover from trip	1
	2			
	1	20	Turbine on line	
		40	Experiencing F.W. p oscillations & Fe plugging Co pump strainers	
15			Resetting M.S. safety valves	
			Heater Drain system being fine tuned	
			RCS tuning continues	
16			Perform 4th RCP trip from 40%	1
		40		
		30	All 40% power testing completed.	
	3	15	Repeat 30% turbine trip to collect missing data due to inst. problem	
17	1	40	With last test	
		15	Commence power escalation to 75% power	
		40		
	7	45	Increasing power at rate controlled by Cond. Polisher [illegible]	

		ACTIVITY	
OCT. 1		Power escalation in progress	
	50	(Feed system limiting escalation rate.)	
18	52	Discovered leak in FW-V-17A Body	
		HD drain tank level controller problem has 1 HD pump out of service, further	1/3
	03	delaying escalation rate	
	57		
19	58	HP level control valve fixed, both HD pumps back in service	1/3
		Blown packing on MU-V-17 (Switched to bypass valve)	
	63		
	67		
20			
	75	Turbine trip due to phase comparison relay on generator output	1/3
	15		
	20		
	35		
	55		
21	63	Turbine trip-repeat of above	1
	15		
	20		
	38		
	70		
22	75	Holding Stable for equilibrium zenon	
23		Commenced 75% power testing	
24			
25			
26			

			ACTIVITY
OCT.	1	75	Completed 75% power testing
27			Received TWG approval to escalate to 100% plateau with intermediate testing at 90%
		90	Noted vibrations on turbine generator exciter bearing No. 9, took turbine off line
28		15	Commenced work on exciter bearing
		8	
29	3	0	Experienced ratchet trip of CRD rods of group 5 when reducing power
			Continuing to repair exciter bearing
			(Repair of RC-V-1 in progress - replaced operator gear box)
30			
			Replaced faulty relay on CRD's which had caused ratchet trip
			Continue work on exciter bearing repair
31			
NOV.	2		Completed repair of exciter bearing.
1	1	15	Replaced gaskets on exciter cooling lines.
		70	
2		90	(Experienced condensate booster pump trip on low pressure, Rx run back to 55% and recovered.)
			Commenced 90% power testing.
3			
	3	0	Rx trip on high pressure after operator inadvertantly turned off power supply to condensate polishing system tripping condensate booster and feedwater pumps
			Repaired RC-V-1 limit switch
4			Repairs completed, returned critical

			ACTIVITY
NOV.	1	15	Returned to power operations, began escalation to 90%
5		90	Waiting for xenon equilibrium
6			
7	3	0	Commenced 90% data collection. Rx trip on variable low press. after heater drain pump tripped causing feedwater pump trip, low press. caused NaOH injection. RC-V-1 again needs repair - operator to be changed out.
8			11/7 trip evaluation in progress Decision made to begin turbine screen outage on 11/11 in parallel with plant cleanup.
9			MS-V-26A yoke found broken (probably caused excessively low press. and resultant NaOH injection on 11/7) RCS cleanup in progress
10	4 5		Commenced 2CS cooldown Replaced gaskets on exciter cooling lines. Turbine screen outage in progress
11			
12			
13			(EFW bell reducer cut from line for replacement)

		ACTIVITY
NOV. 5	0	Turbine screen removal outage continues
14		
15		
16		

~~Extract~~

See 3/13/79 memo for completion

(42)
25
57

Analysis of Actual Critical Path Shown on Enclosure (2)

1. Completing NRC Operating License pre-requisites delayed issuance of the license by 8 days. The Operating License is required before fuel load can begin.

2. Fuel transfer mechanism problems experienced at the onset of fuel loading is not shown on the critical path. Although it was a factor causing the fuel loading activity to be extended longer than it might otherwise need to have been, fuel loading was, in fact, completed in the number of days allotted.

3. The Reactor Coolant Pump 2A clutch failure which occurred on 3/13/78 caused a delay of 6 days of pre-critical testing. After 3/19/78, the test program was resumed with only 3 of 4 Reactor Coolant Pumps in operation. This resulted in additional pre-critical testing on 5/15-16 to complete test requirements with four pumps in operation. Installation of the repaired clutch in early May was accomplished in parallel with the repair of the bellow liners and therefore did not affect the critical path.

4. Steam Generator Instrumentation "Conax" fitting leaks have been a continuous problem throughout the test program. Generally, the leaks occurred due to pressure/temperature cycles of the system caused either purposely or inadvertently. Therefore, in many cases, this problem arose in parallel with another problem and I am considering, for the purpose of this review, only 9 out of a possible 23 delay days attributable to these fittings.

5. We have experienced three inadvertent sodium hydroxide safety injections into the Reactor Core. One on 3/29/78 caused a delay of 8 days to the zero power physics testing. This first injection recovery delay was further compounded by chloride contamination of the Reactor Coolant System due to the use of impure Sodium Hydroxide chemicals. The second injection on 4/23/78 is not considered critical path because of the overriding bellow liners recovery program which also resulted from the 4/23/78 transient. The third injection on 11/7/78 caused a direct critical path delay of 4 days to the power escalation to 100% activity before it was decided to commence turbine [illegible]een removal. On 11/11/78, therefore, the screen outage became controlling.

6. Nuclear Instrumentation/Reactimeter problems caused an approximate 8 day delay to zero power physics testing and 3 more days during 15% power testing.

7. Various Condensate System Strainer/Pump Suction Valve problems caused further delays to 15% power testing (2 days) and power escalation testing (9 days) and was the prime reason for an eight day work outage performed in October. Problems in this area caused several plant trips.

8. Although failure of the Main Steam Safety Valves to function properly on 4/23/78 was the root cause of safety injection, I am considering only that period of time from 5/18/78 through 9/1/78 (105 days) as being critical path due to safety valves. The reason for this is because, even if the valves had functioned properly on 4/23, the valve discharge line bellow liners would have failed and the time it took to fix them, from 4/23 to 5/10 (17 days) was controlling at that point. A subsequent problem with oil leaking from two Reactor Coolant Pump motors caused an additional 3 day delay before plant operations could resume to the point of discovering that the safety valves could not be adjusted or modified to function properly.

9. Removal of the Reactor Internals Orifice Rod Assemblies and Burnable Poison Rod Assemblies was not critical path since it was performed completely in parallel with the steam line modifications.

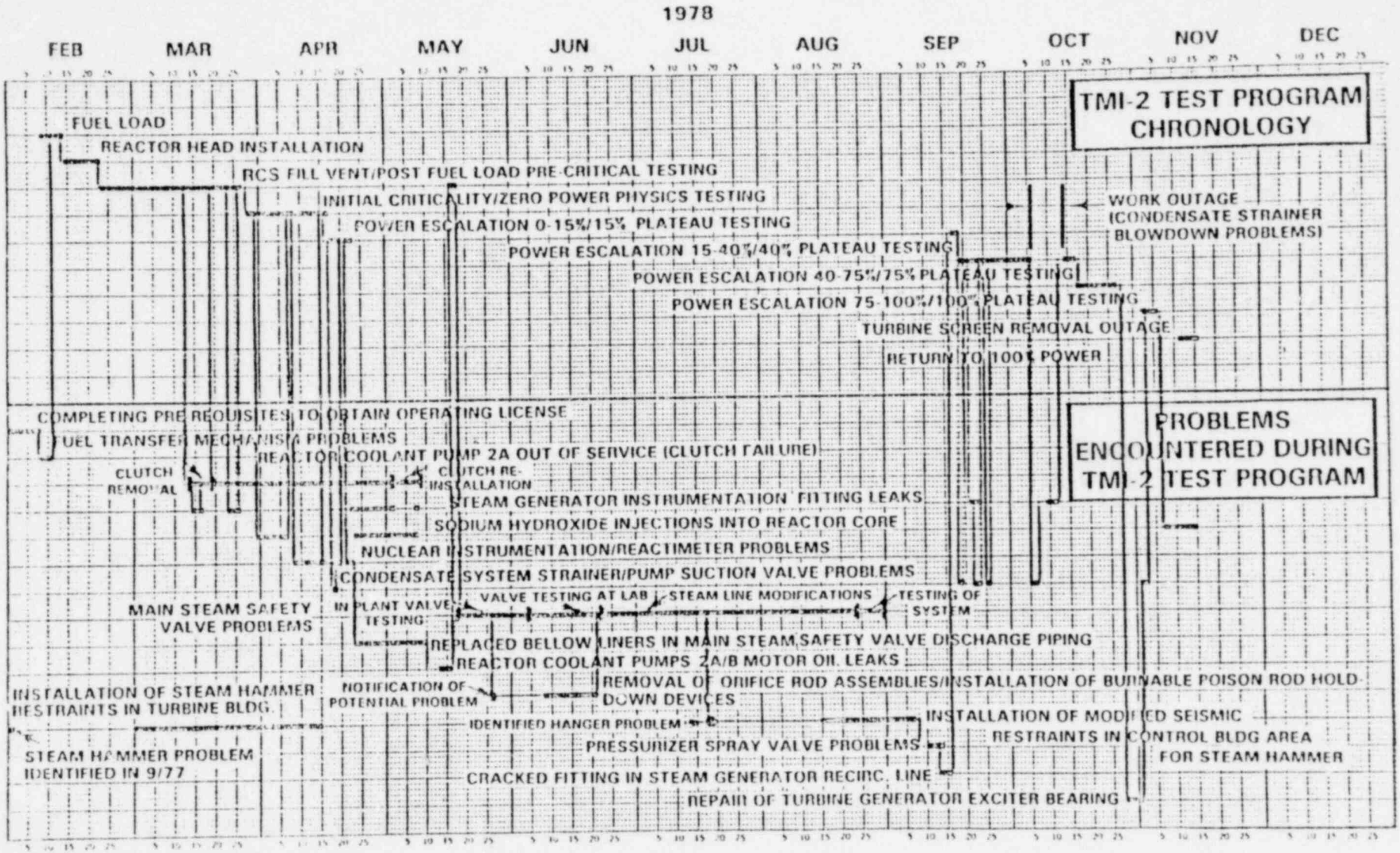
10. In September 1977, it was discovered that Main Steamline snubbers were not provided to accommodate steam hammer vibrations. Apparently when Gilbert Associates (GAI) performed a steam hammer analysis for TMI-1, it was decided that GAI should also do a similar analysis for TMI-2 because, at that time, B&R did not have the in house capability to do it themselves. In that same year, Section 9.3 of the TMI-2 FSAR was written indicating that:

"In the Main Steam System, special attention was given to the dynamic effects of the fast closure of the turbine stop valves on the piping between the steam generators and the turbine steam chest. Hydraulic snubbers are provided to minimize steam hammer while allowing normal system thermal movement." (Subsection 3.9.1.1, 2nd paragraph.)

These words were written prior to the analysis based on the assumption that due to the similarity of piping arrangements between Units 1 and 2, snubbers would be required on Unit 2, as on Unit 1, for the suppression of steam hammer effects. The actual steam hammer analysis was to be performed at some later date after B&R finalized the Main Steam piping arrangement and the location and sizing of thermal and seismic pipe supports and transmitted that information to GAI. For reasons unknown, there are no records of either the agreement to have GAI do the steam hammer analysis or of B&R ever having transmitted the required design information to GAI. As a result of this apparent oversight, no steam hammer snubbers were designed or provided for in the early days of the project. The lack of such snubbers was first noted by inspection during Hot Functional Testing in September 1977.

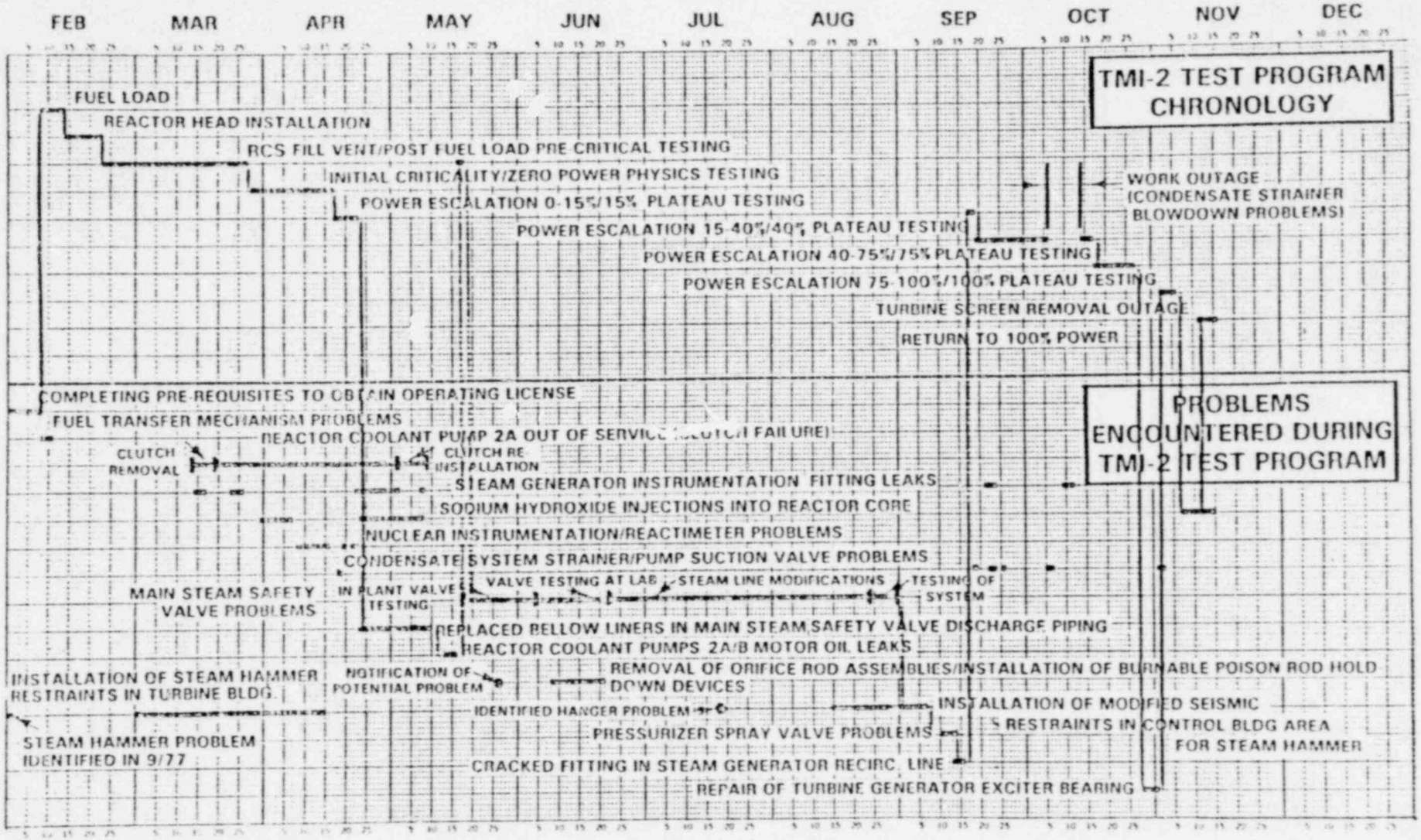
Since 1972, B&R has developed the in house capability of performing steam hammer analysis, so upon discovery of this omission, B&R was directed to proceed with the analysis and design of additional snubbers as required. Because fuel loading and startup testing was scheduled for late 1977 and early 1978, B&R was also requested to calculate the maximum power level the Unit could safely be operated at without having the new snubbers installed in the event lead time for material procurement became critical. B&R subsequently estimated that power level to be about 30%. (B&R letter 3984-GP, 9/13/77 and Project Change Notice 2457 refer.)

ENCLOSURE (2)



ACTUAL CRITICAL PATH SHOWING PROBLEMS AS INTERRUPTIONS TO THE TEST PROGRAM PATH.

ENCLOSURE (2)



ACTUAL CRITICAL PATH (GRAPHED)

B&R performed the steam hammer analysis using as the basis for the analysis a 150 milliseconds turbine stop valve closure time. That information was received verbally from Westinghouse on 9/6/77, with confirmation from Westinghouse by memorandum of the same date. The memo also included a flow vs. closure time curve purported to be typical of these valves which tended to support the use of 150 milliseconds in that the closure was fairly linear with respect to flow decrease. The results of this analysis showed the need for additional snubbers on steam line piping in the Turbine Building area. (Existing restraints provided for dead weight, thermal and seismic loads were found to be capable of accommodating the added steam hammer loads in the steamlines routed through the Control Building Area, except for one seismic restraint with a PSA-35/35 kip snubber which was upgraded with a PSA-35/50 kip snubber.)

Material for these new snubbers was received on site and installation commenced around 3/1/78. Installation was completed by 4/15/78, prior to reaching that point in the Test Program requiring power levels in excess of 30%. Therefore, these snubbers never became controlling on the critical path.

In January 1978, the General Office Review Board (GORB) reviewed the steam hammer analysis ~~snubber problem described~~ above and concluded that since the analysis, design and installation was ~~ie~~ on an expedited basis at the end of construction, an independent review of B&R's efforts was warranted in view of the importance of the snubbers. Met-Ed was requested to perform this review.

Meanwhile, B&R had been attempting to justify the use of an increased turbine stop valve closure time of about 200-250 milliseconds (which B&R had seen for some other plants) in order to demonstrate additional conservatism in the snubber design because one of the snubbers in the Control Building Area was marginally capable of sustaining the calculated loads and increased power levels without snubbers installed were being sought. To do so, B&R requested Westinghouse to check the information previously provided (150 milliseconds) to see if actual test data was available. Westinghouse prepared a flow vs. closing time curve and telecopied it to B&R on 4/25/78. This curve, based on test data, differed from the previously received "typical" curve in that it no longer showed a linear relationship between time and flow. Various interpretations of this curve demonstrated closure times anywhere between 50 to 150 milliseconds.

On 5/17/78, when Met-Ed first met with B&R to review the steam hammer work as requested by the GORB, this new curve was discussed. No agreement was reached as to the most appropriate closure time to use in the steam hammer analysis at that time. During the next several weeks it was concluded that, based on the new curve, an effective valve closure time to use for an appropriately conservative steam hammer analysis of the main steamlines should be 50 milliseconds vs. 150 milliseconds actual closure time used in the previous analysis. Met-Ed made this recommendation to GPU on 6/12/78 (GEM 2544) and GPU forwarded the recommendations to B&R (TMI-II/7025, 6/28/78) requesting an evaluation of the effects of

the new closure time. On 7/18/78 B&R discussed with GPU the results of some limited re-analysis using the 50 milliseconds closure time. This re-analysis showed that the loads on the main steam seismic snubbers in the Control Building Area increase by about 50%, which was in excess of their rated capacity in most cases. B&R recommended that additional snubbers be purchased while they completed the analysis and design of new or upgraded restraints. (The steam hammer snubbers in the Turbine Building previously installed were found to be acceptable without modification.) Again, B&R recommended limiting plant operations to no more than 30% power until the restraints were modified. (At this point in time, however, the plant was shut down for modifications to the steamlines for new safety valves.) These recommendations were forwarded to GPU by letter on 7/26/78 (4249-GP).

The new seismic snubbers were subsequently designed, fabricated and delivered to the site by 8/14/78. Installation was not completed by the time the Main Steamline/Safety Valve modifications were completed on 9/1, so the balance of the installation became critical path and caused an additional 7 day delay to the Test Program. (It should be noted that the snubber installation required the steamlines and surrounding work areas to be cool, so no plant power operations could have taken place in parallel.)

The following Field Change Requests and Engineering Change memos describe the modified or added steam hammer snubbers and seismic snubbers:

Turbine Building - FCR 2457.1
- ECM 5899, 5948

Control Building Area - FCR 2457.2
ECM 9047, 9052, 9053, 9062, 9071

11. After completion of the Main Steam Line restraint installation, the plant was returning to power operations for resumption of the Test Program when the plant experienced problems with pressurizer spray valves and also discovered an unisolable crack in a fitting in an Emergency Feedwater line that serves to route water to a steam generator recirculation line. These two problems caused an additional critical path delay of 6 days.

12. The failure of a Turbine Generator Exciter Bearing during power escalation testing on 10/27 caused another 4 day delay after completion of the 75% power plateau testing.

Considering the aforementioned problems to be equipment problems causing, or having the potential to cause, delays to a normal Test Program, it can be seen that these problems, taken in series, could have caused a delay of about 365 days. In the sequence of occurrence, however, the net delay is about 201 days.

Delays to TMI-2 Test Program Due to Problems Encountered
(2/1/78 thru 11/16/78)

		Delay Days	
		Actual	Potential
1.	Operating License Pre-requisites	8	8
2.	Lack of Main Steam Line Restraints for Steam Hammer Forces (affected S-II portion of lines in Turbine Bldg.)	0	12(1)
3.	Inadequate Main Steam Line restraints for Steam Hammer Forces based on "new" criteria (affected S-I portion of lines in Control Bldg. Area)	7	71(2)
4.	Fuel Transfer Mechanism Problems	0	3
5.	Reactor Coolant Pump (2A) Clutch Failure	8	16(3)
6.	Steam Generator Instrumentation Fitting Leaks	9	23
7.	Sodium Hydroxide Injection Transients	12	31
8.	Nuclear Instrumentation Problems	11	11
9.	Condensate System Strainer Blowdown problems	11	13
10.	Main Steam Safety Valve Problems	105	120
11.	Safety Valve Discharge Bellow Liner Failures	17	17
12.	Reactor Coolant Pump (2A/B) Motor Oil Leaks	3	3
13.	Reactor Internals potential loose parts	0	26
14.	Pressurizer Spray Valve problems	3	4
15.	EFW Fitting failure in Steam Generator recirculation line	3	3
16.	Turbine Generator Exciter bearing failure	4	4
	Totals	201	365

Footnotes:

1. Assumes 30% power level exceeded by 4/3/78 based on original schedule.
2. Assumes power level was greater than 30% on 6/28/78 when concern was discovered and plant operations were immediately terminated.
3. Assumes delay time for clutch removal and reinstallation plus 2 extra test days after reinstallation.

PCC/brb - 12/5/78

Analysis of Test Program Critical Path Assuming Main Steam Safety Valves Function Properly - Worst Case

Referring to the attached Test Program Chronology Bar Chart, it can be seen that, making the above assumptions, events up to 5/18/78 would have remained the same except that the Sodium Hydroxide Safety injection of 4/23/78 would not have occurred. Cleanup from that injection, however, was not critical path. After 5/18/78, plant testing would have resumed with all four Reactor Coolant Pumps back in operation. (Reinstallation of the clutch was done in parallel with bellow liner repairs.)

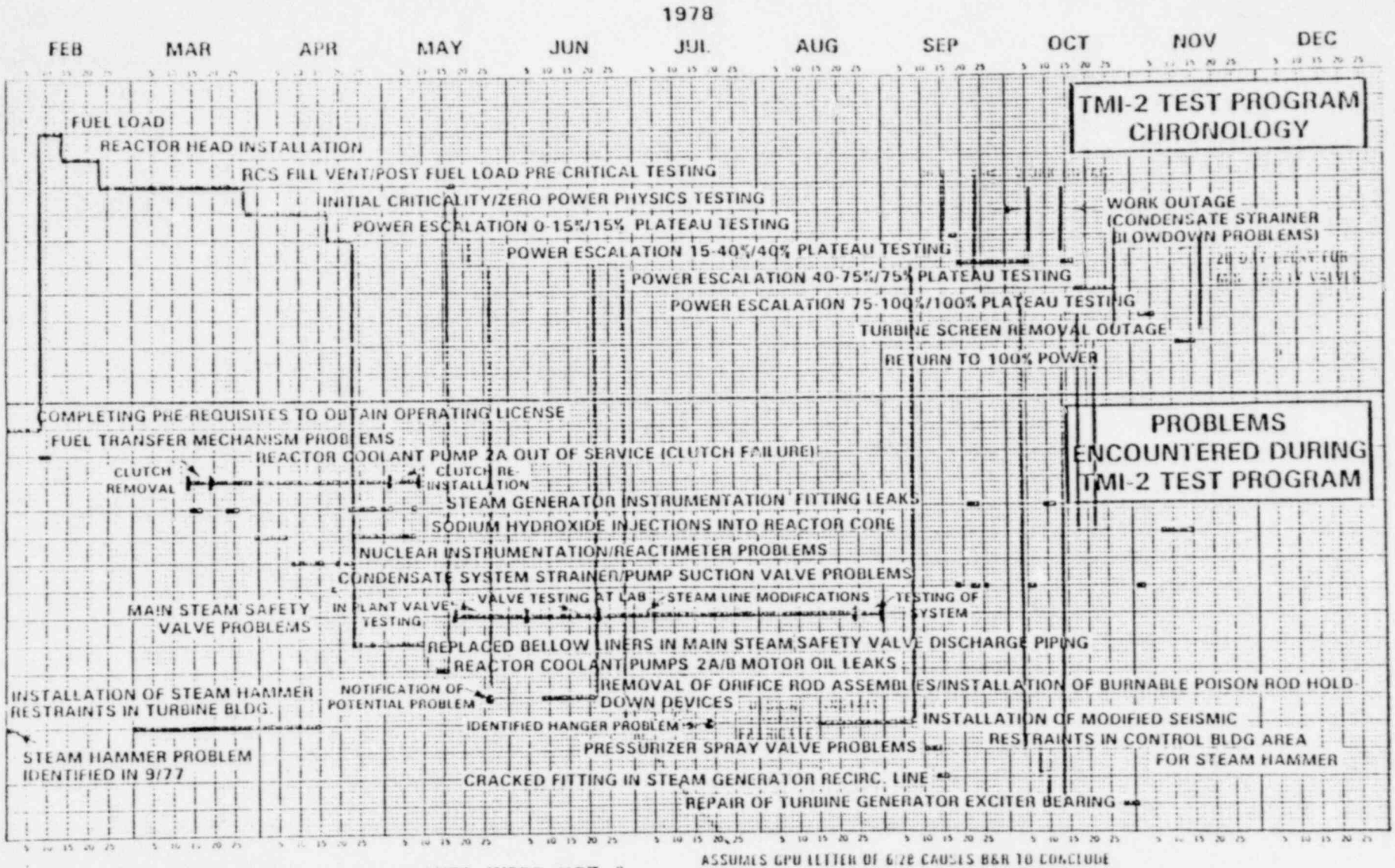
On 5/26/78 B&W notified GPU of potential loose parts in the core based on recently discovered failures at another plant. Based on the severity of the consequences of such an event, we would undoubtedly have decided not to continue plant operations until the problem was resolved. The Orifice Rods were subsequently removed and hold down devices installed on Burnable Poison Rod Assemblies in an expeditious manner, so it can be assumed that the least delay possible to the Test Program would have been 26 days as shown.

About a week later, on 6/28 as events actually occurred, GPU concluded that the steamlines were in jeopardy and again would have terminated operations (since lower than 30% power level testing had already been completed) until adequate supports were installed. This would have caused another direct delay to the program of 71 days.

All other problems actually encountered are considered to have happened at one point or another during plant testing, possibly in the sequence shown on the critical path.

The end result shows that, had events occurred as described above, we would have been 5 days into the Turbine Screen Removal Outage on 10/26/78 rather than 11/16/78. In other words, under this scenario, the Test Program would have been 20 days shorter.

ENCLOSURE (5)
"WORST CASE"



CRITICAL PATH ASSUMING SAFETY VALVES WERE NOT A PROBLEM AND THAT WHEN NEW NOTIFIED GPU OF POTENTIAL PROBLEM WITH ORA/HPRA'S, WE HAD MET OR EXCEEDED THE ESTIMATED OPERATING HOURS ALLOWABLE BEFORE ANTICIPATED TMI OFF.

ASSUMES GPU LETTER OF 6/28 CAUSES B&R TO CONCLUDE THAT PLANT SHOULD NOT OPERATE OVER 30% POWER UNTIL CONCERN IS EVALUATED. OK 7/17 B&R FINISHED EVALUATION AND CONCLUDED PROBLEM WAS REAL.

Analysis of Test Program Critical Path Assuming Main Steam Safety Valves Function Properly - Most Optimistic

Referring to the attached Test Program Chronology Bar Chart, it can be seen that, making the above assumptions, events up to 5/18/78 would have remained the same except that the Sodium Hydroxide Safety injection of 4/23/78 would not have occurred. Cleanup from that injection, however, was not critical path. After 5/18/78, plant testing would have resumed with all four Reactor Coolant Pumps back in operation. (Reinstallation of the clutch was done in parallel with bellow liner repairs.)

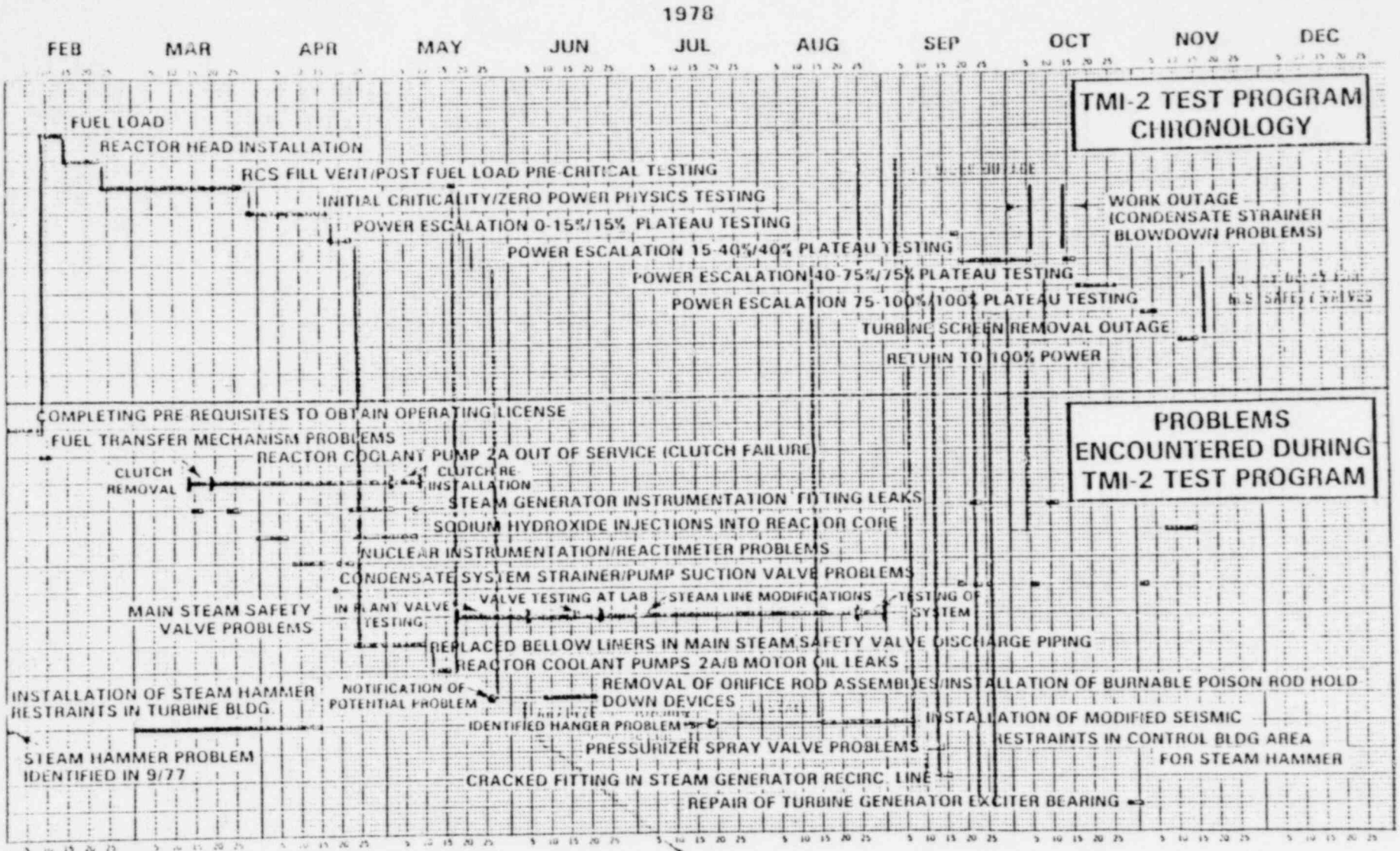
On 5/26/78 B&W notified GPU of potential loose parts in the core based on recently discovered failures at another plant. Based on the severity of the consequences of such an event, we would undoubtedly have decided not to continue plant operations until the problem was resolved. The Orifice Rods were subsequently removed and hold down devices installed on Burnable Poison Rod Assemblies in an expeditious manner, so it can be assumed that the least delay possible to the Test Program would have been 26 days as shown.

Since the assumption is made here that the Main Steam Safety Valve problem did not exist, it is reasonable to also assume that greater emphasis would have been placed on the steamline restraint problem at an earlier point in time. Recognizing the fact that, after 5/26/78, the plant was into an extended outage, we would have taken extraordinary steps to resolve the restraint problems at the same time. Therefore, assuming this problem was identified as controlling on about 6/2/78, the critical path would have been shortened by about 19 days from the "worst case" scenario described on Enclosure (5) due to the parallel activities. The restraint installation would then have been completed on about 8/12/78.

All other problems actually encountered are considered to have happened at one point or another during plant testing, possibly in the sequence shown on the critical path.

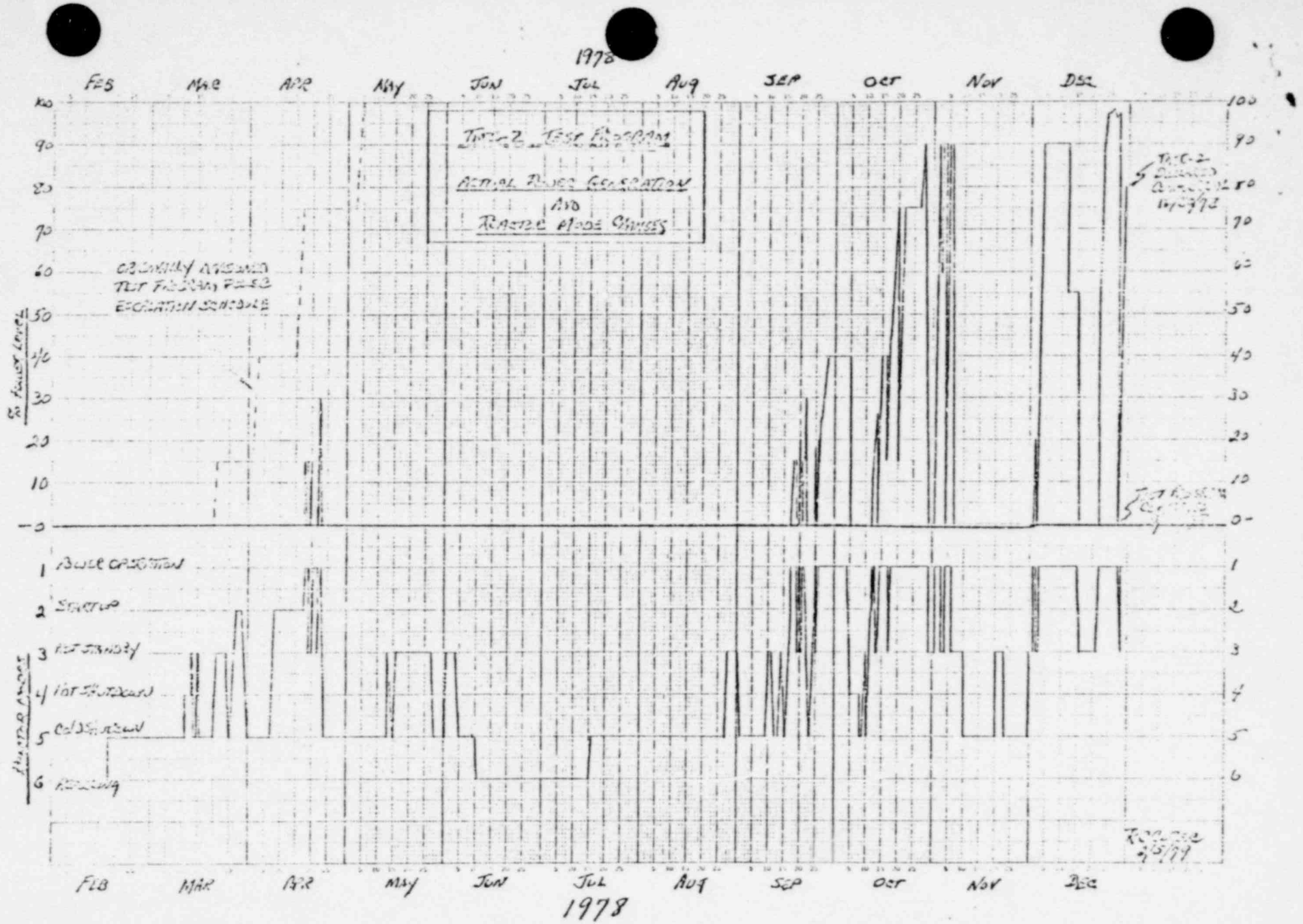
The end result shows that, had events occurred as described above, we would have been 5 days into the Turbine Screen Removal Outage on 10/8/78 rather than 11/16/78. In other words, under this scenario, the Test Program would have been 39 days shorter.

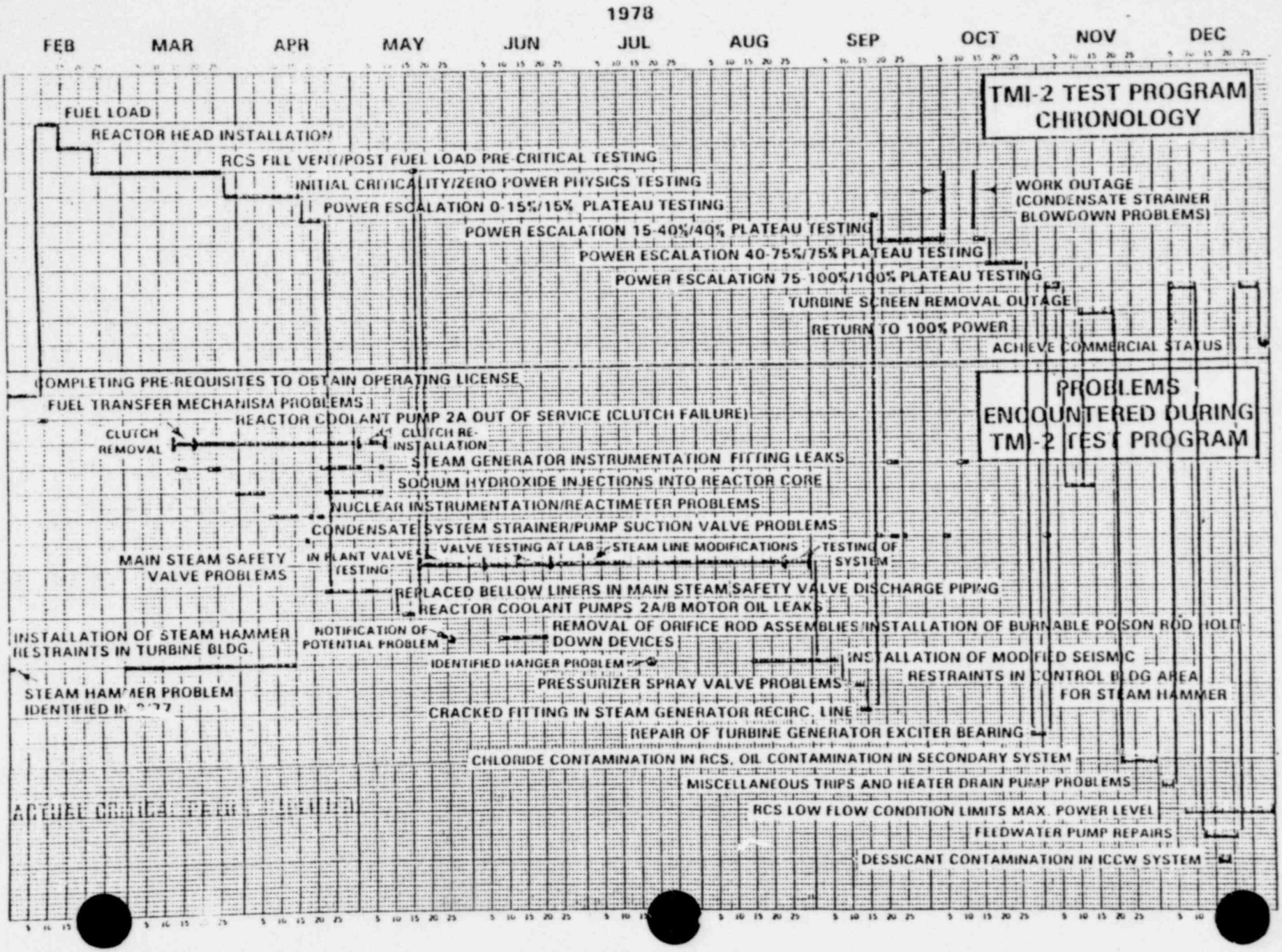
ENCLOSURE (6)
"MOST OPTIMISTIC"



CRITICAL PATH ASSUMING SAFETY VALVES WERE NOT A PROBLEM AND THAT WHEN B&W NOTIFIED GPU OF THE POTENTIAL PROBLEM WITH ORA/BPRA'S, WE HAD MET OR EXCEEDED THE RECOMMENDED MAX. OPERATING HOURS ALLOWED BEFORE ANTICIPATED LIFT OFF.

ASSUMES HANGER PROBLEM WAS RECOGNIZED EARLY (APPROX. 6/2) BECAUSE ENGINEERING EMPHASIS ON SAFETY VALVE PROBLEM DID NOT EXIST ALLOWING MORE TIME TO CONSIDER THE AFFECT OF DIFFERENT TURBINE VALVE CLOSURE TIMES.




1978
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TMI-2 TEST PROGRAM CHRONOLOGY
FUEL LOAD
REACTOR HEAD INSTALLATION
RCS FILL VENT/POST FUEL LOAD PRE-CRITICAL TESTING
INITIAL CRITICALITY/ZERO POWER PHYSICS TESTING
POWER ESCALATION 0-15%/15% PLATEAU TESTING
POWER ESCALATION 15-40%/40% PLATEAU TESTING
POWER ESCALATION 40-75%/75% PLATEAU TESTING
POWER ESCALATION 75-100%/100% PLATEAU TESTING
TURBINE SCREEN REMOVAL OUTAGE
RETURN TO 100% POWER
ACHIEVE COMMERCIAL STATUS
WORK OUTAGE (CONDENSATE STRAINER BLOWDOWN PROBLEMS)
COMPLETING PRE-REQUISITES TO OBTAIN OPERATING LICENSE
PROBLEMS ENCOUNTERED DURING TMI-2 TEST PROGRAM
FUEL TRANSFER MECHANISM PROBLEMS
REACTOR COOLANT PUMP 2A OUT OF SERVICE (CLUTCH FAILURE)
CLUTCH REMOVAL
CLUTCH RE-INSTALLATION
STEAM GENERATOR INSTRUMENTATION FITTING LEAKS
SODIUM HYDROXIDE INJECTIONS INTO REACTOR CORE
NUCLEAR INSTRUMENTATION/REACTIMETER PROBLEMS
CONDENSATE SYSTEM STRAINER/PUMP SUCTION VALVE PROBLEMS
MAIN STEAM SAFETY VALVE PROBLEMS
IN PLANT VALVE TESTING
VALVE TESTING AT LAB
STEAM LINE MODIFICATIONS
TESTING OF SYSTEM
REPLACED BELLOW LINERS IN MAIN STEAM SAFETY VALVE DISCHARGE PIPING
REACTOR COOLANT PUMPS 2A/B MOTOR OIL LEAKS
INSTALLATION OF STEAM HAMMER RESTRAINTS IN TURBINE BLDG.
NOTIFICATION OF POTENTIAL PROBLEM
REMOVAL OF ORIFICE ROD ASSEMBLIES/INSTALLATION OF BURNABLE POISON ROD HOLD DOWN DEVICES
IDENTIFIED HANGER PROBLEM
INSTALLATION OF MODIFIED SEISMIC RESTRAINTS IN CONTROL BLDG AREA FOR STEAM HAMMER
STEAM HAMMER PROBLEM IDENTIFIED IN 1977
PRESSURIZER SPRAY VALVE PROBLEMS
CRACKED FITTING IN STEAM GENERATOR RECIRC. LINE
REPAIR OF TURBINE GENERATOR EXCITER BEARING
CHLORIDE CONTAMINATION IN RCS, OIL CONTAMINATION IN SECONDARY SYSTEM
MISCELLANEOUS TRIPS AND HEATER DRAIN PUMP PROBLEMS
RCS LOW FLOW CONDITION LIMITS MAX. POWER LEVEL
FEEDWATER PUMP REPAIRS
DESSICANT CONTAMINATION IN ICCW SYSTEM