CONNECTICUT YANKEE ATOMIC POWER COMPANY

BERLIN, CONNECTICUT

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November 26, 1979

Docket No. 50-213

Director of Nuclear Reactor Regulation
Attn: Mr. D. L. Ziemann, Chief
Operating Reactors Branch #2
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

References: (1) D. L. Ziemann letter to W. G. Counsil dated September 12, 1979.
(2) D. C. Switzer letter to R. A. Purple dated July 15, 1975.
(3) D. C. Switzer letter to A. Schwencer dated January 3, 1978.

Gentlemen:

Haddam Neck Plant
Additional Information - Steam Generator Water Hammer

In Reference (1), Connecticut Yankee Atomic Power Company (CYAPCO) was requested to respond to NRC Staff concerns on the topic of steam generator water hammer. The questions contained in the enclosure to Reference (1) are addressed in Attachment 1. Subsequent to the receipt of Reference (1), CYAPCO informally received a supplemental set of questions on the same topic from an NRC consultant on this topic. These questions are addressed in Attachment 2.

In addition to the above-noted questions, CYAPCO informally received yet another series of questions which are addressed as follows. The forcing function used in the analysis discussed in Reference (2) represented a simultaneous loss of both feedwater pumps with no other pump start. This representation was determined to be more severe than the uncovery of the sparger due to the geometry of the Haddam Neck feedwater piping, which will not drain down past the sparger.

The following data regarding the feedring is provided.

The feedring is composed of two sizes of pipe, approximately 175 inches of 8 inch diameter (0.5 inch wall thickness) piping, and approximately 175 inches of 6 inch diameter (0.28 inch wall thickness) piping. There are a total of 278, one-inch diameter holes in the feedring.

Lastly, it is emphasized that no occurrences of steam generator water hammer have been noted at the Haddam Neck Plant beyond those discussed in Reference (2). As a result of the minor water hammers reported in Reference (2), design and procedural modifications were implemented as reported. As stated in Reference (3),

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CYAPCO considers its present design and operating procedures adequate to preclude steam generator water hammer events.

We trust you find this information responsive to your requests.

Very truly yours,

CONNECTICUT YANKEE ATOMIC POWER COMPANY

W. G. Counsil

W. G. Counsil
Vice President

Attachment

DOCKET NO. 50-213

ATTACHMENT 1

HADDAM NECK PLANT

ADDITIONAL INFORMATION - STEAM GENERATOR WATER HAMMER

1470 297

NOVEMBER, 1979

NRC REQUEST FOR ADDITIONAL INFORMATION ON STEAM GENERATOR WATER HAMMER

Reference (1) D. C. Switzer letter to R. A. Purple dated July 15, 1975

1. Provide information that demonstrates that the feedwater system and steam generator water level at your facility have been subjected to those transient conditions that are conducive to water hammer, i.e. the addition of cold feedwater or auxiliary feedwater to steam filled feedwater piping and feedring. See NUREG 0291, Page 4 that was forwarded to you on September 2, 1977.

Include the following:

1.1 Describe the expected behavior of steam generator water level as a result of reactor trip from power levels greater than 30% of full power. Include actual plant measurements of steam generator level and other available data such as feedwater flow and auxiliary feedwater flow.

Response

As previously discussed in Reference (1) water hammer in the feedwater system could occur while the plant is in hot standby or in the startup phase since steam generator level is manually controlled during these phases of plant operation. The occurrence of feedwater hammers during these two phases of plant operation have been essentially eliminated due to procedural changes which caution plant operators to avoid large changes in feedwater flow. This is accomplished by requiring the plant operator to start the main feedwater pump prior to shutdown of the auxiliary feed pump during plant startup and vice versa during plant shutdown. The operation of these pumps in this manner will eliminate large changes in feedwater flow to the steam generator during pump switching.

The steam generator water level following a reactor/turbine trip is expected to decrease due to the collapse of steam voids causing the feedwater flow to initially increase. The feedwater regulating valves will then open wide in response to the steam bypass valves opening. These valves will remain open until the Tavg Steam Bypass signal is reduced to a point where the steam bypass valves start to close (Tavg = 545°F.). At this time the feedwater valves will fully close and remain closed until they are manually opened or until T_{avg} increases to 545°F. If at any time the steam generator level is above 69% of the wide range scale the feedwater valves will automatically close to avoid steam generator flooding. Only with the feedwater valves in the manual mode can the valves be opened and turbine latched.

Actual plant measurements of a reactor trip which occurred from full power on May 5, 1978 are provided. This data represents the steam generator water level (narrow range 0-100%) and feedwater flow/steam flow (lbs/hr) for each steam generator. Feedwater bypass flow and auxiliary feedwater flow are not available since they are not recorded. The data which is presented is representative of all reactor trips.

A layout of the location of the feedwater sparger in relation to the normal operating level is as shown in Figure (1). Each time a reactor trip occurs the steam generator level decreases below the narrow range capability which is below the feedwater sparger. The recovery of the steam generator level above sparger will normally take 5-20 minutes. In any event, the feedwater regulating valve will close off due to a reduced Tavg or high steam generator level (69% wide range). This isolation of feedwater from the steam generators will result in the feed ring draining until either the feedwater bypass valves are opened supplying main feedwater or the auxiliary feed pumps are manually initiated. The steam generator level is then manually brought up to normal (30% narrow range).

The normal decrease in steam generator level below the feedwater sparger coincident with the isolation of normal feedwater flow during a reactor trip demonstrates that the feedwater system has been subjected to those transient conditions which are conducive to water hammer. This also demonstrates the satisfactory ability of the plant to recover from these events with no major water hammers reported. Reference (1) also indicates that the existing feedwater piping adjacent to each steam generator remains full even if the steam generator sparger drains down. This will eliminate the possibility of immediately adding "cold" auxiliary feedwater to a steam sparger subsequent to a reactor trip.

1.2 Provide the number and causes of loss of feedwater events during the operational history of the plant. You may refer to material submitted previously.

Response

There have been three total loss of feedwater events which have occurred during the twelve year operational history of the plant. On each occasion this was due to a total loss of offsite power. (See Response 1.3).

1.3 Provide the number and causes of loss of offsite power events during the operational history of the plant.

Response

The following is the list and description of each loss of off-site power event which has occurred at Connecticut Yankee.

Loss of Off-Site Power Events

1) 4/27/68 - The incident commenced at 1,300 hours, when the plant was at 490 MWE. One 115 KV line was out of service for maintenance and repair. The remaining 115 KV line was supplying station services. While restoring the repaired 115 KV line the other 115 KV line tripped creating a loss of offsite power. This occurred due to an error in the switching procedure which was later corrected.

2) 7/15/69 - While operating at 480 MWE, a switch over to remove one of the 115 KV lines from service caused both lines to trip causing a loss of feedwater event.

3) 1/19/74 - During a severe ice storm a momentary fault on the 1772 line coupled with an incorrect protective relaying action caused a loss of all A.C. power. The relaying action was corrected by readjustment. A loss of feedwater event occurred with this loss of off-site power.

4) 6/26/76 - Loss of all A.C. power occurred at 1305 while trying to restore line 1772, line 3991 opened and was finally restored. At 1549, line 1772 and line 1206 tripped and was restored. This loss of A.C. power occurred during the 1978 refueling outage, therefore, no loss of feedwater occurred.

2. If administrative controls have been adopted to limit the flow of auxiliary feedwater for the purpose of reducing the probability of water hammer, show when they are adopted and give the answers to items 1.1, 1.2, and 1.3 for before and after such controls were established.

Response

There are presently no administrative controls to limit auxiliary feedwater flow in order to reduce the probability of a water hammer. There are presently only operating procedure statements which caution the plant operators to avoid large changes in feedwater flow.

3. If administrative controls have been adopted to limit the flow of auxiliary feedwater for the purpose of reducing the probability of water hammer, show that an adequate water inventory and flow will be maintained to accommodate all postulated transient and accident conditions.

Response

See Response #2.

4. If auxiliary feedwater flow in your facility is not at present initiated automatically for normal and accident events, present your evaluation of whether automating the actuation of auxiliary feedwater might increase the probability of inducing steam generator water hammer. One of the signals that would automatically initiate the flow of auxiliary feedwater would be the steam generator low water level. This set point should be above the top of the main feedwater sparger to reduce the probability of steam generator water hammer.

Response

The auxiliary feedwater flow at Connecticut Yankee is presently not automatically initiated. The implementation of an auxiliary feedwater system which initiates when the steam generator level drops to the location of the sparger is not realistic. This type of design would initiate the auxiliary feed pump during every reactor trip and each time the steam generator level was in manual control and inadvertently allowed to drop to this level. Due to the limited difference between the steam generator normal operating level and the feedwater sparger which is approximately 12.5" inches, the auxiliary feed pumps would frequently be started even when an emergency condition did not exist. This inadvertent startup of the auxiliary feed pump each time the steam generator level dropped below the sparger would significantly increase pump wear and maintenance.

Presently the plant operator would respond to a low level in steam generator by quickly opening the bypass valve and using main feedwater flow if it was available. If the main feed pumps were not available the operator would then start the auxiliary feed pumps. This operating sequence limits the number of times "cold" auxiliary feedwater is introduced into a "hot" steam generator to only those emergency events where main feedwater flow is not available. The frequent introduction of "cold" auxiliary feedwater to the steam generator would unduly submit this equipment to additional thermal stress. The probability of steam generator water hammer is reduced by the implementation of a quick acting automatic AFW system, but other significant system reliability factors would be increased. The extent that these factors would affect system reliability is presently not known.

5. Describe the means that will be used to monitor for the occurrence of steam generator water hammer and possible damage from such an event. Include all instrumentation that will be employed. Describe the inspections that will be performed and give the frequency of such inspections.

Response

The occurrence of a steam generator water hammer is clearly audible from the Turbine Building and the Control Room. There is presently no instrumentation employed to detect water hammers since no major water hammer events have been experienced by the plant.

Reference (1) describes the existing feedwater piping arrangement adjacent to each steam generator and shows that the unintentional draining of a long portion of the feedwater line is highly improbable. This piping arrangement would therefore preclude the possibility of extensive damage occurring from a water hammer. The steam generator feedwater piping inside the containment was analyzed in June 1975 by Stone and Webster Engineering to determine the potential effects of flow induced water hammer events. The addition of several supports satisfied the water hammer transient stress levels. Therefore, the possible damage which could occur from a major feedwater hammer would be minor in nature.

Subsequent to a water hammer the plant will normally perform a visual inspection of all feedwater piping, valves and pipe supports which were involved in the event.

6. Describe the reporting procedures that will be used to document and report water hammer and damage to piping and piping support systems. Such reports were requested in our letter to you dated September 2, 1977.

Response

If a major water hammer event occurred which resulted in plant damage a plant information report would be filed. The occurrence of this type of event would also be included in the monthly operational report.

POOR ORIGINAL

ED 1443 REV. 2-71

NORTHEAST UTILITIES SERVICE COMPANY

ENCLOSURE (1)

FIGURE (1)

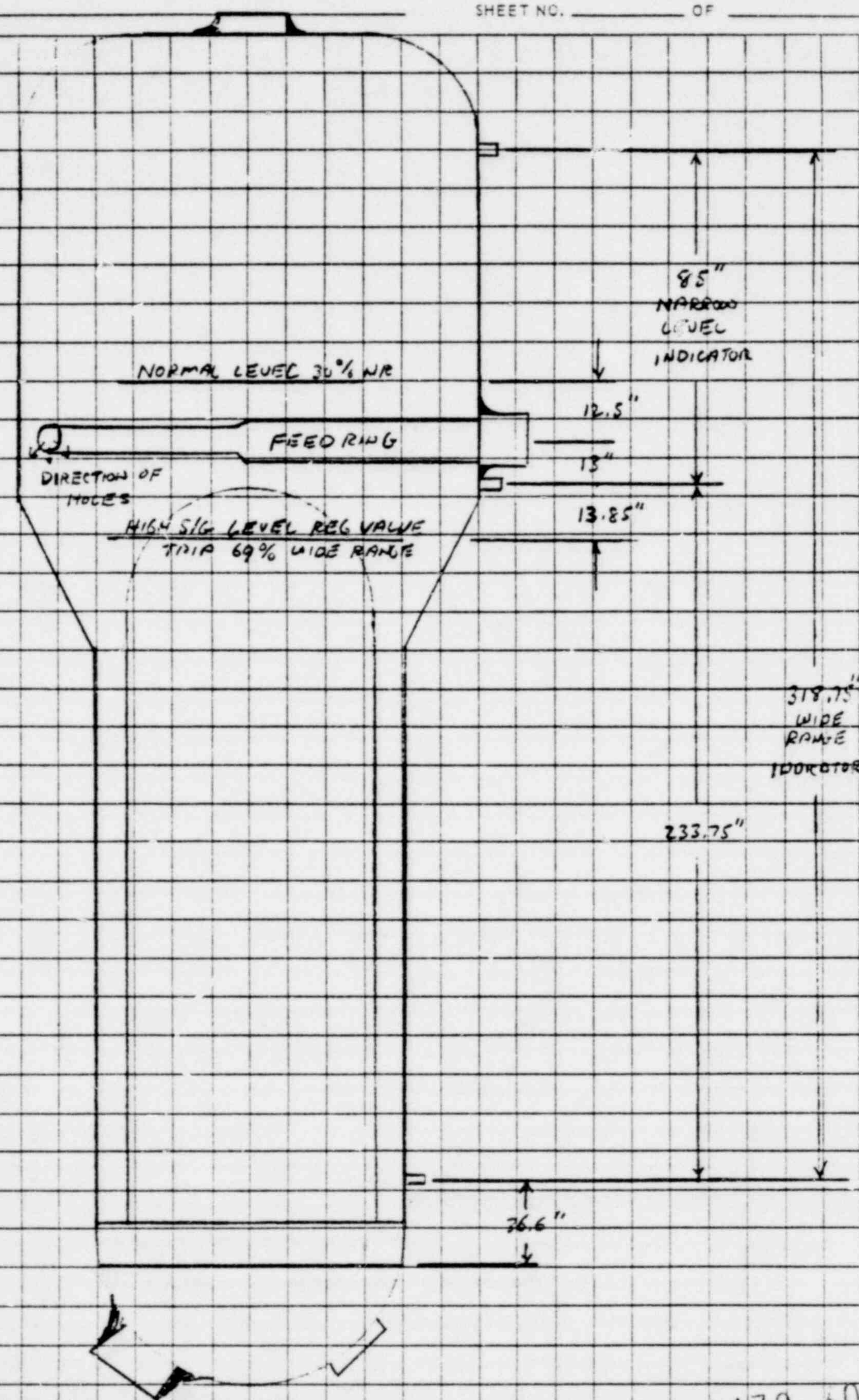
SUBJECT: CY STEAM GENERATOR LEVEL INDICATION AND FEEDRING LOCATION

BY: R ANDMEN DATE: 11/1/79

CHKD. BY: DATE:

W. O. NO.

SHEET NO. OF



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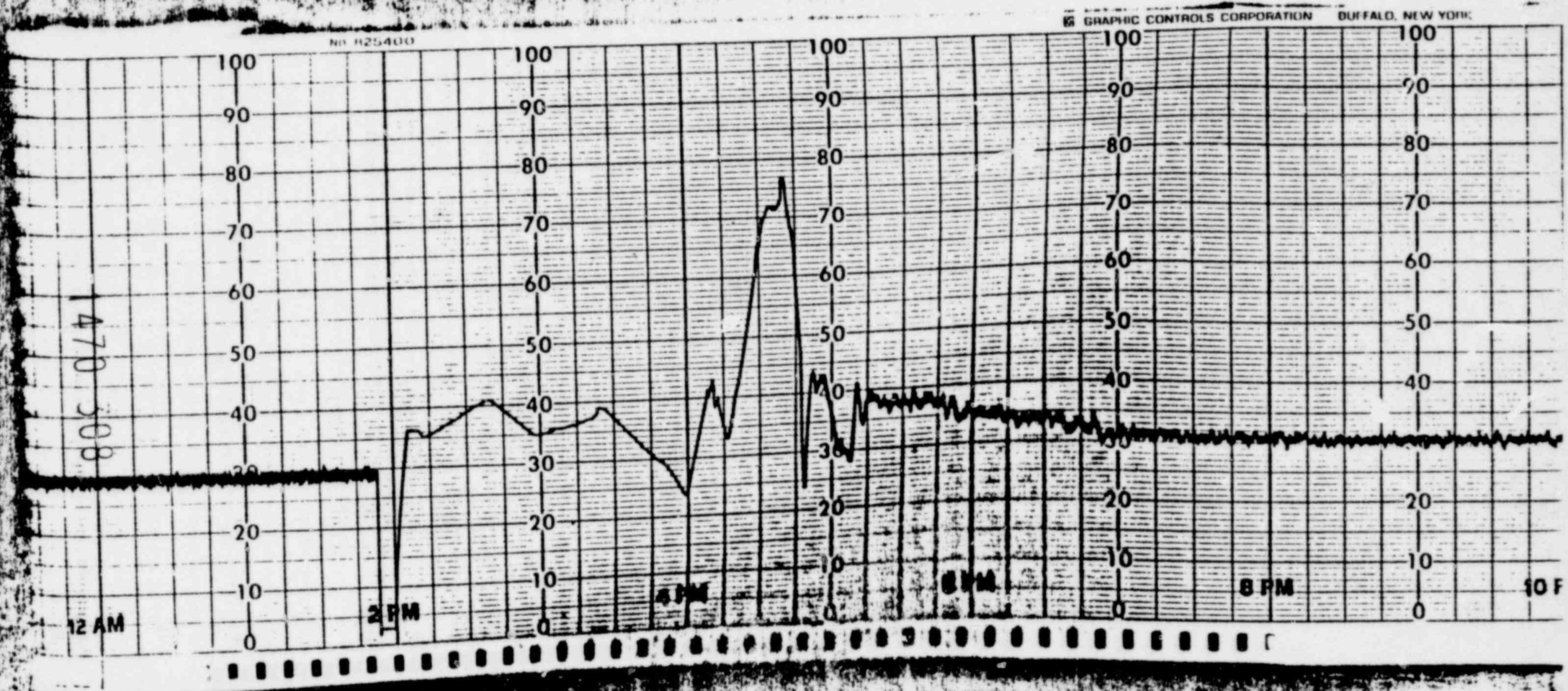
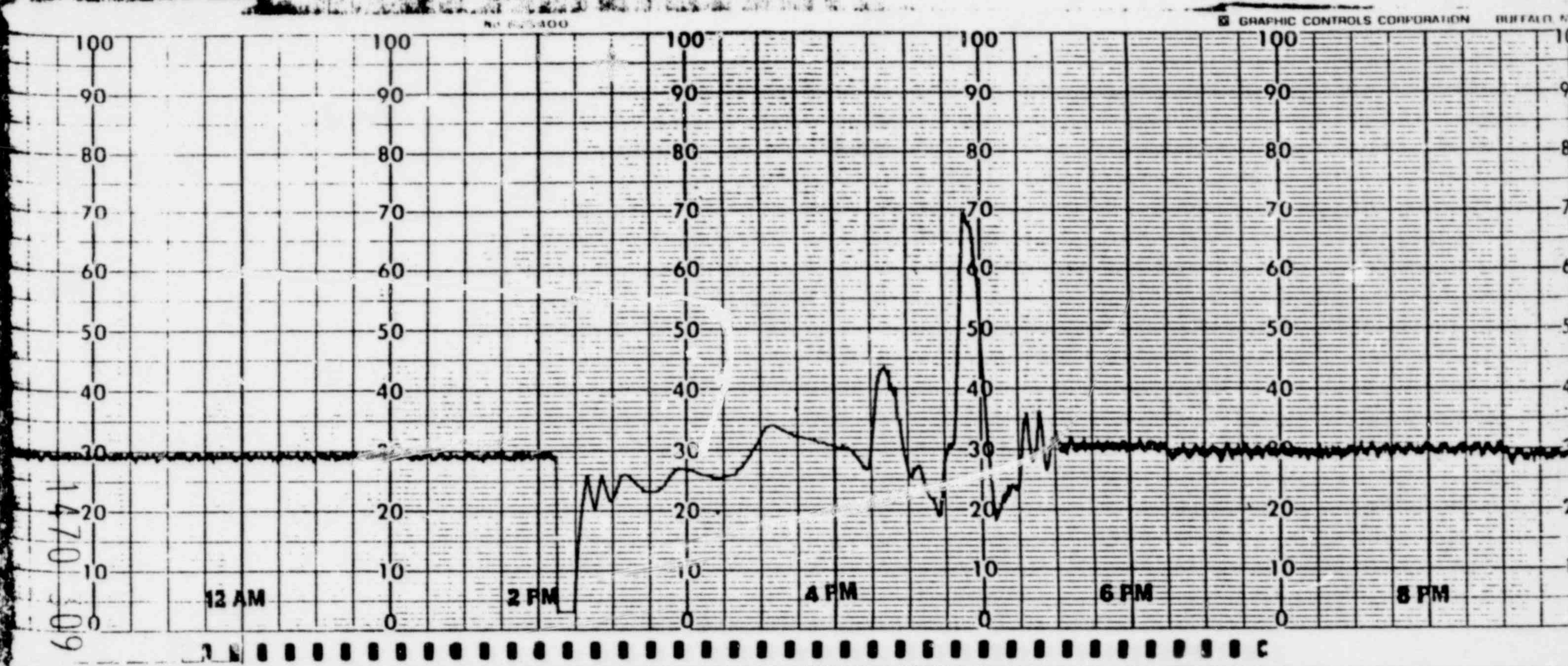
C.V. REACTOR TRIP ON
5/4/78
#1 STEAM GENERATOR LEVEL
(NARROW RANGE)

POOR ORIGINAL



C.Y. REACTOR TRIP ON
5/4/78
#2 STEAM GENERATOR LEVEL
(NARROW RANGE)



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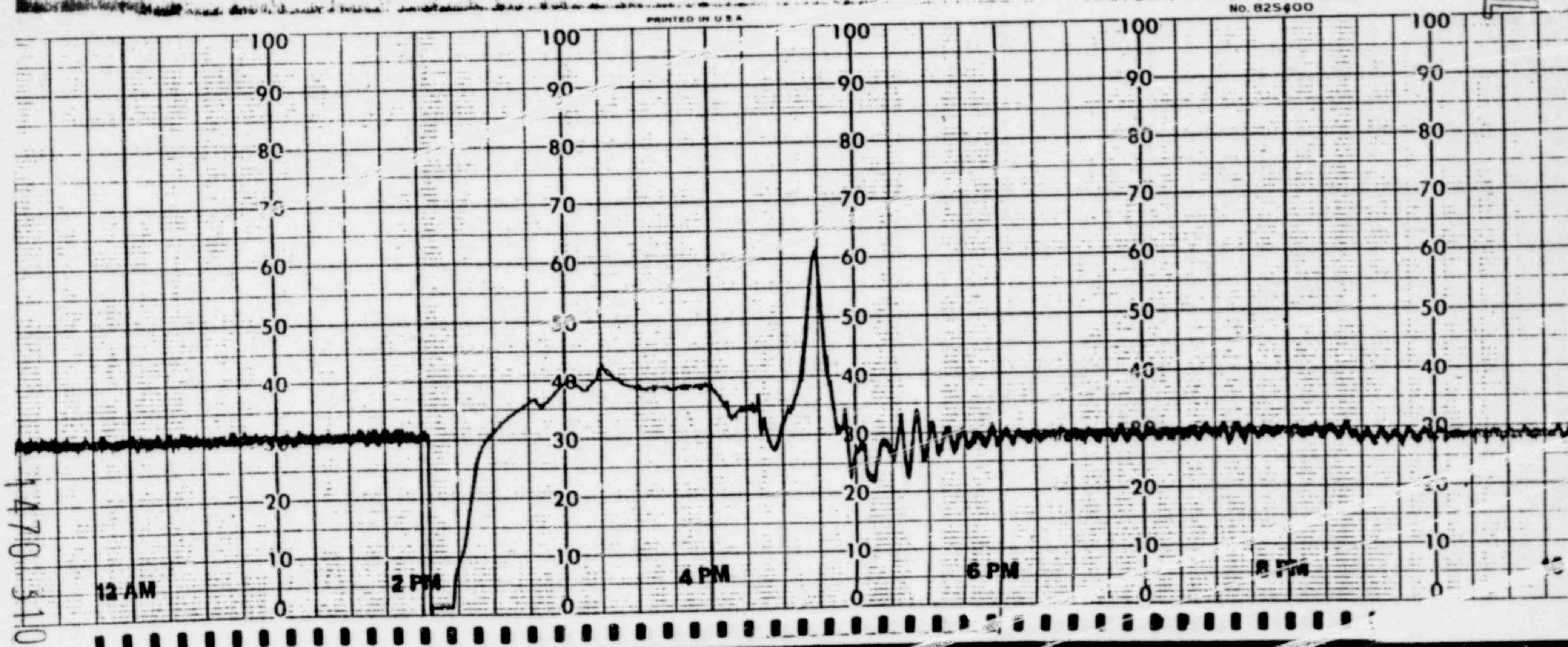
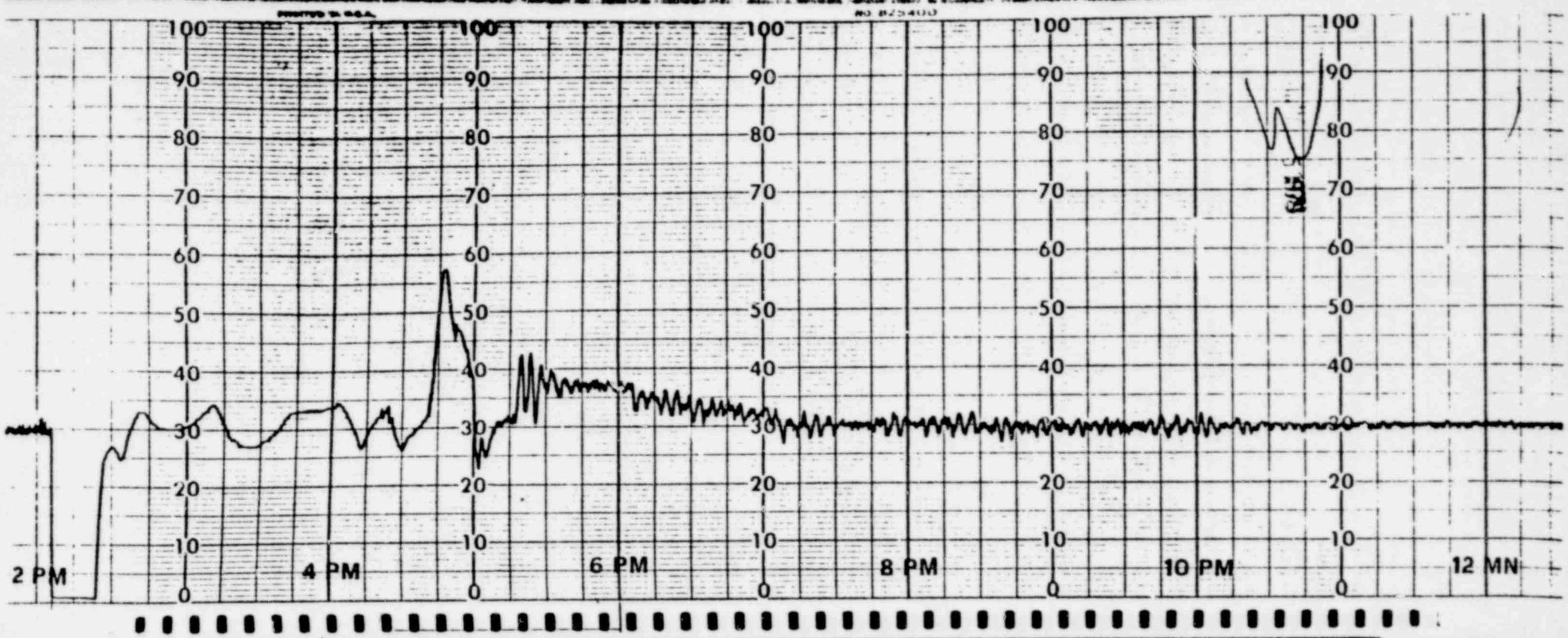
C.V. REACTOR TRIP ON
5/4/78
#3 STEAM GENERATOR LEVEL
(NARROW RANGE)

POOR ORIGINAL

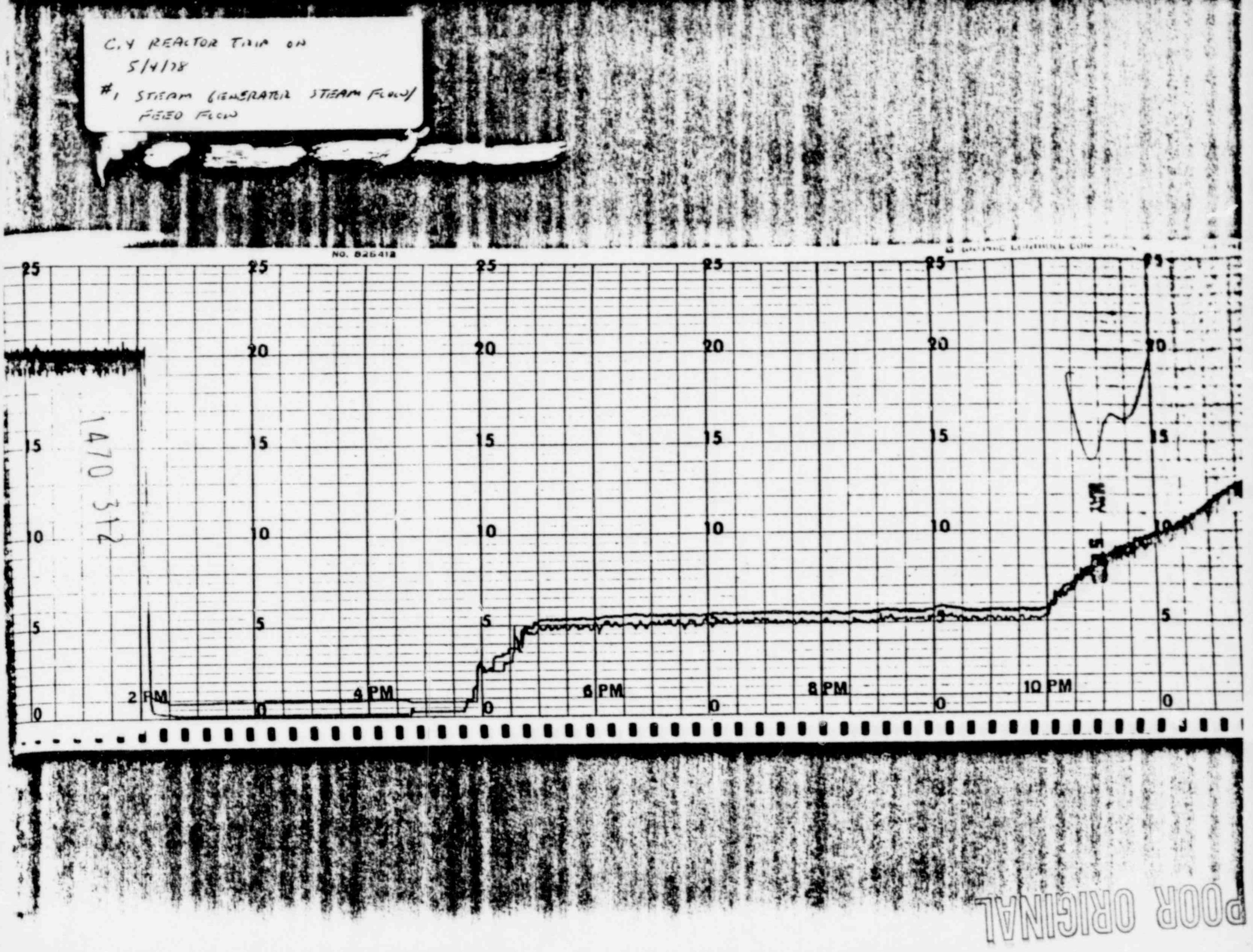


1470 310

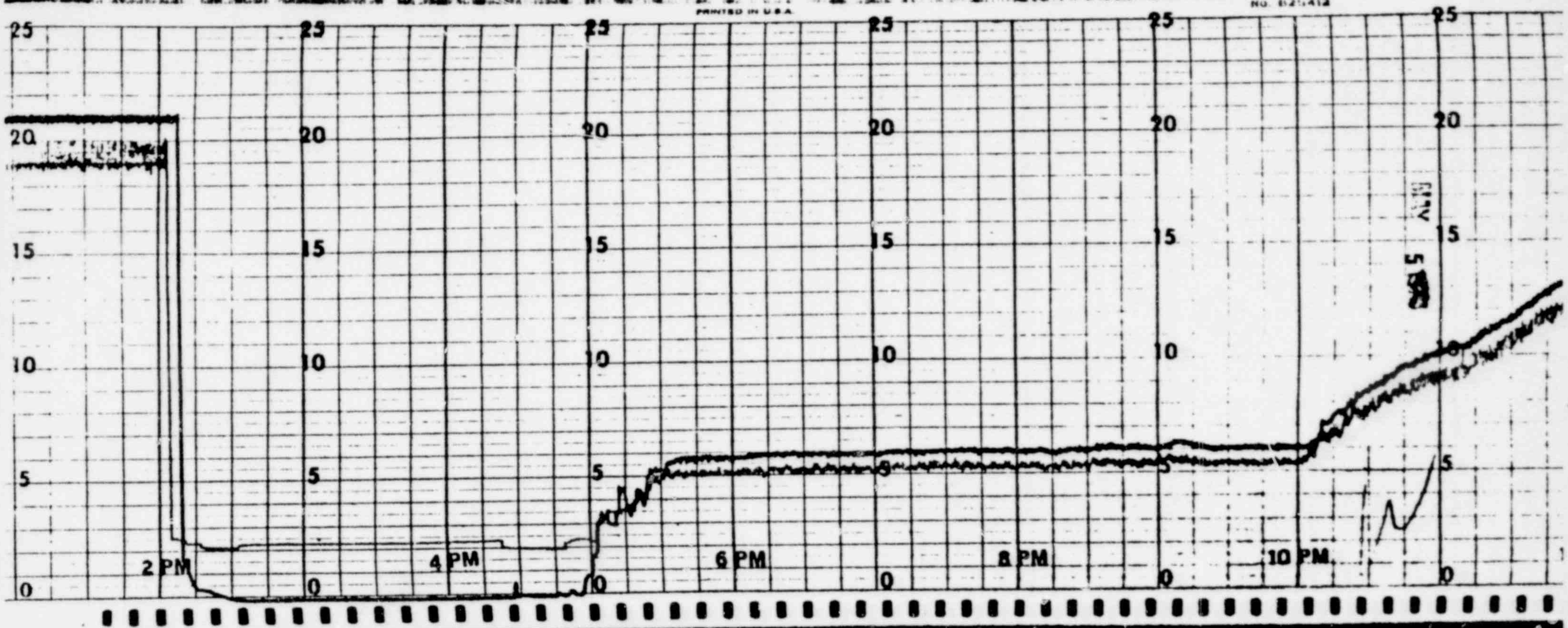
C.Y. REACTOR TRIP ON
5/4/78
... GENERATOR LEVEL
(NARROW RANGE)



1470 311


C.Y REACTOR TRIP ON
5/4/78
#1 STEAM GENERATOR STEAM FLOW/
FEED FLOW
NO. 826412
2 PM
4 PM
6 PM
8 PM
10 PM
1470 312
POOR ORIGINAL

C.V. REACTOR TRIP ON
5/4/78
2 STEAM GENERATOR STEAM FLOW/
FEED FLOW



POOR ORIGINAL

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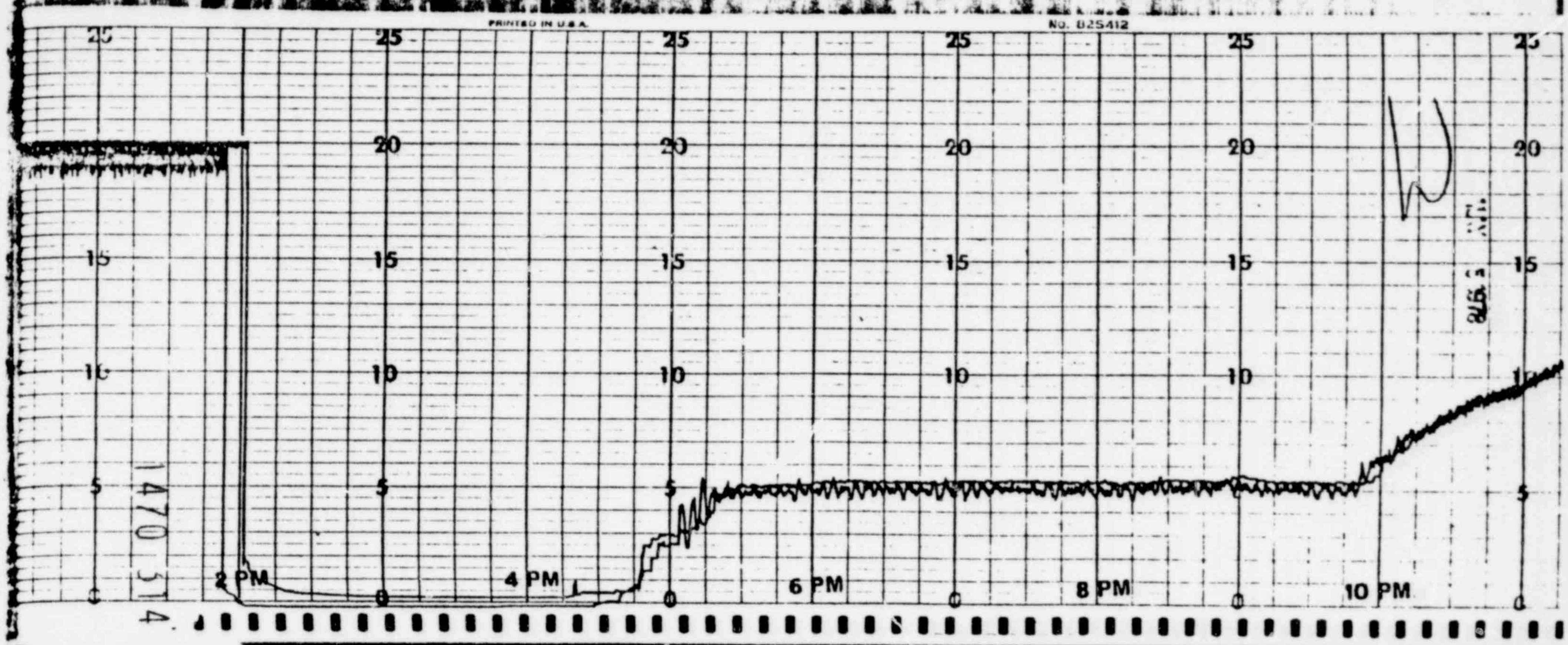
C.Y. REACTOR TRIP ON
5/4/78
#3 STEAM GENERATOR STEAM FLOW/
FEED FLOW



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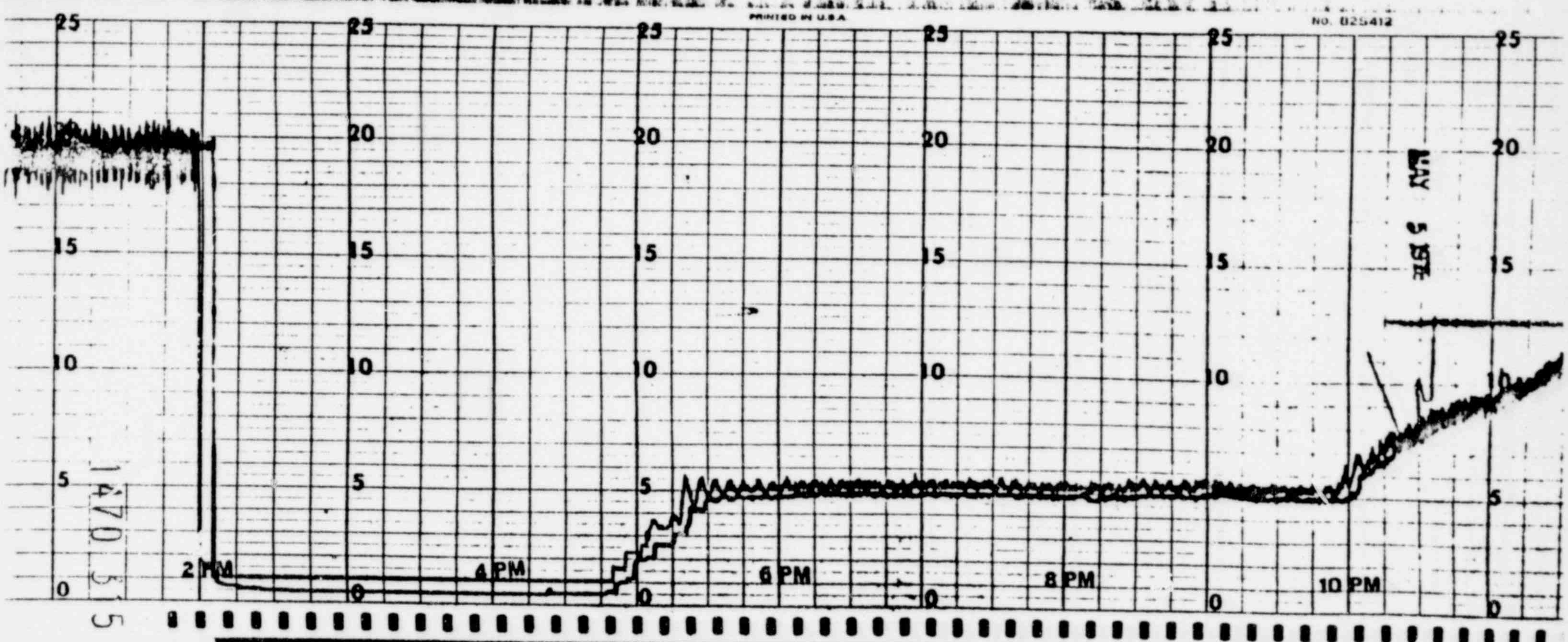
POOR ORIGINAL

C.V. REACTOR TRIP ON
5/4/78
#4 STEAM GENERATOR STEAM FLOW/
FEED FLOW



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DOCKET NO. 50-213

ATTACHMENT 2

HADDAM NECK PLANT

ADDITIONAL INFORMATION - STEAM GENERATOR WATER HAMMER

1470 316

NOVEMBER, 1979

QUESTIONS FOR HADDAM NECK

Reference (A) D. C. Switzer letter to R. A. Purple dated July 15, 1975

1. If any water hammer events have occurred during the feedring uncovery events referred to in the table.

   a. Explain any damage to the feedwater system.

   b. How long was the feedring uncovered?

   c. Was main or auxiliary feedwater being used?

   d. What was the feedwater flow?

   e. Give details of any piping or equipment modifications which were implemented.

<u>Response</u>

The tabulated tables of the Connecticut Yankee operating history relative to feedring uncovery is shown in Figure 2. Due to the limited time for this response and the extensive research necessary to determine the number of feedring uncoveries only a sample period between January 1977 to September 1, 1979 has been provided.

1470 317

The only damage which has resulted from feedwater hammers and equipment modifications which were implemented are discussed in Reference (A). Presently there have been no feedwater hammer events documented and therefore the requested information for items b, c, and d cannot be provided.

2. Describe procedure to be used to recover from reactor trip, including feedwater flow, steam generator water level, etc.

Response

Subsequent to a reactor/turbine trip, the feedwater valves will travel to the full open position to provide maximum feed flow to the steam generator. The main feed regulator valves will then close off when the steam bypass dump valves start to close; this occurs when Tavg = 545^{O}F. These valves will also travel to the closed position when steam generator level is above 69% on the wide range level indicator. The plant operator would then assure that each steam generator is getting adequate feedwater flow by opening the bypass valves if the main feed pumps are still available or by manually initiating auxiliary feedwater if necessary. Adequate feedwater flow is verified by increasing steam generator level. The steam generator level will drop below the feedwater sparger each time a reactor trip occurs. The operator will then manually return the steam generator level to normal (30% narrow range).

3. List main feedwater pump trips.

Response

A list of main feed pump trips are as follows:

1) Sustained low suction pressure will sound an alarm on the main control board and also automatically stop the steam generator feed pumps. Individual suction pressure switches are provided for each pump.

2) If while operating two condensate pumps and two steam generator feed pumps, shutdown of either one of the condensate pumps automatically stops one steam generator feed pump.

4. Do the main feedwater valves fail open or closed?

Response

The main feedwater valves fail in the closed position on loss of control air.

5. Are the bypass valves in the main feedwater lines open all the time? If not when are they closed?

1470 319

Response

The feedwater bypass valves are not open all the time. During plant startup these valves are open and used to maintain steam generator level with one auxiliary feed pump operating. The bypass valves are closed after the main feedwater regulating valves are open and being used to control steam generator level.

7. How are main feedwater valves positioned while shutting down main flow?

Response

When shutting down main feedwater flow the feed water regulating valves are placed in manual and steam generator level is maintained at 25%-50% on narrow range indicator. After turbine stop valves are closed, again the main feed regulator valves are adjusted to maintain 25%-50% on narrow range. The bypass valves are then opened to control steam generator level and then the main feed regulator valves and the feed line motor operated valves are closed. Main feed valves can be used in manual mode if turbine is latched.

8. What feedwater flow is used at startup?

Response

During startup the feedwater flow to each steam generator is through the bypass valves. There is presently no flow indication in these bypass lines so feedwater flow rate can only be estimated. A flow rate of approximately 250-300 GPM for each steam generator has been estimated using the pump head flow curves.

9. At what percent of full power is each main feedwater pump brought into and removed from service?

Response

The first main feedwater pump is brought into and removed from service at approximately 1% full power. The second main feedwater pump is placed on line and removed from service at slightly less than 50% full power.

10. What instrumentation is installed to detect water hammer?

Response

There is presently no instrumentation employed to detect water hammer.

FIGURE 2

TABULATION OF OPERATING HISTORY RELATIVE TO FEED RING UNCOVERY

OPERATIONAL YEARS	YEAR OF OPERATION AND LOSS OF OFFSITE POWER EVENTS	NO. OF UNCOVERIES CAUSED BY:											
		SHUTDOWN				STARTUP				REACTOR TRIP			
		A	B	C	D	A	B	C	D	A	B	C	D
	1977	5	9	7	7	0	6	2	2	2	2	2	5
	1978	4	3	4	8	1	2	9	1	7	5	4	4
	1979 To 9/01/79	0	0	0	0	0	1	1	0	1	1	1	1
LOSS OF OFFSITE POWER EVENTS	7/05/69	-	-	-	-	-	-	-	-	2	1	1	3
	1/19/74	-	-	-	-	-	-	-	-	1	1	1	1
	6/26/76	-	-	-	-	-	-	-	-	Plant Shutdown For Refueling			
	4/27/68	-	-	-	-	-	-	-	-	1*	1*	1*	1*

*Estimated Uncoveries Difficulty in Finding Data.

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FIGURE 2

TABULATION OF OPERATING HISTORY RELATIVE TO FEED RING UNCOVERY

Year Of Operation (Startup To Present)	No. Of Outages & Power Reductions	No. Of Outages With No Feed Ring Uncovery	NO. OF OUTAGES & POWER REDUCTIONS CAUSED BY:					
			Reactor Trip	Loss Of Feedwater	Loss Of Offsite Power	Safety Injection	Other Transients	Planned
1967	19		8	0	0	0	1	10
1968	25		12	0	0	0	0	13
1969	18		6	0	1	0	3	8
1970	17		3	0	0	0	1	13
1971	10		6	0	0	0	0	4
1972	8		3	0	0	0	0	5
1973	7		0	0	0	0	1	6
1974	14		3	0	1	0	0	10
1975	7		2	0	0	0	0	5
1976	7		4	0	1	0	0	2
1977	23	10	1	0	0	0	1	21
1978	13	5	4	0	0	0	0	9
1979 To 9/1/79	9	7	1	0	0	0	0	9

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11/21/79