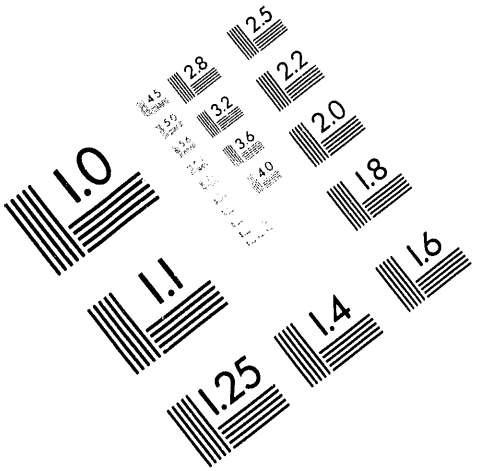

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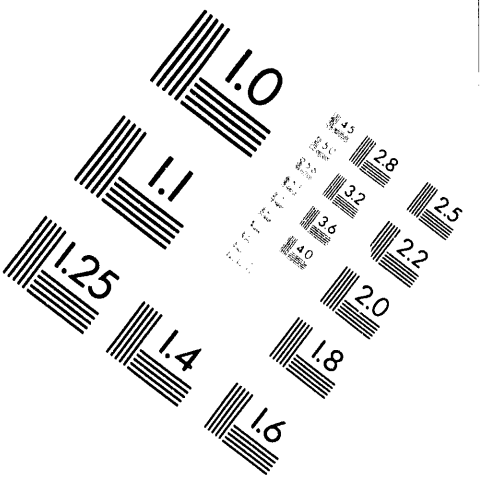

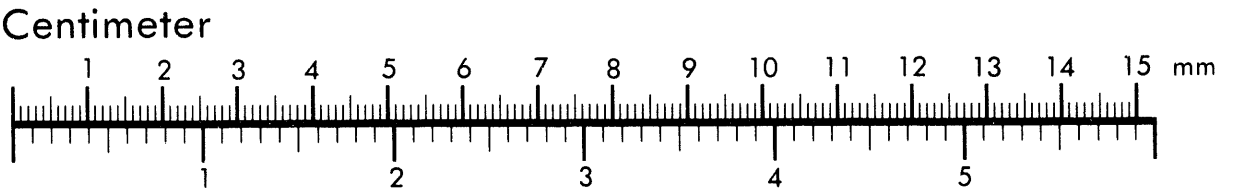

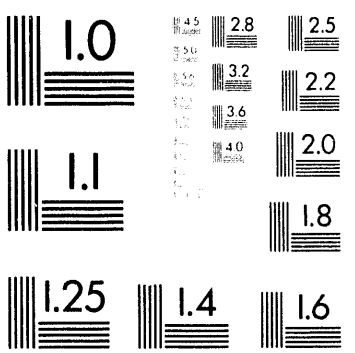

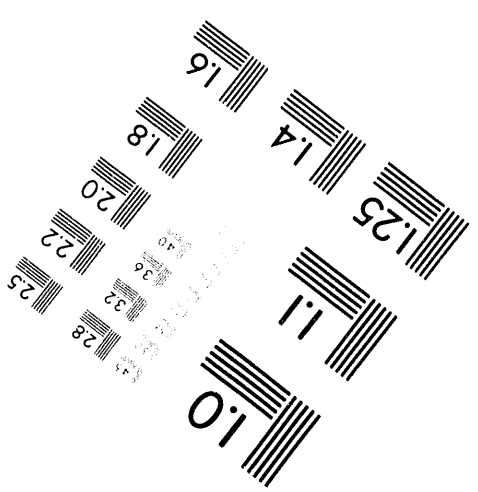

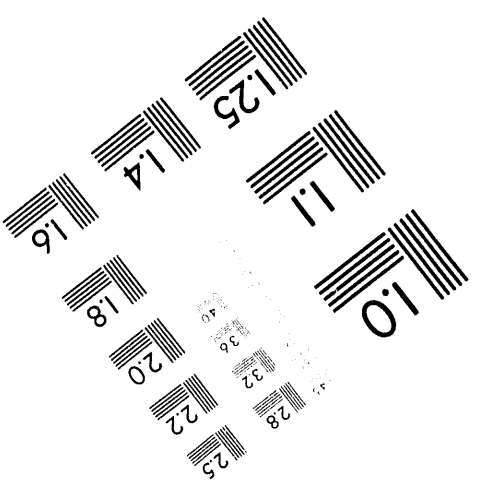

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190-DR STEAM TURBINE BACKUP ADEQUACY REPORT

by

W. H. Radtke
E. R. Keplinger

November 8, 1962

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190-DR STEAM TURBINE BACKUP ADEQUACY REPORT

Introduction

Because of the questionable performance of the 190-DR steam backup system during the power outage of April 6, 1962, it is felt that a general review of the DR secondary water system capabilities and the standby status of the pumping units is warranted. This report shall briefly describe the performance of the steam backup system during the April 6 power outage and the subsequent power outage of July 10, 1962. Since the former outage, tests have been conducted on the steam pump units to determine their capabilities; the test results are presented in this report. A statement of the generally accepted criteria for secondary coolant system adequacy is included and recommendations for meeting the criteria at DR reactor are presented.

Power Outage - April 6, 1962

On April 6 at 1509, BPA lines 1 and 2 relayed out at 100-B and 100-F respectively, creating a complete power failure at all 100 areas. At 190-DR the electric pump units stopped and the flow decayed normally. The seven 190 steam turbines on standby accelerated and gradually picked up the cooling load as the electric pump flow dropped off. The pressure at the top-of-riser (referred to as TORP throughout this report) dropped to a value of 56 psig corrected to the TORP.[1] Two things occurred which were responsible for the unexpectedly low TORP. (Normal TORP supplied from the secondary coolant system following BPA loss would be expected to be in the 80 to 100 psig range.) First, the 184-D boilers accelerated upon loss of power, but the No. 5 standby boiler suffered a faulty forced draft fan which decreased its capacity by approximately 30 per cent. As a result, the steam pressure normally maintained at 228 psig was dropped to approximately 190 psig at 184-D, or 175 psig at the 190-DR steam turbines where the normal operating pressure is about 225 psig. This steam pressure reduction tended to lower the capabilities of the steam turbines to deliver flow at the normal TORP to the reactor. Secondly, the 182-D pump (electric) which supplies cooling water to the 190 steam turbine condensers failed with the power loss, as would be expected. The backup condensing water steam pump at 182-D was on manual operation so did not pick up the load automatically. Therefore, the 190 building steam backup system suffered further losses by operating on non-condensing status.[2]

Although the high tank trip pressure of 50 psi TORP was closely approached, high tank flow was not initiated. Adequate secondary coolant flow was provided DR reactor at all times.

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[1] This TORP is the average of A and B risers from 190 and 105-DR data corrected by subsequent instrument calibration.

[2] The Worthington turbines at 190-DR tend to be quite inefficient when operated on non-condensing; hence, this explains a portion of the observed difference between DR and D where the Westinghouse turbines do not seem to be as sensitive to this change.

Procedurally the backup system was handled in an efficient manner. As soon as the performance of the steam system was observed to be less than expected, two additional steam turbines were placed into service within approximately five minutes at 190-DR. This action plus the effect of gradually increasing steam pressure from 184-D raised the TORP to a value of about 80 psig. This action was a desirable step to increase the flow rate to an expected value; however, coolant flow to DR reactor would have been adequate without the additional pumps.

Correction to Steam Backup System

Following the April 6 outage, steps were taken to assure that if needed again the steam coolant backup system would provide sufficient flow to insure a TORP in the 80-100 psig range. Eight steam pump units instead of the customary seven were placed on standby status. The turbine speed governors were set up to the maximum position. Also, the 182-D steam pump on the condensing system was placed on Copes control for automatic backup.

Subsequent to the power outage, the No. 5 boiler forced draft fan was repeatedly tested and in every instance functioned normally.

Power Outage - July 10, 1962

On July 10, 1962, at 0016 a power line at Priest Rapids Dam relayed out causing three breakers at Midway to open. A surge on the 230 kv line was initiated by this action. At 190-DR the eight electric primary pumps stopped as a result of the power surge and the steam turbines picked up the cooling load. On standby for automatic backup at this time were eight units, auxiliary nozzles closed, and the 182-D condensing water steam unit. The top-of-riser pressure as measured on the 190-DR control room Heise gauge reached a minimum of 98 psig. From test data the TORP should have been 103 psig, which, when considering time differences and drift in calibration, is not at all unreasonable. Numbers 1, 2, and 4 boilers at 184-D were accelerated due to the power surge and other than the Copes control on No. 4 boiler acting somewhat sluggish, the steam load for the emergency condition was satisfactorily picked up and carried. Steam pressure was normal.

The steam pump conditions described above have been in effect on a temporary basis until the testing program discussed below was completed and the results evaluated. It is the primary purpose of this report to present the results of these tests and to make recommendations for the standby conditions of the permanent steam coolant backup system ad DR reactor.

Testing Program

During the month of June, 1962, the steam backup system was tested for flow and TORP using varying numbers of pumping units on the line. Each set of pumps was tested under condensing and non-condensing conditions. Also, the auxiliary nozzles which provide an additional steam jet to the turbines for extra pumping capacity were opened provided another variable in the test conditions.

[redacted]

Results of Test With Auxiliary Nozzles Open

No. of Turbines	Flow (190)*	Flow (105)*	TORP	Boiler Load
9 condensing	35,500	40,000	132	197,000
9 non-condensing	32,100	35,500	108	207,000
8 condensing	33,400	37,000	116	179,000
8 non-condensing	30,000	33,200	96	193,000
7 condensing	30,500	34,500	103	161,000
7 non-condensing	27,700	29,600	80	183,000
5 condensing	22,400	26,000	65	155,000
5 non-condensing	21,900	24,400	59	168,000

Results of Test With Auxiliary Nozzles Closed

9 condensing	bad reading	37,300	118	163,000
9 non-condensing	27,300	31,600	88	165,000
8 condensing	30,100	34,200	103	158,000
8 non-condensing	26,400	29,000	78	152,000
7 condensing	27,600	32,400	93	147,000
7 non-condensing	23,400	26,700	68	147,000
6 condensing	24,800	29,500	79	137,000
6 non-condensing	21,600	24,800	60	138,000
5 condensing	21,700	25,700	64	134,000
5 non-condensing	19,000	21,500	49	136,000

For graphic representation see Figure 1.

NOTE: The steam pressure at 190-DR was above minimum standard requirement (200 psig) throughout the testing.

All TORP data was obtained using a calibrated 0-800 psi Heise gauge. The accuracy should be ± 1 ½ psi.

Very roughly it may be determined from the above data that the loss of the condensing flow turbine is equal in flow or pressure to about the loss of two 190-DR turbines. This must be taken into consideration when advising on the standby steam backup system.

Discussion of Results

Based on the test results and the turbine performance during the latter emergency it seems that, given an adequate testing program to check future turbine performance, a desired steam backup system can be prescribed on the strength of present technical knowledge. The poor boiler performance during the April 6 outage points out the need for the testing of all steam backup components. Further tests including all emergency facilities at 190-D/DR area would be desirable.

*The flow (190) is a summation of the individual turbine metered flows (190) at the reactor. Flow taken from a reactor hydraulic demand curve using the applicable TORP. It is the opinion of the authors that the latter would be the most accurate since current tests are used to continually update the demand curve.

[redacted]

Criteria

The generally accepted criteria for the secondary coolant system backup includes the following requirements. The secondary process water system must be capable of delivering adequate coolant flow to the reactor automatically upon loss of power to the primary system pumps at a pressure sufficient to preclude the possibility of initiating high tank flow. Further, allowance must be made so that this requirement will be met in the event that two of the standby units fail to accelerate.

This portion of the criteria is interpreted to mean that the allowance for steam pump failure can include either two of the 190-DR steam turbine coolant backup units or one such unit plus the 182-D steam pump supplying the condensing water. It is assumed that the probability of losing two steam turbines simultaneously is the same in the two cases cited. However, even though improbable, the loss of all three turbines would still yield adequate reactor coolant flow although slight high tank contribution would be experienced.

Recommendations

In order to meet the criteria for secondary coolant system backup as stated, in part, above, it is recommended that the following minimum conditions be adopted. Specific standby pump conditions may be changed to suit maintenance schedules, etc., as long as these minimum requirements are met.

Pumping Status	Min. No. of 190 Steam Units
1. Auxiliary nozzles open, 182-D condensing steam unit on automatic	7
2. Auxiliary nozzles open, 182-D steam unit manual	7
3. Auxiliary nozzles closed, 182-D steam unit on automatic	7
4. Auxiliary nozzles closed, 182-D steam unit manual	8

The 190-DR turbines will be left at the maximum governor speed setting in order to meet these minimum pumping requirements.

With the steam backup system described above, the failure of either two 190-DR steam turbines or one 190-DR steam turbine plus the 182-D condensor water turbine should not lower system pressure to the point where high tank flow is established. i.e., 50 psig TORP.

The final recommendation is that all work performed on the 190-DR steam turbines which may change the pumping characteristics be followed by testing to assure

conformance to the basic backup criteria. When such testing becomes necessary a copy of the test data will be made available to the process engineer.

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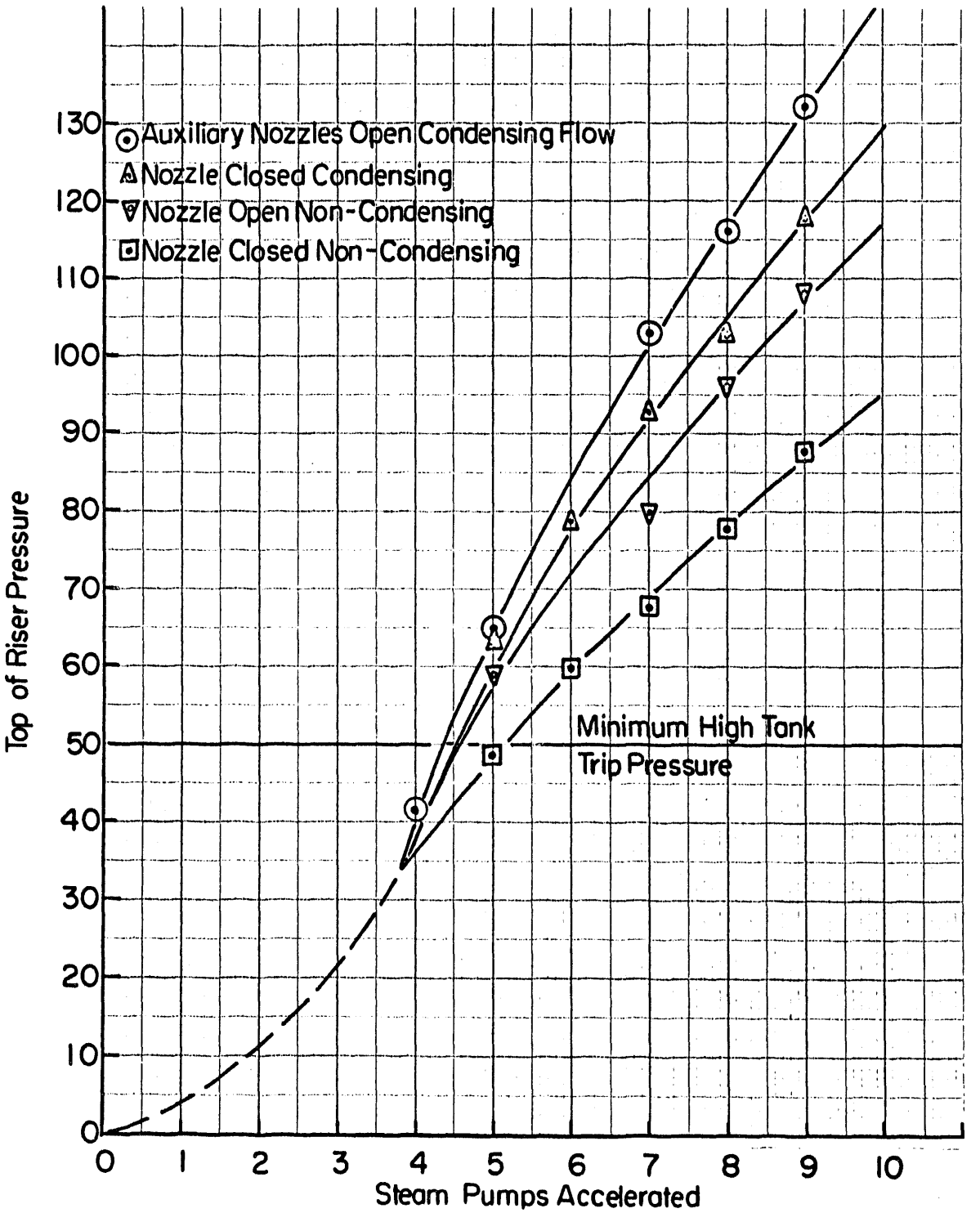
FIGURE – 1

STEAM TURBINE DATA
190 DR



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