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YANKEE NUCLEAR POWER STATION

OPERATION REPORT NO. 36

For the month of

DECEMBER 1963

Submitted by

YANKEE ATOMIC ELECTRIC COMPANY
Boston Massachusetts

January 27, 1964

This report covers the operations of the Yankee Atomic Electric Company plant at Rowe, Massachusetts for the month of December 1963.

Until December 23, the plant was operated continuously at near rated capacity of 167-168 MWe gross. On that date the plant was shutdown to repair a main coolant leak. The leak was similar to that reported in the Operations Report for November 1963 being traced to a second pinhole failure in the seal weld of the plug, over shim position number 26, on the reactor vessel head. The original leak, on the same plug, was in an area immediately adjacent to the most recent failure. To eliminate future recurrences of this type failure the entire seal weld was reworked using a three pass overlay.

On December 25, the generator was phased to the line and plant electrical output was raised to 167 MWe. Having received A.E.C. approval to operate at 600 MWt, power level was gradually increased until December 30 when a power level of 185 MWe was achieved.

Periodically throughout the month control rod exercises and movement for wear equalization were carried out as scheduled.

During the recent refueling shutdown four high flux irradiation test specimens were removed from the reactor vessel. In mid-December the specimens were placed in a lead cask and shipped off site for examination.

Twenty-four Core II silver-indium-cadmium control rods have been loaded into a cask and are now awaiting shipment to a burial facility.

Plant Shutdowns

Shutdown No. 66-3-4	12/23/63 - 12/25/63	A 46.9 hour shutdown to repair a primary system leak in a seal weld of a [illegible] position plug on the [illegible]tor vessel head.

Maintenance

Following is a summary of major activities carried out by plant maintenance personnel during December:

1. A leak in the lines leading to the fuel pit ion exchange unit was repaired.

2. The check valves in the heating boiler feed lines were repaired.

3. The generator hydrogen vent line heat trace was repaired.

4. Relays were replaced on an instrument air dryer control system.

5. No. 1 auxiliary heating boiler was cleaned and inspected by an insurance company inspector.

6. Several diaphragm valves in the waste disposal plant were repaired.

7. A broken contact shoe on the waste disposal hoist was replaced.

8. A broken check valve spring was replaced in No. 3 charging pump.

9. A defective diaphragm valve on the waste holdup tank was repaired.

10. New heat tracing was installed on the waste disposal drumming line.

11. New brushes were installed on the vital bus inverter.

12. The commutator on both battery charges was cleaned.

13. Insulation was replaced around the moisture separators and associated piping.

14. A leak in the seal weld of shim rod number 26 plug was repaired by complete rewelding of the whole seal.

15. Miscellaneous valve packing was added or adjusted as required in both the primary and secondary plants.

16. A 480 v. ground was found on the PCA storage building crane and repaired.

17. No. 17 control rod coil stack was replaced with a spare coil stack. Replacement was necessary due to grounds developing on four of the five coils of the stack resulting from moisture discharge during the seal weld leak.

Chemistry

During the month a program was initiated to measure oxygen build up in the pressurizer. Early in the reporting period samples of pressurizer liquid, gas and steam phase were analyzed for dissolved oxygen, gaseous oxygen and boron. Dissolved oxygen was negative in the main coolant prior to pressurizer level changes but increased to 0.09 ppm immediately following level changes. Pressurizer water contained 0.20 ppm dissolved oxygen prior to the test and decreased to undetectable amounts afterwards. Pressurizer gas samples were quantitatively analyzed and found to contain 95% combustible gases. No oxygen was detected, however, it should be noted that the apparatus used is incapable of detecting oxygen below 0.1%. Condensate samples were found to contain 36 ppm boron, indicating boron volatility of approximately 11%. This verifies data obtained previously from waste disposal operations with boron and laboratory experiments on boron volatility.

Later on in the month the pressurizer vent system was sampled. Flashed gas concentration had increased from 770 cc/liter to 1050 cc/liter. As mentioned previously, oxygen could not be detected initially in the gas, however, an average of 0.5% was detected in this most recent sample. The dissolved oxygen in the pressurizer drain sample also increased from 260 ppb to 370 ppb. An attempt was, therefore, made to lower the overall oxygen content of the pressurizer by establishing a continuous vent to the Low Pressure Surge Tank at a capillary flow rate of 49 lbs/hr.

After eight days of venting, the flashed gas concentration decreased from 1050 cc/liter to 640 cc/liter. The oxygen concentration decreased from 0.5% to 0.2% this being the approximate equipment detection limit. However, water samples from the pressurizer drain line indicated oxygen levels had increased from 370 ppb to 700 ppb. The cause of this increase is as yet undetermined.

Following further continuous venting, the flashed gas concentration and the oxygen content again decreased to 514 cc/liter and <0.2% respectively. Also, the dissolved oxygen in the drain line decreased to 160 ppb.

Following startup after the cold shutdown of December 23, both the gas concentration and oxygen content showed no change while the dissolved oxygen in the drain line further decreased to 40 ppb.

At the end of the reporting period continuous venting of the pressurizer to the Low Pressure Surge Tank was still in progress.

Until the shutdown on December 23, the average main coolant specific activity remained essentially constant at 1.2×10^{-1} µc/ml. Following startup on December 25, the specific activity increased to 3.4×10^{-1} µc/ml but had again returned to the pre-shutdown value of 1.2×10^{-1} µc/ml at the end of the reporting period.

The main coolant crud level was measured at approximately 0.12 ppm until the shutdown, whereupon, the loop bypass valves were opened and the level increased to 13.7 ppm.

A main coolant iodine analysis made at the beginning of the reporting period indicated:

I-133	3.1×10^{-3} µc/ml
I-131	8.7×10^{-4} µc/ml
I-131/I-133 atomic ratio	2.78

Following startup on December 25, there was a small increase in I-131 concentration to 2.9×10^{-3} µc/ml. A steady decrease followed and at the end of the reporting period, the I-131 was 4.0×10^{-4} µc/ml at 185 MWe.

A typical main coolant crud analysis made during the period indicated the following:

Cr-51	2.8×10^{6} dpm/mg
Mn-54	6.2×10^{5} dpm/mg
Fe-59	2.9×10^{6} dpm/mg
Co-58	3.4×10^{6} dpm/mg
Co-60	6.2×10^{5} dpm/mg
Mg-110m	3.3×10^{4} dpm/mg

Reactor Plant Performance

Operation with boron in the main coolant continued throughout the reporting period. Only slight control rod motion was experienced as reactivity losses through burning were compensated for by periodic reductions

in the main coolant boron concentration. The slight control rod motion experienced during the month was that necessary for the wear distribution program.

Considerable data taken during the Core III startup test program has been analyzed and the results are tabulated below:

1. Average boron worth at operating temperature:

   $-0.6 \times 10^{-5} \Delta\rho$/ppm

2. Boron concentration required for all rods out criticality at operating temperature:

   1300 ppm

3. Boron concentration required for all rods out criticality at 250°F:

   1600 ppm

4. Boron concentration required for 5% shutdown in the cold condition:

   1100 ppm

5. Boron concentration required for 4% shutdown at operating temperature:

   200 ppm

6. The incremental worth of all rods banked was fitted over a measured range of bank height from 18 to 70 inches as:

$$\frac{\Delta\rho}{\Delta H} = \left(\frac{1}{3.25 + .1663H} \right)^3$$

7. Total programmed rod worth at operating temperature as determined from rod oscillation data:

	Total Group Worth
Group 1	.012 Δ K
Group 5	.021 Δ K
Group 6	.023 Δ K
Group 8	.025 Δ K

8. The inconel clad Ag-In-Cd control rods are equivalent to 95% of the hafnium rod worth.

9. The moderator temperature coefficient is essentially the same as that measured over previous cores.

As part of the Core III startup program a drop test series for all 24 control rods was made. All control rods were tested once in the cold condition and five times with the reactor at operating temperature and pressure. A recently completed analysis of this data has shown all drop times to be in good accord with that data obtained previously. In the cold condition the average drop time recorded was 1.676 seconds while at a temperature of 514°F Tavg., the average drop time for all 24 rods was 1.454 seconds. The reduction in average drop time between the cold and hot tests is as expected due to changes in water density.

During the month a plot was maintained of actual reactivity behavior versus predicted reactivity behavior to account for any unexplained reactivity variances. At the beginning of the reporting period an unexplained reactivity loss of 0.1% $\Delta\rho$ was measured, this figure increasing to 0.2% $\Delta\rho$ at the end of the month. Across the shutdown of December 23, a reactivity loss of 0.2% $\Delta\rho$ was experienced but was subsequently regained through reduced burnup at rated power in the ensuing two weeks following startup.

The following were determined by means of in-core instrumentation measurements at a power level of 540 MWt with control rod group 2 at 72 3/8" and all other groups at 75 6/8".

$$F_Q = 3.5$$
$$F^{\Delta}_T = 2.3$$
$$QDNBR = 3.5$$

Late in the reporting period a gradual approach of the plant to the most recent authorized power level of 600 MWt was made. The first stage of the power increase consisted of a slow withdrawal of boron from the main coolant accompanied by a corresponding insertion of control rods to maintain Tavg. and plant output constant. At the preselected boron concentration of approximately 50 ppm the main coolant temperature was increased by rod withdrawal while the generator output was held constant by closing turbine control valves. Once the main coolant temperature had stabilized, the generator output was increased until all four control valves were fully open.

This same procedure was repeated until the plant had reached its newly rated output of 185 MWe, corresponding to a reactor power level of 600 MWt at a main coolant average temperature of 527°F.

No difficulties were encountered with the primary plant during the load increase. All auxiliary systems accepted the additional load placed on them.

Turbine Plant Performance

At several points during the plant loading to 185 MWe miscellaneous secondary plant performance checks were made. The resultant data has shown all secondary side equipment accepted the load increase smoothly.

No loss of circulating water discharge vacuum occurred during the month and consequently it is still impossible to determine the complete effectiveness of the modifications made during the refueling outage.

The results of a typical feedwater heater terminal difference measurement made during the period indicated:

@ 184 MWe	1.6" Hg	505 psig throttle
No. 1	9.0°F	
No. 2	15.3°F	
No. 3	6.2°F	

As reported in previous Operation Reports, substantial modifications were made to the suspension system of the main steam piping during the refueling outage. Main steam line vibration had been considered excessive during Core I and Core II operation. A series of tests performed by an outside consulting service during Core II operation resulted in the modification mentioned previously.

During the month, test data on vibration amplitude and frequency were measured at corresponding locations to those measured during Core II. Substantial reductions in vibration amplitudes were recorded at most locations. A slight increase was noted in the frequency of vibration. This most recent data has been transmitted to the construction contractor and it is expected that only minor modifications will be required to make the new damping system completely effective.

Instrumentation and Control

During the month the following maintenance items were carried out by the plant Instrumentation and Control group:

1. Installed new flux wires in drives No. 1 and 3 and investigated power supply problems to the in-core instrumentation system.
2. Repaired the turbine control valve position indicator.
3. Modified spare FN equipment to incorporate recent changes brought about by the plant load increase.
4. Reset the level alarms on the waste disposal loop seal.
5. Checked the resistance readings of temperature detectors in the main generator.
6. Completed decontamination of equipment used during refueling.
7. Cleared the filter paper drive path on the vapor container air particulate monitor.
8. Checked the calibration of the MWe recorder.
9. Performed the bi-annual check of the Civil Defense equipment.

10. Calibrated the four feedwater flow channels to check high readings of integrated flow.

11. Checked operation of the air ejector effluent detector. The pipe to the stack had frozen causing erratic counting rates.

12. Checked sluggish operation of the Low Pressure Surge Tank level channel.

13. Readjusted the high THNR alarms to 555°F and the automatic "rods in" to 529°F and 518°F to their respected requirements at higher power operation.

14. Repaired the incore thermocouple recorder range change circuit board.

15. Readjusted the set points on the main condenser level controls.

16. Reset the boiler feed pump suction pressure switch for operation at higher power.

Health and Safety

During the month of December, 120 drums of solid radioactive waste, containing approximately 552 mc, were prepared. Included in this total are 24 drums containing the effluent drained from the control rod shipping cask. These 24 drums contained 370 of the 552 mc total.

One hundred and two drums of solid radioactive waste, containing as estimated quantity of 1.21 curies were shipped off-site for disposal.

Liquid waste containing a total activity of 0.68 mc was discharged from the plant during December. Gaseous release from the plant contained an estimated 7.0 mc due primarily to radiochemistry sampling. At all times the concentration of waste products discharged from the site was well below the maximum permissible.

Radiation levels of the LPST cubicle area were 110 mr/hr at the entrance, 80-130 mr/hr general area, 200 mr/hr contact bottom of tank south, 350 mr/hr contact bottom north, and 1 r/hr contact bottom center.

Radiation levels measured in the fuel chute lower lock valve cubicle were 15-35 mr/hr general area, 150-200 mr/hr contact lock valve, and 1500 mr/hr contact drain valve.

During the month four high flux irradiation specimens were shipped off-site for examination. Radiation levels and contamination levels measured on the cask prior to shipment were 40 mr/hr maximum contact and 300 dpm/ft^2 respectively. The total estimated activity of the shipment was 70 curies.

Late in the month air-borne activity in the vapor container reached a maximum of 5×10^{-8} μc/cc due to the main coolant leak.

Sealing the leak and purging the vapor container reduced the air-borne activity to 1×10^{-10} μc/cc. Appropriate respiratory equipment was required to be worn by all personnel entering the vapor container during the period of leakage and repairs.

Radiation levels in the shield tank cavity during seal welding of the leak were, 40-100 mr/hr general area, 40 mr/hr work area outside of the control rod coil stack air baffle and 50-150 mr/hr inside the baffle.

Personnel exposures for Yankee plant personnel as measured by film badge for the month of December 1963 were:

Average for all station personnel	=	125 mr
Maximum individual exposure	=	460 mr

Plant Operations

Attached is a summary of plant operation statistics for the month of December 1963 and a plot of daily average plant load for the same period.

Also attached is a revised data sheet of plant operation statistics for the month of November 1963. The corrected sheet is necessary due to a revised feedwater flow calibration which resulted in increased reactor power level.

Additional revisions will be noted in the December sheet due to applied correction factors for main coolant pump thermal input and system thermal losses. Previously these corrections were only made at the end of core life but will now be included as part of the normal monthly tabulations.

YANKEE ATOMIC ELECTRIC COMPANY - OPERATING SUMMARY

DECEMBER 1963

ELECTRICAL		MONTH	YEAR	TO DATE
Gross Generation	KWH	117,518,100	1,004,087,900	2,705,559,900
Sta. Service (While Gen. Incl. Losses)	KWH	7,132,532	67,014,968	197,772,035
Net Generation	KWH	110,385,568	937,072,432	2,507,787,865
Station Service	%	6.07	6.67	7.30
Sta. Service (While Not Gen. Incl. Losses)	KWH	232,200	4,076,413	17,045,251
Ave. Gen. For Month (744 HRS)	KW	157,945	--	--
Ave. Gen. Running (697.1 HRS)	KW	168,581	--	--

PLANT PERFORMANCE				
Net Plant Efficiency	%	28.88	28.51	--
Net Plant Heat Rate	Btu/KWH	11,817	11,970	--
Lbs. Steam/Net KWH		14.00	14.31	--
Circulating Water Inlet Temp.				
Maximum	°F	43	--	--
Minimum	°F	36	--	--
Plant Operating Factor	%	92.55	69.33	64.94

NUCLEAR		MONTH	CORE II	TO DATE
Times Critical		1	15	322
Hours Critical	HRS	704.0	1138.23	22,681.34
Times Scrammed		0	3	41
Equivalent Reactor Hours @ 540 MWt	HRS	707.89	1019.15	16,222.45
Average Burnup of Core	MWD/mtU	766.36	1103.36	--
Control Rod Position at Month End				--

Equilibrium at 600 MWt 527°F Tavg.

Group 1 Rods out-inches	52 4/8
Group 2	76 4/8
Group 3	76 4/8
Group 4	76 4/8
Group 5	76 4/8
Group 6	76 4/8
Group 7	76 4/8

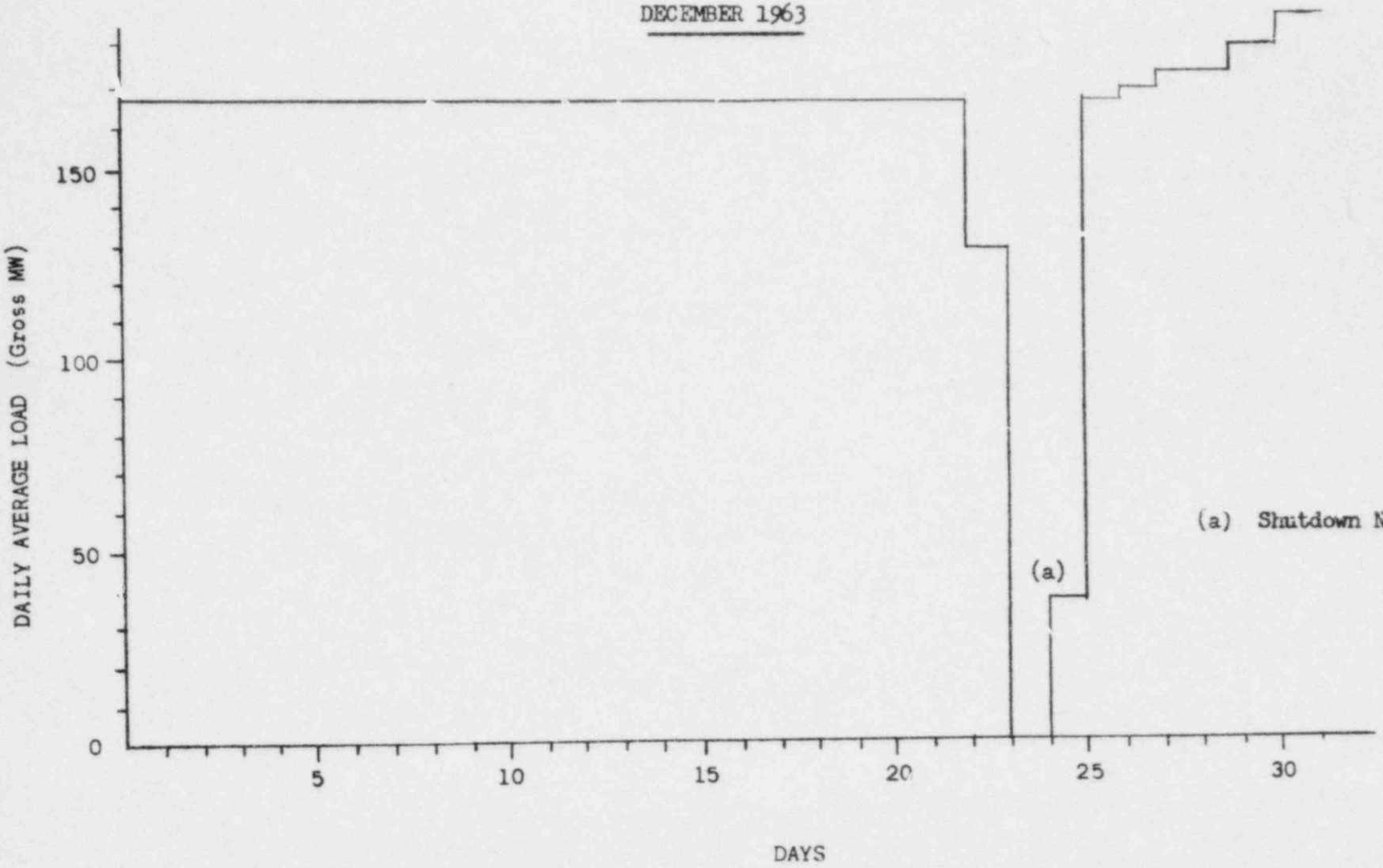
M. C. Boron Conc. 55 ppm

YANKEE ATOMIC ELECTRIC COMPANY

DAILY AVERAGE LOAD

for

DECEMBER 1963



(a) Shutdown No. 66-3-4

YANKEE ATOMIC ELECTRIC COMPANY - OPERATING SUMMARY

NOVEMBER 1963 (REVISED)

ELECTRICAL		MONTH	YEAR	TO DATE
Gross Generation	KWH	51,923,800	886,569,800	2,588,041,800
Sta. Service (While Gen. Incl. Losses)	KWH	3,344,454	59,882,436	190,639,503
Net Generation	KWH	48,579,346	826,686,864	2,397,402,297
Station Service	%	6.44	6.75	7.37
Sta. Service (While Not Gen. Incl. Losses)	KWH	1,380,900	3,844,213	16,813,051
Ave. Gen. For Month (720 HRS)	KW	72,200	--	--
Ave. Gen. Running (338.38 HRS)	KW	153,625	--	--

PLANT PERFORMANCE				
Net Plant Efficiency	%	28.57	28.40	--
Net Plant Heat Rate	Btu/KWH	11,945	12,016	--
Lbs. Steam/Net KWH		14.27	14.36	--
Circulating Water Inlet Temp.				
Maximum	°F	47	--	--
Minimum	°F	43	--	--
Plant Operating Factor	%	43.74	67.24	64.40

NUCLEAR		MONTH	CORE III	TO DATE
Times Critical		13	14	321
Hours Critical	HRS	403.25	434.23	21,987.34
Times Scrammed		3	3	41
Equivalent Reactor Hours @ 540 MWt	HRS	314.90	314.90	15,518.20
Average Burnup of Core	MWD/mtU	340.90	340.90	-

Control Rod Position at Month End

Equilibrium at 540 MWt	514°F Tavg.
Group 1 Rods out-inches	75 3/8
Group 2	67 7/8
Group 3	75 3/8
Group 4	75 3/8
Group 5	75 3/8
Group 6	75 3/8
Group 7	75 3/8

M. C. Boron Conc. 312 ppm