General Electric Company
KNOLLS ATOMIC POWER LABORATORY
Schenectady, New York

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KAPL-M-SCT-10

PROJECT OWL: 8-INCH WATER INJECTION TEST

RUN NUMBER 1

PRELIMINARY RESULTS

Photostat Price $1.80
Microfilm Price $1.80

Available from the
Office of Technical Services
Department of Commerce
Washington 25, D. C.

By

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RESULTS OF FIRST RUN, 8" WATER INJECTION TEST, PROJECT OWL

I. Initial Conditions

The first live run on the 8" water injection test was conducted on March 7, 1956 in Loop #3, Building D-2. Water was injected through a 15 mil orifice in this test.

At the start of the test, the sodium in the loop was at 600°F. There were an estimated 310 gallons of sodium in the loop and 200 gallons of nitrogen in the surge tanks. The initial surge tank pressure was 35 pounds per square inch (gauge). There were about 10 pounds of water in the autoclave and the autoclave pressure was 559 psig.

II. Conduct of the Test

A total of 3.1 pounds of water was injected into the sodium. Water was injected at the rate of 0.024 lbs/sec. (or 12.8 gal/hr. at 480°F). The water injection was terminated between 124 and 130 seconds following the start of injection because of the greatly reduced sodium flow. At about ten minutes following initial injection, a small leak was discovered in the loop at the point of water injection, and the pressure on the loop was relieved by venting off gases. After the leak had apparently sealed itself, the hydrogen was removed by outgasing and the loop pressure was raised to 20 psig by addition of nitrogen. Pressure on the autoclave was reduced to zero (gauge) by venting off steam.

When the loop was heated to 653°F a few hours later, the flow in the loop returned to normal (over 2000 gal/min). Initial attempts to cold trap the loop were unsuccessful; but after the cold trap temperature was raised to about 500°F, cold trapping was started. On March 12, 1956, the loop was secured to permit removal of the injection device. Operations were resumed on March 14, 1956 and continued through March 16, 1956, at which time the loop had been cold trapped to 300°F.

III. Results

A summary of flow, temperature, and pressure data from the run are plotted on the attached graph.

During the first 30 seconds following the start of injection, the sodium flow fell slowly from the initial value of about 3000 gallons per minute, and the trace of the sodium flow indicated increasing flow irregularities. Between 30 and 57 seconds following injection, flow rates between 1600 and 2500 gallons per minute were recorded. At 57 seconds following the start of injection, the flow fell rapidly and the fluctuations ceased. By 100 seconds, there was a steady flow of approximately 100 gallons per minute.

Temperature was recorded at the point of injection and at the strainer inlet. At the point of injection, there was no change in temperature until 50 seconds following start of injection, after which time the temperature rose. At 100 seconds, the temperature rise reached a maximum of 132°F (i.e. the sodium temperature was 732°F) at the point of injection. It then decreased to a 60°F rise at the end of injection. The temperature at the strainer inlet showed only small variations; the maximum variation was a drop in temperature of 18°F at this point.

Pressure was recorded from Photocons at the point of injection, upper surge tank, strainer inlet, and pump outlet. At the first three points, the pressure increased slowly to a rise of 10 psi during the first 60 seconds and more rapidly to a maximum rise of near 40 psi at the end of injection. The Photocon at the pump outlet indicated a maximum rise of 8 psi at the end of injection; this indicated rise appears inconsistent with the other data.

Pressure at the upper surge tank was also observed on a Heise gage. This gage indicated a rise from 35 psig to 69 psig during the injection. One minute after the stop of injection, the pressure fell to 62 psig; six minutes after injection, it fell to 59 psig.

The sodium level in the surge tanks was measured by means of induction coil liquid level indicators. These indicators are valuable only in indicating the approximate liquid level. These instruments indicated that the sodium level rose sufficiently to decrease the surge volume from 200 gallons to about 120-160 gallons during this run.

A summary of the flow, temperature, and pressure variations appears in the graph that follows. Included on this graph is the percent oxygen in the sodium if the water injection was uniform. Additional data is tabulated in the following summary of data.

IV. Discussion

No calibration had been made of the particular orifice used in this test. Another 15 mil orifice was calibrated twice under conditions similar to those of this run and it yielded flow rates of 0.0178 and 0.0197 lbs/sec. This is reasonably close to the 0.024 lbs/sec. obtained in this live run. The orifice used in the live run had been modified to insure that it would not plug.

In addition to autoclave pressure, the autoclave temperature was also measured. However, due to the location of the thermocouple in a pipe at the bottom of the autoclave, this temperature is not considered as accurate as the pressure measurement. The observed pressure of 559 psig or 574 psia corresponds to a saturation temperature of 481°F. The thermocouple indicated a temperature of 237°C or 459°F, 22° lower than saturation.

Since change in pressure over the two-minute interval is more important than absolute values of pressures, the accuracy of the Photocons should be particularly good. The 36 psi rise on the upper surge tank Photocon is in good agreement with the 34 psi rise indicated by the Heise gage.

The variations in water injection rate during the run are not accurately known. The total water injection is well established; but, because of the slow chart speed and small chart scale on the instrument recording the autoclave liquid level, a uniform rate of injection can not be verified.

It should be noted in the results that the large temperature rise near the point of injection occurred only after the substantial loss of sodium flow. This temperature rise was caused by the reaction between water and sodium, and it was confined to a relatively small portion of the sodium.

It should also be noted that the pressure traces, while somewhat spasmodic, took a definite upward trend at the same time that the sodium flow dropped.

It is of interest to compare the observed surge tank pressure rise with the pressure rise expected from a material balance if the water and sodium react only according to the reaction:

$$N_a + H_2O = N_aOH + \tfrac{1}{2} H_2.$$

Under these conditions, a pressure rise (equal to the partial pressure of hydrogen) of 36 psi would be expected; this is in good agreement with the actual maximum pressure rise. However, if the water was injected at a uniform rate, a pressure rise of 17 psi would have been expected at the end of 60 seconds; the actual pressure rise was considerably less. Some of the possible reasons for the variation in the rates of pressure rise include a non-uniform water injection rate, hydride formation to a varying extent, oxide formation to a varying extent, and the formation of slowly-reacting steam bubbles.

In conclusion, it does not appear that large temperature and pressure excursions develop at this rate of injection until the flow is greatly reduced. A test, without the strainer, to insure greater flow for a longer time could confirm this.

Enclosed is a summary of data for this test.

SUMMARY OF DATA

First Live Run of 8" Water Injection

Date	March 7, 1956
Location	Loop #3, Building D-2
Orifice	15 mil diameter
Total Water Injected	3.1 pounds
Water Injection Rate	0.024 lbs/sec (12.8 gal/hr)
Initial Autoclave Pressure	559 psig
Initial Loop Pressure	35 psig
Initial Loop Temperature	600°F

Time Following Injector Start (Seconds)	Loop Flow (GPM)	Temp. Change Point of Injection °F	Temp. Change Strainer Inlet °F	Press. Rise Point of Injection PSI	Press. Rise Strainer Inlet PSI	Pump Outlet PSI	Surge Tank PSI	Comments
0	2980	-	-	-	-	-	-	
10	2800	0	0	2	2	0	4	
20	2660	0	0	2	2	0	7	Loop Flow
30	2660	0	0	2	5	2	9	Fluctuating
40	2560	0	0	6	5	2	9	Greatly
50	2340	0	0	6	5	2	10	
57	1920							Loop Flow
60	740	+6	-9	8	11	2	11	Becomes Smooth
64	320							
70	320	+13	-9	16	19	4	13	
80	200	+27	-9	24	25	4	18	
85		+76						
90	150	+104	-5	30	29	6	21	
100	100	+132	0	32	33	6	23	
110	100	+124	0	30	37	6	31	
120	100	+104	-5	34	40	8	36	Injection
130	100	+62	0	42	37	8	36	Stopped
180		+20	0	38	40	8	33	Between 124 and 130 sec.
240		+6	0	32	37	8	33	
300		+6	-18	25	32	8	31	
360		+6	0	25	32	8	30	

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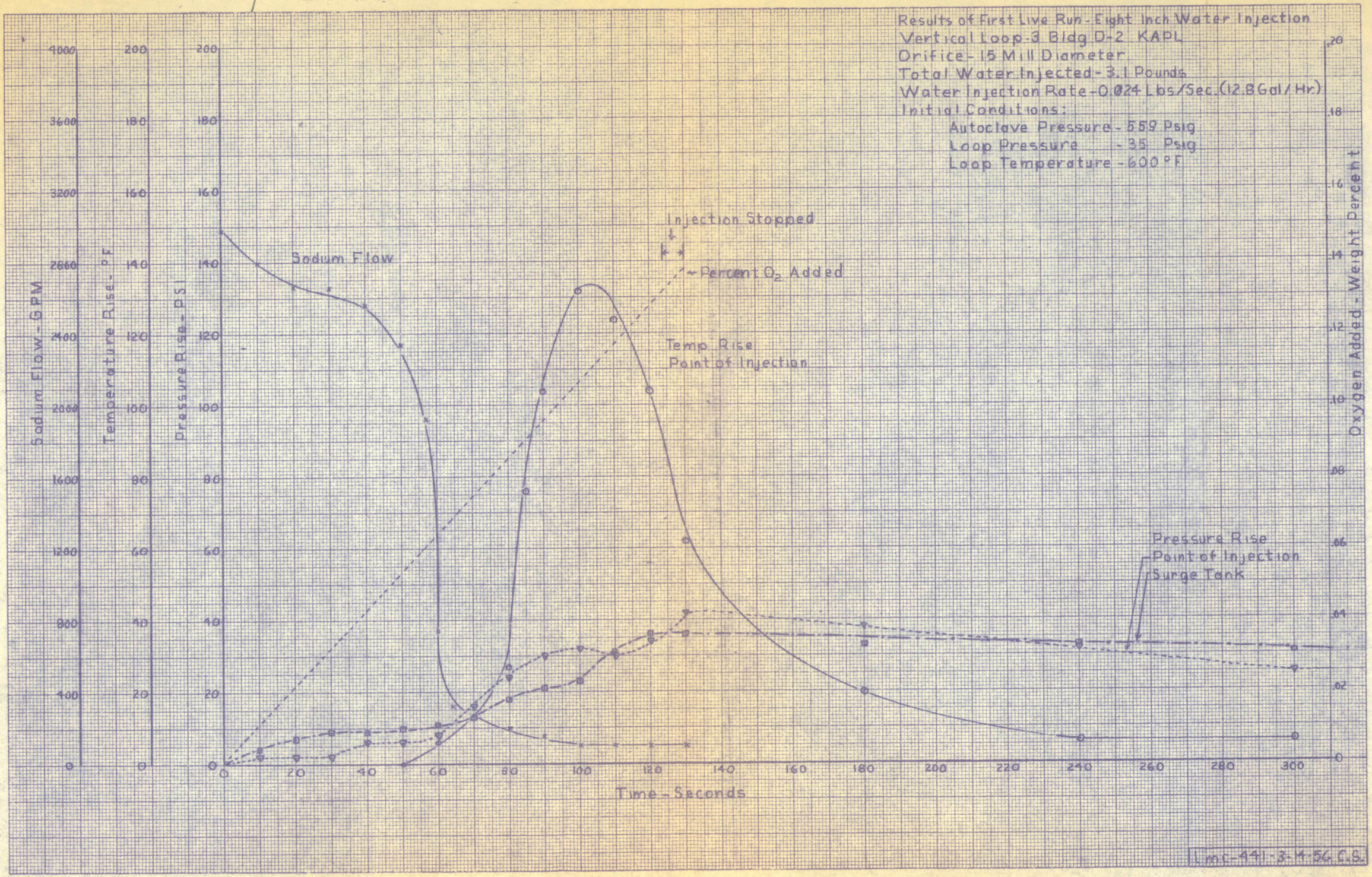
Results of First Live Run - Eight Inch Water Injection
Vertical Loop-3 Bldg D-2 KAPL
Orifice - 15 Mill Diameter
Total Water Injected - 3.1 Pounds
Water Injection Rate - 0.024 Lbs/Sec. (12.8 Gal/Hr.)
Initial Conditions:
Autoclave Pressure - 559 Psig
Loop Pressure - 35 Psig
Loop Temperature - 600°F



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