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APPROVALS
K. H. Kline

AUTHOR: K. A. Davis (2)
DEPT & GROUP NO: 791-22

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TITLE: Tests of the HNPF Plugging Meter

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PROGRAM: HNPF

SUBACCOUNT TITLE: Plugging Meter Calibration

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STATEMENT OF PROBLEM

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A plugging meter capable of continuous automatic operation was designed for the Hallam Nuclear Power Facility. One of the plugging meters constructed for the HNPF was tested to verify proper performance prior to installation at the HNPF. Inasmuch as the plugging meter was of advanced design using several heretofore untested concepts, testing of not only the plugging meter element but the entire system of control and readout equipment was necessary.

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ABSTRACT

A plugging meter designed for the Hallam Nuclear Power Facility was tested. Plugging performance was satisfactory and excellent reproduceability was achieved. Although the time limitations precluded complete testing of the automatic control equipment, the tests performed gave satisfactory indication of correct performance.

I. SUMMARY OF RESULTS AND RECOMMENDATIONS

The plugging meter was connected to a sodium loop and the control and readout equipment were connected to the plugging meter. The entire assembly was set up to duplicate, so far as possible, the operation and environment anticipated in practical operation at the HNPF. In the initial tests, the plugging was erratic and there was audible evidence that the plugging valve was not closing properly. The plugging meter was returned to the shop for examination and rework as needed. Upon examination it was found that the spring to hold the plugging valve in closed position was too short. A new spring was installed and the plugging meter was returned to the test facility. The performance tests were resumed. However, the delay resulting from the repairs limited the amount of time available for the tests. This problem was aggravated by the fact that the opening of the loop for removal of the plugging meter and the subsequent re-installation increased oxide content and made "clean up" more time consuming.

Tests of the plugging meter with 305°F and 607°F sodium with oxide concentration varying from 10 to 35 ppm were desired. The time available did not permit "sodium clean up" so the existing sodium, containing about 80 ppm oxide, was used.

Operation at 607°F was conducted and the plugging meter performed satisfactorily. The plugging valve opened and closed properly and well defined plugging indications were obtained. However, since the automatic control apparatus was designed for the 10 to 35 ppm oxide concentration region and the sodium used contained 80 ppm, the complete test of automatic operation was not possible.

However, by manually overriding the controls as necessitated by the deviation, the system performed satisfactorily. It was concluded that the test was adequate and that the plugging meter and control and readout system was shown to be satisfactory.

II. METHOD USED AND DESCRIPTION OF EQUIPMENT

Principle of Operation

The function of this plugging meter is to measure sodium oxide concentration. The operation is based upon the temperature-solubility relationship of sodium oxide in sodium. The amount of oxide which can be in solution is a function of the sodium temperature. The relationship between oxide concentration and sodium temperature has been studied by several investigators. The KAPL curve (1) is widely used.

In operating a plugging meter, the sodium is passed through it at some selected flow rate. In this plugging meter the normal flow rate is 1 gpm (See Figure 3). To begin a plugging run, the flowing sodium is cooled at a selected rate in order to reach a temperature at which the oxide cannot remain in solution and therefore, precipitates. At this temperature, the oxide precipitate plugs an orifice and this occurance is signaled by the flowmeter indicating a substantial decrease in flow. In this plugging meter, plugging is defined to occur at a flow of 0.6 the normal value. This point is indicated in Figure 3. The temperature of the sodium at this point is read and the corresponding oxide concentration is read off a curve such as the KAPL solubility curve. (1)

In order to restore the meter to normal operation (unplug it), the cooling is stopped and the plugging orifice is opened to allow a large volume of relatively clean hot sodium flow through and flush out the oxide. When this flushing has been accomplished, the orifice is closed to its normal operating condition and the plugging cycle may then be repeated.

(1) KAPL Memo ILG-7, 1953

In this plugging meter, this sequence of operations may be manual or automatic as desired. In automatic operation, a cam programmer establishes cycle.

Tests

The HNPF plugging meter is of advanced design and the testing involved not only the plugging meter element, but the entire control and data readout system. The test set-up was made to duplicate so far as possible the conditions expected in practical operation. The operating conditions included:

1. Sodium at 305 and 607°F.
2. Sodium oxide concentration of 10 to 35 ppm.
3. Cooling air at 150°F.
4. Sodium flow rate at 1 gpm.

The plugging meter was connected to a small sodium loop capable of supplying sodium at a range of temperatures up to 1000°F, at pressure up to 20 psi, and at a flow rate up to 20 gpm. A means of varying the oxide content from 10 ppm and higher was available. The sodium loop is diagrammed in Figure 1. The control circuit is diagrammed in Figure 2.

Prior to flowing sodium through the plugging meter, the piping was heated to approximately 400° and the air and any contaminating vapors were pumped out. The sodium, at 400°, was then pumped through the plugging meter. After several hours, the temperature was increased to 607°F and the sodium was pumped through at 1 gpm for one day. This was to verify the integrity of the piping and to thoroughly wet the flowmeter electrodes prior to conducting tests.

Inasmuch as the time available did not permit cleaning the sodium to achieve an oxide concentration in the 10 to 35 ppm range, the sodium available containing about 80 ppm oxide was used. The plugging meter was tested at 607°F and satisfactory plugging operation was readily achieved. For convenience, and to expedite the testing, the temperature was reduced to 530°F and the operation was switched to "automatic". Since the programmer was designed for sodium containing 10 to 35 ppm oxide, fully automatic operation was not achieved.

However, the system was adequately tested by manually overriding the programmer as needed. A sample of a plugging run is shown in Figure 3. A series of such plugging runs was made and the reproducibility was excellent. For example, the plugging temperatures for 530° sodium were: 452°, 448°, 444°, 446°, 442°, 442°, 442°, 442°. Evidently, at the beginning of these tests a uniform distribution of oxide did not exist, but after several passes through the system a uniformity was achieved and the plugging temperatures repeated precisely 442°.

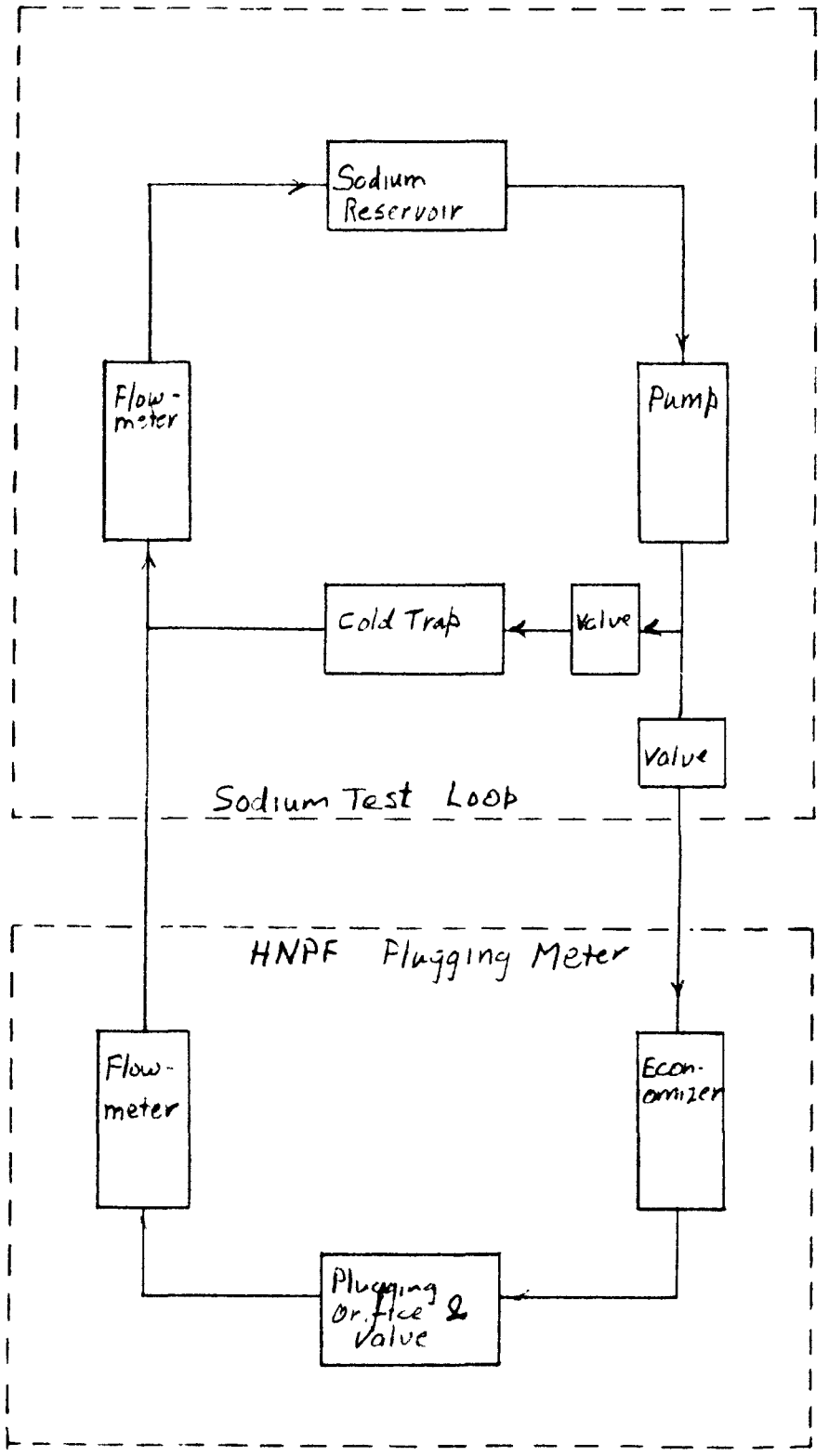

Figure 1 Schematic Diagram of Sodium System

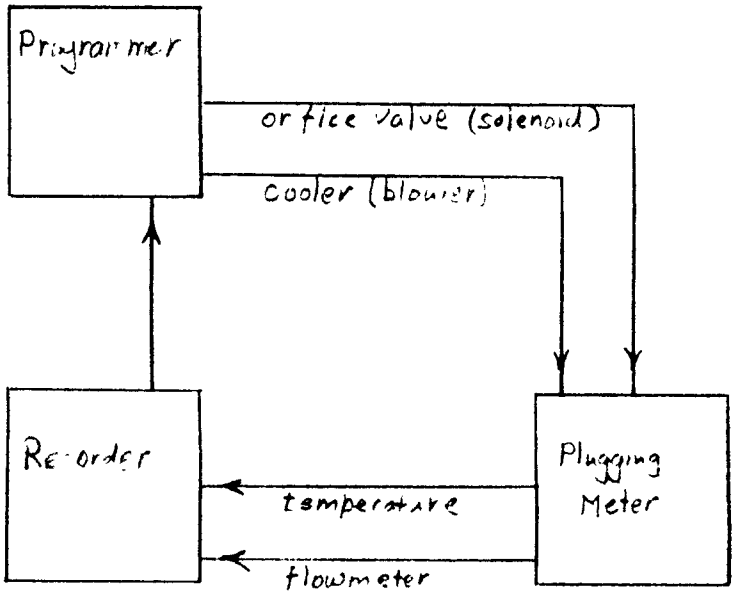

Figure 2 Simplified Block Diagram of Control System

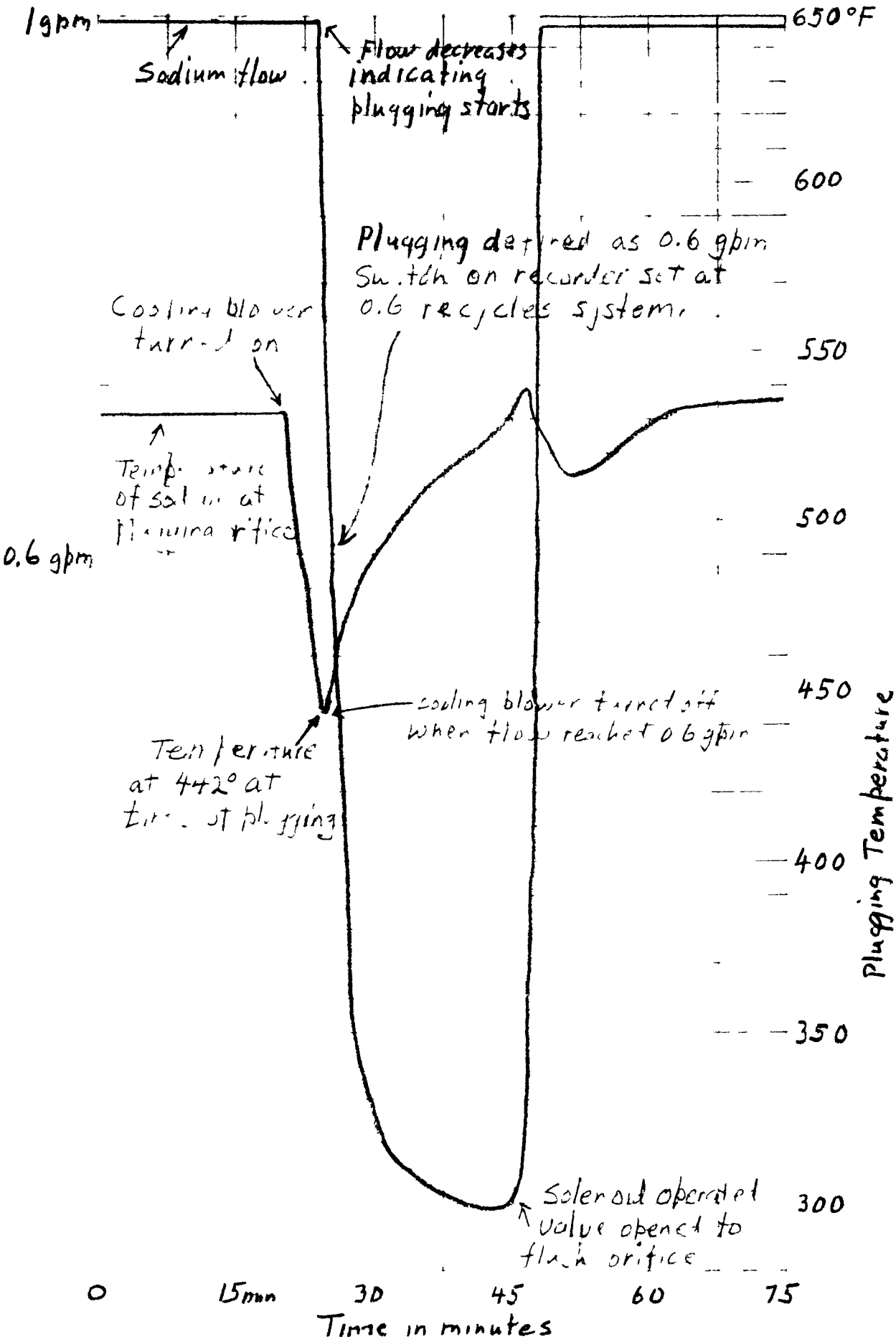

Figure 3 Plugging Curve