MASTER

ATOMICS INTERNATIONAL
A Division of North American Aviation, Inc.

NAA-SR-MEMO -4127

Do not remove
this sheet

This document contains 7 pages

This is copy _____ of _____ series _____

REPRODUCED FROM BEST
AVAILABLE COPY

UNCLASSIFIED

Security Classification

*NAA-SR-MEMOs are working papers and may be expanded,
modified, or withdrawn at any time,
and are intended for internal use only.*

This report may not be published without the approval of the Patent Branch, AEC.

- released
1/18/60

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

WRITTEN BY R. W. Atz <i>RWAtz</i>		ATOMICS INTERNATIONAL A Division of North American Aviation, Inc.	TOR NO. 4127	
SECTION	Sodium Reactors		GO 7508	
GROUP	Sodium Components		LEDGER ACCT. 3621	
UNIT	Coolant Systems Equipment		SUB-ACCT. 4908	
APPROVED BY: (SUPERVISOR) <i>Leppard</i>		PROGRAM	Hallam Nuclear Power Facility	
OTHER		PROJECT	Development and Tests of Mechanical Pumps for Sodium	
		TWR	5201	
		DATE	Oct. 19, 1959	
		PAGE	1	OF 7

TO: J. C. Cochran*

COPIES TO:	C. L. Dunsmore* 795-52	L. E. Manners 795-53
	R. E. Fortier* 795-52	J. E. Owens 794-41
	W. J. Hallett* 794-41	H. P. Schroeder* 794-41
	J. A. Leppard* 794-41	G. E. Turner* 794-41
		I. Villalva 795-53

SUBJECT: Transient Tests of HNPF Prototype Sodium Pump Drives.

CONTENTS:	I	STATEMENT OF PROBLEM	PAGE 1
	II	SUMMARY OF RESULTS AND RECOMMENDATIONS	PAGE
	III	METHOD USED, DESCRIPTION OF EQUIPMENT, SAMPLE CALCULATIONS . . .	PAGE
	IV	REFERENCES AND APPENDICES	PAGE

I STATEMENT OF PROBLEM

The operation of the sodium pumps in the HNPF requires a knowledge of the response capabilities of the pump drive and control equipment. The two prototype pumps are equipped with duplicate control systems and will be tested under equivalent operating conditions.

The objectives of this portion of the test program are to:
 1) demonstrate that the pump speed control system will respond as defined in the equipment specification; and 2) determine optimum values of controlling variables that will minimize the oscillations that occur in the sodium flowrate when transient signals are imposed on the pump speed control system.

It is the purpose of this report to describe the transient test program.

II SUMMARY OF RESULTS AND CONCLUSIONS

The results of this test program will describe the performance of the pump speed control system in relation to the requirements set forth in the Equipment Specifications.¹ In addition, the optimum values of the controllable variables in the pump drive equipment will be obtained.

948

2

These optimum values are those that produce a minimum number of oscillations in the pump speed when a transient signal is introduced to the pump speed control system. During the course of this evaluation the following variables will be measured:

1. Sodium flow
2. Pump shaft speed
3. Pump suction pressure
4. Pump discharge pressure
5. Excitation current to the Eddy current clutch
6. Power to the pump drive motor.

These six quantities are to be recorded simultaneously.

III DESCRIPTION OF DRIVE EQUIPMENT AND CONTROL OPERATION

The variable speed drive for each pump consists of two assemblies; namely, 1) the drive motor and eddy current clutch, 2) the pump speed control system. Both pump drive motors are constant speed machines; one is an 8 pole, 835 rpm motor, and the other is a 6 pole, 1135 rpm motor. Because of these differences the operating characteristics of the drive systems will not be the same. In each case, the eddy current clutch consists of a driving rotor mounted on the motor shaft, a driven rotor mounted on the pump shaft, and a stationary coil to provide the magnetic coupling between the two rotors. A magnetic amplifier controls the excitation current to the clutch coil, which effects changes in the magnetic coupling between the two rotors. The output current from the magnetic amplifier is regulated by a signal from the pump speed control system. This experiment will determine the variation of the control current during transient speed changes.

The pump speed control system, consists of two resistance-capacitance networks and an a.c. amplifier using a feedback circuit. Each of the resistance-capacitance networks contains an adjustment feature to modify its operation. An adjustment can also be made in the feedback circuit. The source of sodium flow information for this controller is the e.m.f. generated by the

12" magnetic flowmeter on the pump test loop. The pump speed control system* is arranged so that the speed may be adjusted manually with a rheostat, or regulated automatically. A change in sodium flow rate results in a change in the d.c. emf developed at the flowmeter. This d.c. signal is the input to one resistance-capacitance network (hereafter called "rate" network) through which it passes on to a converter where it is changed to a.c. This a.c. signal is amplified, rectified, and transmitted as a d.c. signal to the magnetic amplifier. A portion of this amplified signal is fed to the second resistance-capacitance network (hereafter called "reset" network). These rate and reset networks function independently. The rate network provides a lead, or anticipatory, signal to the magnetic amplifier and the reset network furnishes an offset correcting signal for the feedback circuit. The feedback circuit is required for system stability.

During operation, the error signal will appear initially at full voltage value across the rate network. Depending upon the setting of the rate control, this voltage will gradually decrease to zero. Concurrently the voltage across the reset network will go from zero to a new level. The time for these changes to occur will depend upon the settings of the controls. The setting of the proportional band control will determine the magnitude of the voltage change.

When both of these processes occur at the same time, the decrease in voltage because of the effect of the rate network and the increase in voltage by the action of the reset and proportional band controls, a net voltage is transmitted to the a.c. amplifier. The a.c. amplifier converts this information to a current that is supplied to the magnetic amplifier, which in turn changes the clutch coil excitation current, correcting the pump speed to the new condition. The entire process is repeated until the set point is matched.

*Minneapolis-Honeywell "Three-Mode-Electro-Volt Controller."

548 4

IV PROCEDURE

Flow will be established in the test loop and adjusted so that at the design pump speed, the pressure drop across the loop will be equal to that in the HNPF (54 psi at 7200 gpm, Ref. 2). This valve setting will be unchanged throughout the test program. The experimental procedure will consist of causing the automatically controlled pump speed to deviate from its set point. Step changes in the input signals to the automatic control system will come from a voltage divider which is connected to the magnetic flowmeter output. The flowmeter output signal exceeds the input capacity of the automatic speed control system; a voltage divider is needed to supply a fraction of the flowmeter output to the control system. Changing the ratio of this voltage divider causes step changes in voltage to appear at the control system input.

The first step toward determination of the control settings will be as follows. With the reset and rate controls set at zero, a 10% increase in the input signal from the flowmeter will be applied to the automatic control system. The changes in the levels of the variables being recorded will be noted. This procedure will be repeated as the proportional control is advanced from its zero position to the maximum value in fixed increments. This operation will be stopped when the resulting cycling of the sodium flow rate reaches its minimum value. The proportional control will then be moved back one setting; this point will be called P_0 .

Secondly, with the proportional control at P_0 and rate control at zero, the reset control will be advanced one point. A 10% change in level of input signal will again be imposed upon the system and the changes in the variables recorded. This procedure will be repeated with the proportional control at P_0 and the rate control at zero for all values of reset control. At the value of reset control where the frequency of oscillations resulting from the transient signal appears to be a minimum, the reset control will be turned back 1 step; this point will be known as S_0 .

Finally, with the proportional control set at P_o and the reset at S_o the rate-time control will be advanced one point. A 10% change in input signal to the automatic control will be performed and the resulting changes recorded. This procedure will be repeated for all values of rate-time control. The value for which the minimum amplitude of oscillations in sodium flow rate occur will be designated R_o .

Using the values of P_o , S_o , and R_o , obtained as shown above for reference points, a series of tests as outlined in Table I (Ref. 3) will be performed. The twelve runs shown in Table I will all be made at 10%, 50%, and 100% of design speed. All six variables (listed on page 2) will be recorded during every run.

The testing will also include negative changes in the flow-meter input signal. In this way the behavior of the pump drive controllers may be observed during both acceleration and deceleration.

948 6

TABLE I
SCHEDULE OF TESTS

Test No.	Settings		
	P	S	R
1	Po	So	Ro
2	2/3 Po	2/3 So	2/3 Ro
3	3/2 Po	3/2 So	3/2 Ro
4	Po	So	Ro
5	3/2 Po	3/2 So	2/3 Ro
6	2/3 Po	2/3 So	3/2 Ro
7	Po	So	Ro
8	2/3 Po	3/2 So	3/2 Ro
9	3/2 Po	2/3 So	2/3 Ro
10	Po	So	Ro
11	3/2 Po	2/3 So	3/2 Ro
12	2/3 Po	3/2 So	2/3 Ro

V REFERENCES

1. Equipment Specification AT5-353, "Electric Drives for HNPFF Test Pumps."
2. IOL to R. Atz from C. L. Dunsmore, June 11, 1959, "Pressure Drop Simulation for Pump Dynamics Test."
3. IOL to R. Atz from J. M. Zimmerman, Dept. 596-91 (Rocketdyne), Sept. 2, 1959, "Experimental Design of the Evaluation of the Sodium Pump Control System for The Hallam Reactor."