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CRYOGENIC MOCK-UP LOOP

DESIGN STUDY

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INFORMATION CATEGORY

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INTRODUCTION

A helium cooled cryogenic system will be installed in the Plum Brook Reactor HT-1 Facility in the near future. This system will make possible high flux reactor testing of NERVA components at cryogenic temperatures in flowing gas. Before reactor testing is attempted, it is mandatory that the test fixtures and components be capable of withstanding cryogenic temperatures and high gas flow. The effects on the test item by the cryogenic mock-up system can be determined. Then, other effects measured in the cryogenic irradiation facility could be attributed to irradiation. It is therefore logical that a mock-up system be available at WANL to determine suitability of test fixture design and to isolate cryogenic temperature effects prior to shipment of the experiment to Plum Brook for testing. The desired loop would be capable of simulating a helium flow of approximately 0.5 lb/sec at 50°R. A system utilizing cryogenic gaseous nitrogen is proposed as a possible loop mock-up for use at WANL, and is described in this report.

DESCRIPTION

A mock-up loop, utilizing cryogenic gaseous nitrogen was constructed, and is illustrated in Figure 1. This system utilizes standard 110 liter liquid nitrogen dewars as a source of nitrogen and expells the gas to the atmosphere after passing it through the test fixture.

Calculations indicated that the required gaseous nitrogen flow to mock-up the helium flow rate of the WANL Cryogenic Loop facility was attainable. A helium flow rate of 0.5 lb/sec at 115 psia and 50°R are nominal Cryogenic Loop conditions and were therefore chosen to be simulated. The boiling point of nitrogen, 140°R, is obviously the limiting lower temperature of the nitrogen system, so the

required nitrogen flow was evaluated at this temperature. The nitrogen mass flow, at 25 psia and 140°R, which is equivalent, on a Δp basis across the sample, to helium flow at the nominal conditions noted, is 0.1 lb/sec¹. This flow rate corresponds to approximately 0.9 gallons/min of liquid nitrogen. Ten kilowatts of heat are required to vaporize this quantity of liquid nitrogen. The system constructed to provide these conditions consisted of W-2 water cooled mock-up spare parts and standard LS-110 (Linde) liquid nitrogen dewars. No cryogenic valving was available so the valves of the LS-110 dewars were utilized. Figure 1 and Figure 2 schematically describe the loop system. Figure 3 is a photograph of the control and data acquisition systems which were adapted from available equipment. Figure 4 shows the assembled system parts inside the building and Figure 5 the gas exit external to the building. Figure 6 shows the internal design of the liquid evaporator and Figure 7, the exit of the system in operation. The system operation was discontinued after feasibility was demonstrated. Full gas flow was not attained in the tests because connected electrical heater capacity was not sufficient to vaporize the full flow of liquid nitrogen. Preliminary, short term tests of PBRF test fixtures could definitely be performed in a loop of this type.

CONCLUSIONS AND RECOMMENDATIONS

A PBRF cryogenic loop mock-up system utilizing nitrogen gas is feasible. Such a system is capable of evaluating the effect of flowing cryogenic gas on test

¹Vance, et al, "Applied Cryogenic Engineering," 1962, p. 28.

fixtures and components proposed to be tested in PBRF. The mock-up loop would expend approximately 1 gallon of liquid nitrogen per minute. The cost of liquid nitrogen is approximately 90 cents per gallon; therefore, the operating cost of this system is less than \$1.00 per minute. The duration of a test is limited only by the volume of connected liquid nitrogen dewars. Runs exceeding one and one-half hours are feasible with no modification to the present system except the addition of heating capacity.

Suggestions from experimenters for utilization of such a system, to assist in present test programs, are invited.

Figure 1 - Cryogenic Mock-Up Loop
(Schematic)

R - Relay
 HR - Heater
 TR 1 - Temperature Control
 TC - Thermocouple

Figure 2 - Cryogenic Mock-Up Loop
 (Electrical)

Figure 3 - Data Acquisition and Control Systems

Figure 4 - Cryogenic Mock-Up Loop

Figure 5 - Exit of Experiment Loop External to Building

Figure 6 - Liquid Evaporator, Internal

Figure 7 - System in Operation