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LOOP EQUIPMENT
TO: R. B. Lindauer
FROM: L. J. King

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ABSTRACT

The major portions of the test program required for demonstrating the operability and dependability of the PAR in-pile slurry loop complex are listed. The responsibility for making the tests is divided to give Westinghouse the responsibility for assembling the loop, loop auxiliaries, and controls and demonstrating their satisfactory operation out of pile and to give ORNL the responsibility for testing radiation monitoring systems and instruments, carriers and tools for handling the radioactive loop and samples, and loop segmenting equipment. The program for test runs at the reactor site is outlined.

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1.0 INTRODUCTION

The purpose of this report is to outline the program of pre-operational tests which must be made on PAR in-pile slurry loop equipment.

The PAR in-pile slurry loop program, a cooperative program between the Pennsylvania Advanced Reactor Project and the Homogeneous Reactor Project, is aimed at providing experimental data concerning the effect of neutron irradiation on the properties of $\text{ThO}_2\text{-UO}_3$ slurries, the effect of neutron irradiation on slurry corrosion of container materials, the effectiveness of catalysts for internal recombination of radiolytic gases under reactor conditions, and the location and distribution of the fission products. These aims can be achieved only by making successful in-pile runs, collecting and analyzing the operating data, sampling the slurry during the runs, and segmenting the loops and recovering the corrosion specimens.

The inherent inaccessibility of radioactive equipment requires that equipment which may become contaminated or activated and the devices for handling this equipment be of demonstrated reliability. When equipment is designed for performing certain functions in connection with the operation of an in-pile loop, the ability of the equipment to perform properly must be thoroughly investigated before it can be assumed that the design is adequate. Even slight modifications to equipment which has a long history of dependability must be tested before the modified equipment can be considered acceptable for radioactive service. The cost of in-pile experiments and the potential hazards associated with them combine to make demands for safety and dependability which cannot be compromised.

Oak Ridge National Laboratory is responsible for assuring the satisfactory operation of all PAR in-pile slurry loop equipment since the equipment is to be operated at the Laboratory by ORNL personnel. Oak Ridge National Laboratory safety and health physics requirements must be met; and the Reactor Experimental Review Committee must be satisfied that there is no credible possibility of an accident which will result in damage to ORR facilities or in danger to operating personnel, ORNL employees, or inhabitants of the area surrounding the Laboratory.

In order that all equipment be tested and all operations be tried prior to the irradiation of the loop and that expensive duplication of effort be minimized, the specific items which comprise the pre-operational demonstration must be listed; and the responsibility for making the demonstrations must be given to Westinghouse or ORNL. It is not practical to attempt to draw fine lines of demarcation, so any list such as this must be fairly general.

The pre-operational demonstration of the PAR loop and auxiliaries can be divided into two major portions--one involving tests to be made at the Westinghouse facilities in Pittsburgh, and one involving tests to be made at Oak Ridge National Laboratory.

The demonstration program has been divided to give Westinghouse the responsibility for assembling the loop, loop auxiliaries, and controls and demonstrating their satisfactory operation out of pile and to give ORNL the responsibility for testing radiation monitoring systems and instruments, carriers and tools for handling the radioactive loop and samples, and loop segmenting equipment. Usually, but not always, the tests for which one of the groups is responsible will be made at the facilities of that group. Where it is not otherwise stated here, it should be assumed that the responsibility for a particular demonstration lies with the group in whose facilities the test is being performed.

2.0 EQUIPMENT DEMONSTRATION AT WESTINGHOUSE

The portion of the pre-operational demonstration which is to be made at the Westinghouse facilities in Pittsburgh is composed primarily of a 500-hour slurry run in the first loop package and the loop auxiliaries. This involves assembling the equipment to be tested, filling and starting the equipment, running for 500 hours, sampling slurry, sampling high pressure water, possibly sampling gas, injecting slurry and catalysts into the main loop, shutting the equipment down, flushing the equipment, inspecting the equipment to determine the effect of the run on the equipment, and removing selected pieces of equipment for simulated maintenance. The general purpose is to demonstrate the operability of the flowsheet.

2.1 Assembly of Equipment

The equipment layout for the ORR installation must be shown to be satisfactory before the loop can be irradiated. Since this can be demonstrated by a run made with the loop package in the reactor beam hole while the reactor is not critical, it is not obvious that the equipment layout for the 500-hour run in Pittsburgh must duplicate the layout proposed for the reactor site installation. It is felt, however, that the layout of equipment which is for handling slurry must duplicate the layout proposed for this equipment at the ORR site.

Piping and equipment connections should be duplicated so these connections can be tested. Connections which are to be welded at the ORR site should be welded for this run. Connections which are to be screwed fittings at the ORR site must be screwed fittings for this run. Connections which should receive special attention are the Autoclave Engineers, Inc. disconnects on valve assemblies and the U-tube disconnects which connect the loop package to the rest of the equipment.

As a part of this demonstration, the U-tube disconnects should be placed and tightened remotely in the same way they will have to be handled at the ORR site.

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2.2 Slurry Fill System

The slurry fill system layout must duplicate in every detail the in-pile layout. Slurry handling is not sufficiently predictable that data can be correctly extrapolated.

It must be demonstrated that this system, when connected to the loop, makes possible filling and starting the loop with no excessive area contamination and with no chance of plugging lines and equipment which will not be readily and safely accessible at the in-pile site. Oak Ridge Research Reactor Health Physics authorities must approve this system.

2.3 The 500-Hour Demonstration Run

The PAR in-pile slurry loop equipment (the loop package, loop auxiliaries, and controls) should be operated at 525°F and 1700 psi for 500 continuous hours with 500 g Th/liter slurry circulating in the main loop. Cessation of circulation would be prima facie evidence of cessation of the run.

It should be assumed that the equipment is in-pile and is inaccessible. Therefore, if difficulties which require access to the equipment arise, it is to be considered that the attempted run was not successful. Other difficulties, those which can be corrected remotely, must be assessed individually. In general, if the experiment could be kept running in-pile, it should be assumed that the 500-hour run has not been interrupted.

During the run, sampling and injection devices should be tested. These items are discussed more fully in succeeding sections.

2.4 Sampling

Provisions have been made for sampling the slurry in the main loop, the gases in the off gas system, and the high pressure water loop. Each of these sampling systems should be tested.

The slurry sampling system should be used to remove ten slurry samples from the main loop during the demonstration run. These samplings must be carefully watched for leakage. One drop of irradiated slurry from high power density runs could easily result in a contact dose rate of 40 r/hour and could contain 0.6 curie of mixed fission products and 0.6 curie of protactinium. Demonstration of drip-free slurry sampling is imperative.

Slurry samples should be analyzed for thorium content so the ability of the system to provide reproducible results can be evaluated.

2.5 Injection Device

A device will be provided for injecting thorium, uranium, or recombination catalysts into the loop through the main loop sampling system during a run.

This device should be able to do this safely and effectively and must be satisfactorily demonstrated before it can be used during an in-pile run.

2.6 High Pressure Water Heating and Cooling Capacity

The ability of the high pressure water system to supply sufficient heat for keeping the slurry at 525°F should be demonstrated. Also, the ability of this system to remove 60 kilowatts of heat from the main loop must be shown.

2.7 Instrumentation

One objective of the 500-hour run will be to demonstrate the adequacy of all instruments and controls. The ORNL Instrumentation and Controls Division has indicated that special attention should be given certain instruments while these instruments are in service during the 500-hour run. Particularly, it is required that a complete check be run on the efficiency of the primary loop temperature control. Repeated opening and closing of the "Little Richard" control valves inside the loop and subsequent testing of their leak-tight shut off should be included in the testing of instrument components. The linearity as well as possible zero-shift of the Foxboro DP cells should be observed under operating conditions. All pressure switches mounted on loop components should be observed for a setpoint drift with temperature, and any temperature effects on the strain gages should also be noted. The Gems Flowswitches as well as the Fischer & Porter d/p switches should be closely observed for good operation and repeatability.

2.8 Main Loop Leakage

While a leak of radioactivity into the loop vapor container during an in-pile run would not necessarily indicate cause for terminating an experiment, one would certainly have to assume that the main loop were leaking unless there were proof to the contrary. The potential contamination of the loop container and eventually the segmenting cell would indicate that a termination of the run would be required. For this reason the 500-hour run can be considered satisfactory only if no leakage from the main loop system is apparent. One indication of a main loop leak is the addition of water in excess of the amount required for replacing the volume removed by sampling.

2.9 Loop Draining

A procedure must be developed which will remove all loose solids from the loop after a run. Otherwise, these loose solids might contaminate the segmenting cell when the loop is cut.

One possible way of determining whether the draining method will remove the solids would be to drain the loop according to the proposed procedure and then fill the loop with cold water and circulate the water with the main loop pump while introducing and removing a moderate quantity of water. The circulation would tend to keep the solids suspended so they would be carried

out in the small but continuous purge stream. If, after a reasonable quantity of flush water had been purged through the loop, no solids had been collected, it might be assumed that the draining procedure was adequate.

The results of this test would be an important factor in determining the necessity of using a hydroclone to provide clean water for flushing the solids from the loop while keeping the total flush water volume small.

2.10 Post-Run Inspection

At the conclusion of the run the equipment, valves, and pumps should be inspected for excessive wear. Instruments should be checked where it is suspected that the set-points might have changed. All available engineering data must be recorded and evaluated.

2.11 Maintainability of Equipment

Where it has been agreed between Westinghouse and ORNL that equipment should be designed to have a certain degree of maintainability, it must be shown that this maintainability exists. In particular, the high pressure water pumps (except the pump scrolls), the d.p. cells, and the valve assemblies must be shown to be removable and replaceable through mock-ups of the pressure chamber cover plates and the shielding.

2.12 Demonstrations at Westinghouse for which ORNL is Responsible

ORNL is responsible for demonstrating the adequacy of the sample valve decapper, Chamber "A" seal mechanism (for the sampler penetration into Chamber "A"), Chamber "A" internal piping, and the tools for use with the Chamber "A" disconnects and the sampler. Parts of these demonstrations will be made during the 500-hour run in Pittsburgh.

3.0 EQUIPMENT DEMONSTRATION AT ORNL

The portion of the pre-operational demonstration which is to be made at the Oak Ridge National Laboratory is composed of inspecting the entire installation for conformity to design (especially to demonstrate proper interconnections), demonstrating the operability and adequacy of carriers, handling tools and service systems, and demonstrating satisfactory operation of the entire equipment complex with cold and hot D₂O runs in and out of pile.

3.1 Installation Inspection

The equipment layout at the reactor site must be checked against design drawings and a complete set of "as-built" drawings made available. Maintenance and future modifications will be facilitated by the availability of drawings which exactly describe the installation.

3.2 Loop Package and Dummy Plug Handling

All equipment for handling the loop package and dummy plug must be tested. The insertion, withdrawal, and moving of the loop package and dummy plug must be practiced until it is certain that these operations are being performed satisfactorily and that the tools and carriers are adequate.

3.3 Sampling

The systems for handling the slurry, gas, and high pressure water samples must be demonstrated. In each case the entire process from taking a sample to performing the required analyses should be demonstrated on non-radiative samples before any radiative samples are taken. Every piece of equipment and every operation associated with sampling must be tested.

3.4 Shielding

The demonstration that the shielding is adequate cannot be made until the loop equipment is operated in the reactor. When in-pile operation is started, an extensive monitoring survey must be made and the shielding must be modified if modification is found to be necessary.

3.5 Services

ORNL is responsible for providing services such as electrical power, process water, reactor cooling water, off-gas, drains, ventilation, and instrument air. These systems are to provide services of certain characteristics (voltages, pressures, capacities, etc.) at various tie-in points to the loop equipment. It must be demonstrated that these systems are available and adequate at the correct locations.

3.6 Irradiated Slurry Handling

The equipment for handling irradiated slurry removed from the loop must be thoroughly demonstrated. Adequate provisions must be made for emptying the loop and storing the drained slurry. If it is decided that the waste slurry must be available for chemical processing studies, it must be demonstrated that the provisions for sampling the waste slurry are safe and adequate. This system must be extensively tested with non-radiative slurry before irradiated slurry can be introduced into it.

3.7 Test Runs

Before an in-pile run can be made, it must be determined that there is no likelihood that the equipment will be damaged and no credible possibility of an accident which will result in damage to ORR facilities or in danger to operating personnel, ORNL employees, or inhabitants of the area surrounding the Laboratory.

The loop complex must be tested with out-of-pile runs and low power density in-pile runs. Operation at high fission power densities will be attempted only after the accumulation and evaluation of experimental data which are sufficient to prove the adequacy of the equipment.

After assembly of the equipment at the reactor site, a cold D₂O out-of-pile run, a hot D₂O out-of-pile run, a slurry out-of-pile run, a hot D₂O in-pile run, and a ThO₂ slurry in-pile run will be made before any fissionable material is put in the loop. Progression through this sequence can be only as fast as equipment performance will allow.

3.8 Operating Procedures

Loop operations will be performed according to detailed check sheets. Before a loop is irradiated, there must exist a complete set of tested procedures for all operations which are in any way associated with loop operation or equipment handling.

3.9 Segmenting Facility

The segmenting facility was designed to make possible segmenting the loop and recovering for study various loop components. The success of the loop program depends heavily upon the operability of the segmenting facility. The recovery of loop corrosion specimens must be assured. The results from metallurgical analyses of these specimens are of major importance to homogeneous reactor design groups. It is also important that loop components such as the main pump be made available for study. The segmenting facility must be thoroughly tested before any attempt at segmenting an irradiated loop is made. A mock-up of the loop package should be segmented so every detail of the segmenting procedure can be tested before an irradiated loop is put into the cell.

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