DOE/SF/70030-T63

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DOE/SF/70030--T63

October 12, 1981

DE82 008262

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SUBJECT: DOE Contract No. (DE-AT03-76SF70030) Work Package No. 40 10.1
LMFBR Steam Generator System Development, WPT No. SG027

*Transmittal of Chemical Leak Detection Test Plan for Prototype
Steam Generator Test at SCTI/ETEC*

Dear Mr. Winters:

The attached Chemical Leak Detection Test Plan is provided for use
as an Appendix to the Test Request. This document has been reviewed
by ETEC and DOE-RRT, and their comments have been incorporated.

Dr. P. M. Magee may be contacted regarding this transmittal.

Very truly yours,

W. V. Leeburn
W. V. Leeburn, Manager
Steam Generator Projects

Attachment

WVL/DWL/mj

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SCTI CHEMICAL LEAK DETECTION TEST PLAN1. OBJECTIVE

Tests will be conducted on the CRBRP prototype steam generator at SCTI to determine the effects of steam generator geometry on the response of the CRBRP chemical leak detection system to small water-to-sodium leaks in various regions of the steam generator. Specifically, small injections of hydrogen gas (simulating water leaks) will be made near the two tubesheets, and the effective transport times to the main stream exit and vent line hydrogen meters will be measured. The magnitude and time characteristics of the meters' response will also be measured. This information will be used by the Small Leak Protection Base Program (SG027) for improved predictions of meter response times and leak detection sensitivity.

2. BACKGROUND

As part of the Small Leak Protection Base Development Program, chemical leak detection modules and their associated control and instrumentation systems have been designed. These systems will be installed in the Clinch River Plant, and are first being field tested. Testing of the basic hydrogen and oxygen meters at Argonne National Laboratory has verified that the meters meet all functional requirements of SDD-53. Calculations, based on the module geometry and flowrates, indicate that all SDD-53 module requirements are also met. The Few Tube Test (FTT) Program conducted in the General Electric Steam Generator Test Rig (SGTR) provided an early test bed for the Mark I Chemical Leak Detection module. Based upon this test, the module design evolved into a second generation (Mark II), which is prototypic of the modules to be installed in CRBRP. The adequacy of the Mark II design will be assured by tests of a module and associated control panel at EBR-II during late FY-81 and FY-82.

The module is installed downstream of the evaporators, in the common line, of the EBR-II Intermediate Heat Transport System. The EBR-II tests will emphasize the capability of the detection system to function under plant operating conditions, its response to simulated leaks of various sizes, testing of the CRBRP alarm level settings, and operational checkout of all leak detection system procedures.

These tests are sufficient to qualify the CRBRP reference leak detection module, meters and control panel. They do not, however, address the effects of the steam generator design on leak detection system performance. That is, such questions as transport time, reaction product "hideout", and the division of reaction products from a leak in the hockey stick region to the vent-line and mainstream detectors. The prototype steam generator test at SCTI will be used to address these questions.

In the prototype steam generator, the transport times and system responses to small injections of hydrogen gas at the tube-sheets will be measured. The injections will utilize the Leak Injection Devices (LID's) installed inside the steam generator. Monitoring will be done with the two SCTI facility hydrogen meters. The technical direction and management of this auxiliary test effort is performed under Base Program SG027 as part of DRS 53.16.

3. TEST EQUIPMENT

3.1 Leak Injection Devices (LID's)

Nine LID's are installed in the prototype steam generator. Six are attached to the outside of the thermal sleeves next to the upper tubesheet and three are attached to the shroud near the lower tube-sheet. The LID design is shown in Figure 1, and placement and numbering of the LID's is shown on Figures 2 and 3. Each LID consists of 0.125 in OD stainless steel tubing (0.049 in wall) connected to a diffuser section by a fusion weld. The thick-walled tubing reduces the volume of the supply system and increases measurement accuracy. A 2 mil thick rupture disc is burst to start the gas injection. Each injection line is coiled within the steam generator to provide a heat exchanger section and exits the unit through an instrument port. The injection system and the LID's are capable of withstanding extended

FIGURE 1. LEAK INJECTION DEVICE

FIGURE 2

LID PLACEMENT IN UPPER
TUBESHEET REGION

FIGURE 3
LID PLACEMENT IN LOWER
TUBESHEET REGION

times (>6 months) of exposure to hot sodium (1000°F) prior to their operation.

Each injection line will have its own isolation valve. The valves will be high temperature, high pressure ball valve designs with small orifices and low Cv factors. After each injection, this valve will be closed, and shall form the isolating boundary after the injection module is disconnected from it. Due to the design of the freeze seal and the distance from the seal to the valve (~2 ft or 0.66 m), there is no way that liquid sodium can come in contact with the ball valve.

The primary objective of the design of the in-module leak injection devices (LID's) is to completely contain the combustion flame resulting from the injection of water into sodium. This design objective has been achieved and the operation of the device verified by an extensive test program described in ASME Paper 77-JPGC-NE-7, "Development Testing of Leak Injection Devices for Use in Testing Leak Detection Modules in LMFBF's," by S. G. Stehling, J. C. Hunsicker, and R. T. Sperberg.

Current plans call for all injections to be made using hydrogen gas. If a water injection is determined to be desirable it would be accomplished toward the end of the test program after all steam generator thermal-hydraulic test requirements have been met. One LID attached to the upper tubesheet, and currently designated for use during simulated decay heat removal sodium flow, will be reserved for possible use as a water injector.

3.2 Injection Module

The SCTI gas injection module will be supplied by GE. It is schematically illustrated in Figure 4. The module is designed to be self-contained and portable. Portability is required as the two injection locations (upper and lower tubesheet) will be on different platform levels in SCTI.

The module will interface with a hydrogen disposal system to be supplied by ETEC. The module will also require 120 v AC power. Gas supply will be by standard high pressure bottles which shall also be supplied by ETEC. Gases to be used are argon and hydrogen.

Figure 4. GE-ARSD Leak Injection Module

3.3 Inpipe NaOH Injector

Provisions have been made to permit the installation of an ANL inpipe NaOH injector in the 14 inch SCTI main loop piping. However, the inpipe injector will not be installed for the CRBRP prototype steam generator tests. The SCTI leak detection test program does not call for any inpipe injections; comparable injection tests will be conducted at EBR-II.

3.4 Leak Detection Meters

The SCTI facility hydrogen meters will be used to monitor the injections. The meters are located in positions corresponding to those to be utilized in the Clinch River plant: off the sodium outlet pipe of the evaporator and off the running vent line.* Meter data will be taken, as functions of time, off the DAS; and, during the actual injections, recorded on strip chart recorders. Strip chart recorder speed shall be approximately 1 in/min.

4. Work Scope

A total of nine hydrogen gas injections, one for each LID, will be made. The injections are summarized in Table 1. One upper tubesheet and one lower tubesheet injection will be made during sodium only flow. During the sodium only flow injections, the initial hydrogen injection will be made at a sodium flow rate of 25% of full flow. The injection will then be switched to argon to keep the LID open and the sodium flow rate raised by 25% of full flow. Hydrogen injection will be resumed as soon as the hydrogen background measurement is stable. This process will be repeated until hydrogen injection at full flow is achieved or until the LID plugs. During Thermal Performance Testing, one upper tubesheet and one lower tubesheet injection will be made at simulated plant operation of 60-70 MW_t (Table I, DRS 53.31).

* At one time, it was planned to supply a MK II O-H module to SCTI. Instead, only one OH module was fabricated and sent to EBR-II for extended testing. The lack of a MK II OH module does not penalize the scope of the SCTI injection tests.

TABLE I

SCTI OPERATING CONDITIONS FOR H₂ INJECTIONS

<u>LID No.</u>	<u>Condition</u>
1	Sodium Only Flow - initially at 25% full flow and raised in increments of 25% of full flow to full flow
2	Simulated Plant Operation, 60-70 MW _t
3	Simulated Plant Operation, 40-50 MW _t
4	Low Sodium Flow (12%) - Nom. Water Flow
5	Simulated Decay Heat Removal with 3 to 7% sodium flow
6	Same as 5 except reserved for possible water injection
7	Same as 1
8	Same as 2
9	Same as 5

An additional upper tubesheet injection will be made at 40-50 MW_t simulated plant operation (Table I, DRS 53.31). One upper tubesheet injection will be made at low sodium flow (12%)/nominal water conditions (Table II, DRS 53.31). The remaining three injections will be made at simulated decay heat removal conditions with 3 to 7% sodium flow (Table III, DRS 53.31). Of these last three, one upper tubesheet LID will be reserved for possible water injection at the end of the Thermal Performance Testing.

All injections will be of hydrogen gas and of five minutes duration. The pressure behind the rupture disc will be rapidly increased to burst the disc; the hydrogen flowrate will then be decreased to a steady value of $\sim 3 \times 10^{-6}$ lb/sec (800 SCCM) consistent with the controlling orifice size. Steady-state steam generator and loop conditions will be required for ten minutes; two minutes prior to the injection, during the five minute injection, and for three minutes after the injection is terminated. Data will be collected during this ten minute period. Hydrogen concentrations (ppb) will be recorded off both meters at least once every five seconds on the DAS. In addition, strip chart recorders will record the ion pump current and membrane temperature for both hydrogen meters at a chart speed of at least 1 in/min. If a water injection is made, strip chart recordings of the oxygen meters will also be required. The hydrogen gas flowrate will be recorded from the gas supply module. The following SCTI DAS data will be recorded frequently enough to insure that operating conditions do not vary during the ten minute test duration:

- a. Sodium flowrate
- b. Sodium inlet and outlet temperatures (steam generator)
- c. Vent line sodium flowrate (if available)
- d. Vent line sodium temperature (if available)
- e. Water flow rate
- f. Water inlet and outlet temperatures
- g. H-meter diffusion membrane temperature (both meters)
- h. Oxygen concentration (from O-meter).

The time of disc rupture will be recorded and marked on the two hydrogen concentration outputs to provide a zero time datum.

5. TEST FACILITY INTERFACES

5.1 Leak Injection Devices

The tubing interface shall be 0.125 inch by 0.049 inch wall. ETEC shall supply tubing and valves to connect each injector tube to the gas supply module.

5.2 Injection Module

The portable hydrogen gas injection system weighs approximately 375 pounds (minus gas supply bottles) and will require a working space approximately 6 ft by 6 ft by 6 ft. The internals of the portable injection system are enclosed in a standard 19-inch rack that stands about five feet high. The injection system should be placed as close as possible to the leak injection device interface valves at both the upper tubesheet and lower tubesheet location. Minimization of tubing length from injection system to LID is essential. Electrical hookup requirements are 120V, 60Hz.

5.3 Conduct of Tests

The injection tests will be conducted under the direction of a GE test engineer. Data will be recorded as specified in Section 4 of this test plan. Data analysis and test reporting will be the responsibility of GE.