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PROPOSED REVISION AT WALTZ MILL SITE (WANHES)
FOR FUEL ELEMENT CLUSTER TESTING
(Title Unclassified)

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by

R. L. Ramp
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Fluid Flow Laboratory

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Approved By:

E. A. DeLubay

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Fluid Flow Laboratory

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ABSTRACT

Full power hydrogen corrosion testing of fuel element clusters is required for the development of the NERVA reactor fuel assembly and core components. At present, cluster testing can be done only at the WANL Large Site and is facility-limited to approximately half power and half flow conditions.

The limited amount of development testing already accomplished has yielded valuable results. This work has verified the integrity of the support block assembly design. It has resulted in material changes and design improvements for the support block insulating cup. The development of successful chucks to carry the electric power to the cluster has indicated that full-power testing by electrical resistance heating is possible. The WANL reactor design activity is looking to the corrosion testing of full clusters to proof-test their design of fuel element components and configurations for NERVA.

This proposal recommends the increase in capability of the Waltz Mill Site by the design and construction of a new cluster corrosion test furnace with the necessary gas and water flow systems and an increase in the present heater power supply to accommodate full power testing. This proposal also recommends the revision necessary for simultaneous operation of the two single element furnaces in the Waltz Mill Hydrogen Test Cell.

DISCUSSION

Hydrogen corrosion testing of NERVA reactor fuel elements is conducted by flowing high pressure hydrogen through the coolant passages of the element while it is resistance heated to the required temperature by electrical direct current. The Westinghouse Astronuclear Laboratory, WANL, has two facilities for this testing. One is at the Large, Pa. Site, the other at the Waltz Mill Site in Westmoreland County, Pa.

The test complex at Large consists of two cells and is primarily concerned with development work. Cell No. 1 has a single element horizontal furnace. Cell No. 2 has a vertically mounted single cluster furnace. A common d. c. power supply, which can be switched to either cell, consists of four separate rectifier units supplied by induction regulator-controlled transformers. Each unit has a voltage variable from 0 to 80 with a maximum current rating of 8750 amps. By means of remotely controlled interconnection switches, the supplies may be connected in series, series-parallel or parallel combinations, depending upon the voltage and current requirements of the test. Storage and flow systems are provided for liquid and gaseous hydrogen and for gaseous helium. WANL policy regarding area safety requires that the maximum permissible hydrogen flow in any test at the Large Site is approximately 0.2 lbs/sec.

In a typical single element test, hydrogen at a full power flowrate of 0.04 lbs/sec is passed through the coolant holes of a fuel element heated to 4800°F by 800 kilowatts of direct current (4000 amperes at 200 volts are representative values). Gaseous helium surrounds the external surface of the element to prevent corrosion.

For cluster testing, a total flow of approximately 0.15 lbs/sec of hydrogen is passed through the fuel element coolant passages. Gaseous helium surrounds the cluster surface in the conventional testing to prevent corrosion. Approximately 2.4 megawatts of electrical power are used to heat the element to the required temperatures (16,450 amperes at 147 volts are typical values in a test and are close to the maximum power supply capability). These are approximately half power conditions with respect to the NRX reactor.

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The Waltz Mill Corrosion Test Facility (WANHES) presently consists of one horizontal single element furnace, similar to that at the Large Site, with a 0-300 volt d. c. 5000 ampere power supply. A duplicate furnace, to be operated from the same supply, is presently being procured to augment the first in the performance of fuel element quality control tests. This will increase the number of fuel elements that can be tested during a given period by eliminating test delays due to the maintenance and repair of furnace components such as heat exchanger sections.

NEED FOR CLUSTER FURNACE AT WANHES

A cluster furnace facility, capable of heating a fuel element cluster to the equivalent of reactor full power, is necessary to the NERVA core component development and qualification program. Below are listed a number of the problem areas which will be investigated with the device and typical tests that can be made. It is a vital support to the design, test, analysis, and qualification of core components under simulated NERVA conditions.

1. Integrated tests qualifying the cluster assembly.
2. Development, qualification and corrosion studies of specific core components and configurations, e. g. , tie rods, thermocouples, support blocks, filler strips.
3. Studies of fuel element corrosion in cluster configuration and investigation of "pin-holing" phenomena.
4. Developmental testing of single fuel elements; i. e. , a back-up facility for the single element furnaces.
5. Furnace heater development for special tests.
6. Testing of particular cluster components or configurations in the event that reactor tests at the Nevada Site reveal problem areas requiring immediate investigation or development.

This facility can also be a development tool to measure parameters that cannot be conveniently monitored during an actual reactor test. Typical examples are: coolant channel

pressure profiles; more controlled measurement of tie rod strain and temperature; cluster component characteristics as a function of variable cluster loading.

Since the cluster testing at Large is limited by the power supply available and the use of increased hydrogen flow is considered hazardous to the safety of personnel, it is proposed to design and install this higher capability into the Waltz Mill facility. This test complex is situated in a remote location with few personnel and is designed to accommodate the greater electric power capacity and the hydrogen flow rate capacity needed for cluster testing. The present test cell is sufficiently large to accommodate the two single element furnaces plus the proposed larger vertical cluster furnace, including the additional water, helium, and hydrogen flow systems needed.

PROPOSED REVISION TO WANHES FACILITY

It is proposed that a new cluster furnace system capable of operation at 5000°R and 1200 psi be designed, built, and installed at the WANHES facility with procurement to be initiated October 1, 1966. Figure 1 shows the present installation of the test facility with two horizontal furnaces, the test cell, control room, the fuel element preparation and post-examination rooms and the electric power installation. The proposed additions are shown with the resulting revisions to the present arrangement.

The system design will be basically similar to that at Large except that it is scaled up to provide higher flow (0.25 lbs/sec) and greater power (4.8 megawatts). Provision will be made for controlled multi-gas injection into the test specimens (e. g. methane, argon). Attention will be given to the improved insulation and coolant techniques, in order that equipment failure and operation downtime can be held to a minimum.

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Considerable experience has been gained using the cluster furnace at the Large Site.* This experience will be used to incorporate a number of design features into the new furnace which will result in improved performance. The thermally hot end of the furnace will be electrically grounded. A simpler, more easily operated furnace vessel closure will be used. The heat exchanger will be improved by design changes in the tubes and in the striker plate. The experience already gained with heat shields of various configurations and materials, and the tentative plan to use a guard heater over the hot end of the test specimen will make it possible to reduce radiation heat losses and will give improved control of temperature gradient along the specimen. With the new furnace design, it will be possible to improve instrumentation of the test specimen by providing more room and more direct access for instrument connections.

Ample gas storage facilities already exist at the WANHES site. The gas and water systems were installed during initial site construction and can be easily extended to facilitate installation of the new system. The present coolant water system is designed to dissipate heat generated by the single element furnace in a spray pond, see Figure 1. With the increase in furnace power to a possible 7.2 megawatts, it will be necessary to increase the capacity of the system by adding an eight foot cooling tower section to the pond. The spray pond basin was originally designed to accommodate the addition of a standard size cooling tower section.

The electrical power supply presently consists of a transformer-rectifier combination operating from a 4160 volt power line. The 0-300 d. c. voltage range is controlled by a remotely

*WANL-TME-1072, "First Single Cluster Test WANL Hydrogen Corrosion Test Facility,"
R. D. Foster, M. C. Gilchrist, February 25, 1965.

WANL-TME-1284, "Single Cluster Corrosion Tests WANL Hydrogen Corrosion Test Runs
November 24, 1964 - August 12, 1965," R. D. Foster, M. C. Gilchrist, August 25,
1965.

WANL-TME-1375, "Single Cluster Corrosion Test Summary - August 1965 to March 1966,"
L. A. Salvador, R. D. Foster, L. Wagner, April 1966.

operated transformer tap-changing switch and a magnetic amplifier control circuit for smooth vernier voltage adjustment between taps. The maximum rated current output of the rectifier is nominally rated at 5000 amperes. A d. c. power bus already installed between the rectifier cabinet location and the test cell has provisions for water cooling which will increase its current carrying capability to 35,000 amperes.

If the present design fuel element is retained, the full power cluster requirement of 4.8 megawatts would be 23,200 amperes at 207 volts. If the higher void fraction design element is used with a 10% increase in coolant hole diameter, the 4.8 megawatt power requirement would be 21,200 amperes at 226 volts. The test specification for the new high void fraction element, however, calls for a 50% higher flow. This requirement raises the cluster full power figure to 7.2 megawatts with electrical values of 25,900 amperes at 278 volts.

The increased power requirements can be met in two ways. In the first, the increase in power can be gained in one combination of transformer and rectifier, each of increased capacity. The second solution is to procure four identical duplicates of the present 1-1/2 megawatt units to gain the needed power. The cost differential between these two alternatives is negligible.

The second way is judged to be the most desirable for a number of reasons. First, the switchgear-transformer-rectifier package has already been designed and engineered. This would minimize or possibly eliminate the need for engineering design and drafting which cause very serious delivery delays. It has been established that a simple re-order of one or more of the power packages, similar to the one existing at Waltz Mill, would require a delivery time of 6 to 8 months less than that required if a higher power unit had to be designed and built. In addition, the procurement and storage of repair or replacement parts would be simplified. It is anticipated that a guard heater requiring an independent power supply will be used in cluster testing. The use of a number of similar rectifier units is also needed for the proposed

simultaneous operation of the single element furnaces described below. These are compelling reasons for the multiple-unit method of increasing the Waltz Mill Facility for the development and quality control testing of NERVA fuel elements.

It is also proposed to provide at a small increase in overall cost, simultaneous operation of the two single element furnaces at the Waltz Mill Site. This is important and desirable since, with the present trend toward longer tests for fuel elements, the overall testing rate can be maintained or increased. The labor cost per test can be reduced. With this type of operation, it should be possible to conduct cluster testing in the same cell without interfering with or delaying the schedule of quality control testing.

Since the rectifier units are of the indoor type, it is planned to dismantle the present element-preparation and post-examination room to mount the four new rectifier cabinets adjacent to each other as shown on Figure 1. For rectifier cooling, the present fan duct in the top of each cabinet will be vented into a common plenum to be built on the roof. If the fan noise is too serious for effective working conditions, a large squirrel-cage type blower in the roof plenum may be a satisfactory answer. A four inch sound absorbent wall as shown in Figure 1, will be used to isolate the rectifier cabinets from the rest of the area in which they are located. Outside wall vents will be installed to provide cooling air to the rectifier cabinets. The four additional transformers are mounted on separate pads in a way such that the heavy current a. c. bus wires to the rectifier cabinets are of minimum length. The added high voltage switchgear units can be mounted together as shown.

The cost of the electric power system revision is based in part on firm estimates from the supplier of the existing power supply and also reflect the actual costs incurred in the installation of the original equipment approximately one year ago.

SUMMARY OF EQUIPMENT COSTS

A. Furnace and Gas Systems for Cluster Furnace

1. Furnace vessel and support	\$ 40,750
2. Heat exchanger and transition piece	45,000
3. Exit gas filter	1,500
4. Gas loop and system	14,000
5. Water system including eight inch cooling tower with pump, piping, and instrumentation	16,000
6. Control and instrumentation	17,500
7. Prism system	1,000
8. Service equipment (hoist, etc.)	1,000
9. Miscellaneous hardware, fittings	<u>2,000</u>

Total Cost of Cluster Furnace and Gas System \$138,750

B. Electrical Equipment for Cluster Furnace

1. Four switchgear cabinets, one switchgear control cabinet, four tap-changing transformers, four rectifier cabinets, 0-300 volts, 5000 amperes per rectifier unit. (Based on firm proposal price, dated March 4, 1966.) With necessary control panels.	\$260,000
2. Seventy-six (76) feet of a. c. bus for transformer connection to rectifiers. Eighty-six (86) feet of d. c. bus bar to load. Includes weather seals, clamps, and miscellaneous hardware.	19,808
3. Installation of transformer, switchgear, a. c. and d. c. bus and control panels; material and equipment cost and installation of exhaust plenum, wall vents, and roof fan for rectifiers, concrete pads for transformers, rectifiers, and switchgear.	36,575
4. Bus bar , cable, switch to connect furnace to main power bus.	<u>18,000</u>

Total Cost of Electrical System Revision 334,383

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C. Equipment for Simultaneous Operation of Single
Element Furnaces

1. Additional piping, valves and instrumentation.	\$ 6,000
2. Additional bus bar - 25 ft.	3,750
3. 15,000 ampere bus bar switch.	4,200
4. Additional power supply control equipment	<u>2,500</u>

Total Cost \$ 16,450

Total Cost of Proposed Installation \$489,583

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Figure 1

Waltz Mill Hydrogen Corrosion Test Cell

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