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WANL-TME-1381

February, 1966

Westinghouse Astronuclear Laboratory

UPGRADING OF THE SINGLE ELEMENT

HYDROGEN CORROSION TEST

(Title Unclassified)

MASTER

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ABSTRACT

A hardware development program was undertaken at WANL Fluid Flow Laboratory to upgrade furnace performance for the single element hydrogen corrosion test. Hot and cold end chucks were designed to eliminate electrical arcing failures of the fuel element under test. Molybdenum radiant heat shields were installed to reduce heat losses from the test sample thereby decreasing the element radial temperature gradient. Improvements in furnace instrumentation have facilitated the collection of more complete test data from which evaluation of single element test conditions can be made. Although the single element hydrogen corrosion test does not duplicate conditions found in the NERVA reactor, the following changes were made to improve the degree of reactor simulation: A twenty mil hydrogen flow passage cut into the hot chuck approximates reactor nozzle end corrosion. An inlet gas seal prevents mixing of the helium and hydrogen atmospheres and allows simulation of pinholing pressure conditions. The molybdenum shields decrease the radial temperature gradient in the test sample by 250°R.

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INTRODUCTION

NERVA reference fuel undergoes a high temperature corrosion test to evaluate the quality of the NbC coating at reactor operating conditions. This test is performed at WANL by centrally placing a single fueled element in a horizontal water cooled pressure vessel which is equipped to resistance heat the test sample by direct current. Simulation of reactor flow and pressure conditions is provided by passing 500 scfm of hydrogen through the 19 coolant channels. Entering the element at ambient temperature and a pressure of 660 psig, the hydrogen exits at approximately 4460°R and 560 psig. An inert atmosphere of helium flows over the outside surface of the element to protect the exposed graphite (both the element outer surface and the furnace fixtures) from hydrogen attack. Element surface temperatures (which are measured at 11-inch intervals along the length of the element with an optical pyrometer) are used to determine applied power level approximating reactor operating temperature profiles.

During the 1965 contract year, two studies¹ were made of furnace operating conditions and practices to determine the quality of reactor simulation

1. TME-1193 and TME-744, Supplement 1

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provided by the single element test and what improvements could be made in furnace geometry to overcome present limitations. This report describes the results of recommendations made through these studies for upgrading the electrical test.

IMPROVEMENTS IN FURNACE HARDWARE

The first area in which work to improve furnace operation was undertaken was that of revising the electrical chucking hardware. Chucks are the furnace fixtures which physically hold the test sample (i.e. the fuel element) in the center of the pressure vessel and provide the electrical contact through which the heating current passes. They are machined from graphite (usually ATJ) in order that they may withstand the high temperature and avoid thermal stresses on the element which would arise if material of a different thermal expansion were to be used (such as refractory metals). The existing hot end chuck simply consisted of a cylinder centrally broached with a hexagonal hole to conform to the outside dimensions of the element with a tight sliding fit (Figure 1). Strong physical and electrical contact was obtained when the hot element expanded into the slightly cooler chuck opening. Each chuck was hand fitted to the individual test sample to prevent electrical arcing which would invariably result from too loose a fit. Chucks of this type behaved well for the short duration tests required of NRX-A2 and NRX-A3 reactor elements, but as longer and more severe tests were introduced for subsequent builds, arcing

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Figure 1. One Piece Hot End Chuck

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failures of the force fit chuck became more frequent. The apparent cause of these hot end arcing failures was the graphitization of the chuck and element -- a molecular ordering process which occurs in graphite above 4000°R as a function of time causing the material of both chuck and element to shrink away from each other forming arcing gaps. To eliminate this problem for the testing of NRX-A5 elements a means had to be found to maintain good electrical contact at the hot end despite changes in element dimensions.

Several experimental chucks were designed and tested in an attempt to overcome the problem caused by graphitization shrinkage. Most of the new designs employed some form of movable tapered fingers which could, with a screw, be forced to clamp the element tightly and thereby, it was hoped, provide a more positive mechanical contact with the element than had been afforded by the old sliding fit. This method however produced a new problem which had not been experienced with the old one piece chuck, namely, that of providing a gas tight seal for the movable segments at high temperature. Such a seal was necessary to prevent the helium atmosphere (which is maintained about the outer surfaces of the element at a pressure 100 psig higher than the hydrogen exiting into the hot chuck to prevent hydrogen corrosion of uncoated graphite) from leaking through cracks between chuck parts and entering the channels of the element inhibiting corrosion. A good helium seal had been provided by the one piece chuck when the element expanded tightly into the hex opening leaving diffusion through dense graphite

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(such as is ATJ) as the only leakage path. The use of movable segments for better electrical contact made it necessary that the one piece seal concept be abandoned and a new high temperature gas seal devised. A solution to the problem was obtained by taking the best from both approaches. The solid hex broached cylinder was combined with movable pins which could follow element contracting maintaining good electrical contact. This was accomplished by drilling three holes through the side of the chuck to accommodate 1/4 inch diameter graphite dowel pins which were placed perpendicular to the element surface on alternate flats. The pins were held in place by a graphite spring clasp around the outside which would remain elastic at high temperatures maintaining constant pressure and electrical contact during shrinkage. (See Figure 2). Thus the one piece hex broached chuck preserved the good helium atmosphere seal while the spring loaded pins acted as an arc suppressor in the event of changes in element dimensions. This innovation together with the recently initiated practice of electrically grounding the thermally hot (electrically cold) end of the furnace has materially reduced arcing failures at the hot end.

One additional design change was incorporated in the three pin chuck to make it useful for testing of A5 fuel elements. The one piece chuck used previously had contacted the element over the last two inches (from 50" to 52" measured from the cold end). The NRX-A5 elements, however, had a one inch non-fueled tip attached with graphite cement to the hot end. In order to prevent current

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Figure 2. Spring Loaded Three Pin Chuck

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from passing across the glued joint and through the non-fueled tip, the element was shifted 1-1/2 inches downstream so that the chuck now covered 49-1/2 to 52 inches and the last 1-1/2 inches of the hex broach was undercut by 20 mils to prevent electrical contact with the tip. (See Figure 3). Two things resulted from this change: First, hydrogen was now allowed to back flow over the last 1-1/2 inches of the outer surface of the element in the 20 mil gap created by the undercut. This condition provided a corrosion test for the element end coating permitting evaluation of the interelement flow effects found at the hot end of the reactor due to "brooming" of the elements in the cluster. The second change which resulted from moving the element downstream was a shift in the test axial temperature profile which will be discussed in a later section.

Two important problems in the area of the cold end chuck had also become apparent from experience with the electrical test; arcing due to movement of the element in the cold end chuck and arcing due to movement of the cold chuck in its retainer ring. The cold end chuck like the hot chuck, is a graphite fixture whose function is to mechanically hold the test sample at the center of the furnace and maintain electrical contact with it. The original cold chuck consisted three 4-inch long tapered finger segments which were clamped to the outer surface of the element by being forced into the cone shaped cavity in the chuck with a retaining nut. (See Figure 4). Thus the primary function of the cold chuck was to grip the element like a vise to provide good electrical contact where the element would never get hot enough to

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Figure 3. Drawing for the Three Pin Chuck Body

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Figure 4. Old Cold End Chuck

expand tightly into its container. It was found, however, that due to thermal expansion movement of the element along the axis and general buffeting of the cold end chuck by furnace pressure fluctuation, the element would occasionally move inside the fingers resulting in arcing failure. The answer to this problem was found by shortening the fingers to 1-1/4 inch length and increasing their taper to 15° which provided greater leverage to grasp the element firmly. In addition the new fingers were loaded through a chrome vanadium steel spring (with a 1000 pound/inch constant) which would prevent relaxation of gripping pressure in the event that the retaining nut should loosen in its threads (as had been occasionally noticed on long term tests). Finally the direction of the taper was reversed to point downstream in order that access might be had to the retaining nut without removing the chuck from the cold end of the furnace as had been previously necessary. (See Figure 5). This last change in configuration was required to permit loading with the three pin hot chuck which had to be fitted to the hot end of the element before insertion into the furnace. These innovations provided a firm mechanical grip for maintaining precise element positioning and good electrical contact throughout the most severe tests.

The second cold chuck problem, that of arcing between the cold chuck and its retainer ring, had a similar origin. Now that the element was held firmly on the hot end by expanding into the chuck cavity and on the cold end by spring loaded fingers, some means had to be found to allow for the 3/8 inch thermal

Figure 5. Spring Loaded Cold Chuck With Labyrinth Gas Seal

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expansion which the element experienced along its axis. The cold end chuck, like the hot chuck, is held in a graphite "retainer ring" which is in turn threaded into the metal furnace electrode. Since the hot chuck is held fast in its retainer ring some provision must be made to allow for relative movement between the cold end chuck and its retainer ring during thermal expansion. This movement is permitted by letting the cold chuck slide in the retainer ring. Unfortunately, any gap which occurs in a high current DC circuit, even a slight one, will, as has been noted before, initiate arcing. So, as would be expected, the sliding contact between chuck and cold retainer ring provided the source for occasional arcing failures. It was found, however, that arcing between the cold chuck and retainer ring could be easily avoided by simply attaching four flexible metal pigtailed between the chuck and retainer. This additional electrical contact although never carrying the full heating current, provided the needed continuity to prevent arcing when slight breaks in the circuit would occur during chuck movement. Thus by combining the positive grip of spring loaded fingers with the arc suppressing pigtailed, arcing failures at the cold end of the furnace have been virtually eliminated.

Some additional development work on the cold end has been devoted to finding a positive gas seal which would prevent the element hydrogen atmosphere from mixing with the external helium atmosphere. This seal is desirable for two reasons. First mixing of the helium and hydrogen atmospheres is detrimental to obtaining good test results. If, for example, hydrogen is allowed to

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leak out into the element external environment it will attack the uncoated graphite surfaces of both the element and graphite furnace fixtures with the result that the corrosion weight loss data taken for the coated bores will be distorted by weight loss due to external corrosion of pure graphite. If on the other hand helium is allowed to leak into the hydrogen atmosphere, corrosion of the bores will be inhibited giving an unrealistic test result. Present practice for preventing gas leakage through the spaces between the fingers is to maintain the helium atmosphere at 1/2 pound higher pressure than the hydrogen inlet pressure (660 psig nominal). By balancing the pressures at the inlet this way, hydrogen leakage to the external atmosphere is eliminated and helium leakage into the bores is kept at a minimum. A positive gas seal on the cold end of the element would, however, eliminate the uncertainty in the corrosion test of admitting even small quantities of inert gas to the bores without the risk of releasing hydrogen into the atmosphere.

A second reason for the development of a cold end gas seal arises from the following observations from TME-744. Channels in the reactor with high power factors (located in the center of the core) have higher pressures than the interelement region. This condition creates an outward driving pressure which forces hydrogen through any flaws in the bore coat producing pinholes through the element to the surface. At present the helium atmosphere in the corrosion test is everywhere at a higher pressure than the hydrogen in the channels. This condition inhibits the formation of pinholing limiting the scope of

the test. A cold end gas seal would allow dropping the helium atmosphere pressure below the hydrogen inlet to simulate the pinholing condition without leaking hydrogen into the atmosphere.

A cold end gas seal was developed which could be used with the spring loaded cold chuck (see Figure 5). It consists of two consecutive hex broached washers made of plastic material which could slip over the outside of the element and seal against the flats. One of the washers was made of teflon (which withstands temperatures up to 500°F) so that it could be pressed directly against the cold end fingers to seal the cracks between them. The second washer was made of RTV rubber (rated for a slightly lower temperature but much more flexible than teflon) which could be crushed against the flats by being squeezed between two slightly tapered pieces of boron nitrate. The entire assembly was mounted in the chuck cavity just behind the fingers so that it could be loaded with the chuck spring and retaining nut. Viton O-rings were placed around the outside of the boron pieces to seal against the wall of the chuck cavity completing the labyrinth seal. Now hydrogen admitted through a quick disconnect fitting threaded into the chuck nut (See Figure 6) was forced to travel through the channels of the element since no leakage path was available to the external atmosphere.

Under test the seal was able to hold the hydrogen inlet pressure 100 pounds higher than the helium atmosphere pressure. Thus the helium atmosphere

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Figure 6. Direct Gas Inlet With Assembled Cold End Chuck

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could be set anywhere from the level of the element inlet (660 psig) to that of the outlet (560 psig), producing any desired level of outward driving pressure. This arrangement was successfully used on several tests to produce pinholing, and while overly severe may develop into a tool for comparative test of pinholing tendencies.

The Second Phase of hardware development work was concerned primarily with revising the radiant heat shields in the furnace in order to improve the corrosion test simulation of reactor operating temperature profiles. During the corrosion test the fuel element is surrounded by three concentric tubes which act as thermal radiation heat shields to prevent radiation heat loss from the test sample and protect the furnace walls from overtemperature. The heat shields used for the original build of the single element furnaces were made of a porous commercial graphite and had several inherent disadvantages. First of all graphite is a poor material at best for use as a radiant heat shield.* The radiation of thermal energy $\dot{q}$ is described by the equation

$$\dot{q} = \epsilon \sigma (T_R^4 - T_o^4)$$

where T_R is the temperature of the radiating material, T_o is the temperature of the objects in its environment to which it radiates, ϵ is a quantity describing the efficiency of the material as a radiator (called the emissivity) and σ is a constant. The effectiveness of a radiation heat shield then is

*Reference the discussion of shielding in TME-1193.

determined by its ability to maintain a temperature T_0 very close to that of the radiating material T_R in order to minimize the heat loss $\dot{q}$ from the radiator (the fuel element in this case). As larger temperature differences are allowed to exist between the element and the first shield, the energy lost by radiation from the element increases in proportion to the fourth power of this difference. This is precisely what happens with graphite shields. Because graphite is a very efficient radiator with an emissivity close to one, the first graphite shield radiates most of the energy it receives to the second shield, the second shield to the third and the third shield to the furnace wall which is kept at low temperature with water cooling. In addition the three graphite shields used require heavy graphite supports which form an excellent path to conduct shield heat to the walls. The total effect then of using graphite heat shields is to maintain a large element to shield temperature difference which encourages the radiation of as much as 4 kilowatts of energy per inch of element surface at the hot end.*

Several disadvantages then are inherent with the use of poor radiation shielding on the corrosion test. First of all, too much heat is radiated to the furnace body causing it to operate above its design temperature level with ensuing wear and tear on hardware. Secondly because of excessive heating of a large mass of furnace material a long cool down time is

*See TME-744, Supplement 1

required after extended tests. Most important of all, a high radiation heat loss from the element surface causes a large temperature difference (radial temperature gradient) between the surface and internal material of the element. The standard corrosion test (designated 1B) using graphite shields suffered from a 450°R radial gradient at the hot end which is somewhat severe as compared to nominal reactor conditions and provided a condition which tended to damage the element under test. TME-1193 points out that a large radial gradient causes thermal stress in the element which may result in cracking of the bore coat followed by a rapid corrosion failure or cracking of the element proper causing an electrical abort. In order to reduce the problems associated with high radial gradients and improve the simulation of reactor temperature profiles in a single element, the following changes were made in the furnace shielding scheme. Ten mil thick molybdenum sheet was rolled into tubes (fastened with molybdenum rivets) which were used in place of the three concentric graphite shields. The three tubes were spaced 1/4 inch apart and fastened together by 1/8 inch wire wound tungsten nuts and bolts (See Figure 7). The tungsten bolts protruded through the outer most shield supporting the whole structure and centering it in the furnace cavity.

Molybdenum is a refractory metal with an emissivity of about .3 (far lower than graphite which has emissivity close to 1) and consequently proves to be a very inefficient radiator. As a result the inner moly shield loses

*See TME-744, Supplement 1

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Figure 7. Fifteen Inch Triple Molybdenum Shield

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little of the heat radiated to it by the element to successive shields and remains at quite a high temperature once it reaches equilibrium. This provides a high temperature surface for the element to radiate to which has the effect (in accordance with the radiation equation) of reducing the total heat lost by radiation from the element surface. In addition the use of thin closely spaced moly shields considerably reduces the mass of shielding material (over graphite) which must be brought to equilibrium temperature thus reducing heat up and cooldown time. Finally the use of thin tungsten bolts to support the shields virtually eliminates heat conduction from shield to shield and shield conduction losses to the furnace body.

Nine modified shielding arrangements were tested in a series of 50 experimental furnace runs to obtain an optimum configuration which produced the least radial gradient combined with a satisfactory axial temperature profile in the test sample. Shields with three and four concentric layers were tried in 48, 36, 21, and 15 inch lengths to determine the effect of changes in shield length and number on the temperature profile of the fuel element. Surface temperature measurements were made in each case at 4, 15, 26-1/4, 37-1/2, and 48-1/2 inch lengths from the cold end of the element through the furnace view ports with a Pyro optical pyrometer. In addition 22 mil holes were drilled into the element webbing at all view port locations in order to observe maximum internal material temperatures. Experimental data showing element temperature profiles for various shielding arrangements is plotted in Figures 8, 9, and 10. From the observed temperature

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Figure 8. Temperature Profiles Obtained With Three and Four 48-Inch Long Molybdenum Shields

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Figure 9. Comparison of Temperature Profiles
Obtained With 15, 21 and 48-Inch Long Molybdenum Shields

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Figure 10. A Comparison of Element Temperature Profiles
Obtained With Graphite and Molybdenum Shielding (1B vs 1BM) With the Reactor

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data it can be seen that, in general, all the moly shields tried reduced the radial gradient at the hot end (surface vs. maximum internal material temperature) from 450°R to a much less severe 200°R. (Figure 11 gives a representative plot of element surface temperature vs. radial gradient for three 15 inch long moly and three graphite shields.) Because the heat lost by radiation from the element surface had been reduced, it was found that the power required to heat the element to the same level of internal material temperature that had been observed in the old LB* corrosion test was 5% lower with the moly shields. This figure is seen to be note worthy considering that only 7% of the power applied to the element in a standard corrosion test is lost through radiation.¹ No significant difference in temperature profile could be obtained by increasing shield length over 15 inches (see Figure 9). This phenomena is probably explained by the observation that most of the radiation losses suffered by the element occurs within the last 20 inches.¹ The 15 inch long shield, then, which covers the element from the hot chuck back to the 35 inch station protects most of the sensitive area where surface temperatures are high enough to sustain radiant heat transfer, and leaves little to be gained by extensions toward the

*LB is the designation for the standard hydrogen corrosion test used in quality control evaluation of A4 reactor element coatings. It was characterized by a +830 ±20 kilowatt electrical power, element temperature profiles shown in Figure 10, and use of three 48 inch long concentric graphite shields.

1. Ibid. TME-1193.

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Figure 11. Radial Temperature Gradient for Graphite and Molybdenum Radiant Heat Shields

cold end. Increasing the number of shields, however, had the effect of flattening out the axial temperature profile. In tests that were run, for example, setting the same hot end surface temperature (4600°R at the 48-1/2 inch station) for four shields as had been done with three, the surface temperature at the 38-1/2 inch station was made some 250°R higher by the addition of another layer of shield (see Figure 8). Increasing the number of shields, however, did not diminish the hot end radial gradient and consequently offered no simulation improvement. In fact, the net result of using four moly shields instead of three was simply to elevate the axial temperature profile (decreasing its slope) and cause a greater departure from reactor operating conditions than had been inherent with the graphite shields.

Thus it turned out that the 15 inch long triple moly shield produced the best improvement in radial gradient which could be attained without adversely effecting the axial temperature profile. Consequently it was this moly shield arrangement together with the spring loaded cold chuck and the three pin hot chuck which was chosen for quality control corrosion testing of A5 reactor elements.

IMPROVEMENTS IN CORROSION TEST INSTRUMENTATION

In order to provide a sound basis for evaluating the quality of electrical test reactor simulation so that test results may be effectively used to predict reactor performance, it is necessary to make an accurate determination of the

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element temperature environment. According to standard practice for QC corrosion testing of NRX-A3 reactor elements surface temperature measurements were regularly made with a Pyro optical pyrometer at three axial locations (49.75, 38.75, and 16.25 inch stations measured from the cold end) where easily accessible side view ports were available. The view port located at the 5-1/4 inch station was obscured by the old cold chuck and that for the 27.5 inch station is located on the top of the furnace where it was not easily accessible for viewing. During the QC testing of NRX-A4 elements and the hardware development program that followed, efforts were made to obtain more complete temperature data on the corrosion test. Part of the cold end chuck was cut away permitting observation of the element surface temperature at the 5-1/4 inch station. A system of prisms was installed and calibrated to permit temperature measurements through the top view port at 27.5 inches. In addition several tests were run with 22 mil holes drilled radially into the element webbing (at view port locations) as close as possible to the center channel. Radiation coming from the cavity could be observed with the optical pyrometer providing a measure of the internal material temperature. Surface and internal temperature data taken on standard runs were averaged to provide axial and radial temperature profiles for corrosion test samples (as has been shown in Figures 10 and 11). These profiles provide the basis for present comparison of the corrosion test with reactor temperature conditions.

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In addition to the program for measurement of element material temperatures, work has been initiated to obtain measurements of exit gas temperature for the corrosion test. The first efforts along this line consisted of immersing a tungsten 26% rhenium thermocouple 1/2 inch into the gas stream at a location 12 inches down stream from the exit (hot) end of the element. A view port placed at right angles to the thermocouple allowed observation of the sheath tip with an optical pyrometer so that comparisons could be made of emf output with surface temperature measurements. Gas temperature measurements were made in each of five LMB* tests (tests 1768 through 1772) where 4740°R was set at the 48.5 inch station on the element surface and the internal material temperature averaged 4940°R. In each case thermocouple emf indicated a temperature of 4460°R. Optical measurements of thermocouple tip temperature yielded a figure of 4476°R. These experimental results agreed well with calculated estimates of corrosion test exit gas temperature which ranged from 4561°R in the center channel to 4331°R in peripheral channels at the 52 inch station for the 1B test.¹ Plans are in progress for supplementing these thermocouple numbers with gas temperature measurements obtained from study of spectral radiation and by means of an enthalpy probe.

*LMB is the designation for the standard hydrogen corrosion test used in quality control evaluation of NRX-A5 reactor elements. It is characterized by 785±20 kilowatt power, element temperature profiles shown in Figure 10 and the use of three 15 inch long molybdenum shields.

1. TME-744 Supplement 1

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Two additional measurements of furnace parameters have been made recently. The inside surface temperature of the inner moly shield was measured optically at 3750°R opposite the 37.5 inch station. This figure should assist analysis of heat transfer parameters in the LMB test. Voltage measuring probes were successfully tested at the 37.5 and 48.5 inch stations for thermal and electrical design. This was accomplished by lowering tungsten electrodes through top view ports onto the fuel element surface during test and measuring the voltage drop between them with a potentiometer. Hot element resistance measurements such as this may be useful in future studies of local corrosion and graphitization in the electrical test.

SIMULATION IMPROVEMENTS

To reduce the difficulty of interpreting electrical test results in terms of reactor performance it is desirable that reactor operating conditions be duplicated as closely as possible in the corrosion test. Thus in order to allow proper evaluation of design improvements in fuel elements the foregoing hardware development work was conducted with the ultimate aim of achieving a better overall simulation of reactor environmental conditions. Changes made in the hot end chuck arrangement, for example, not only eliminated arcing to the element but provided a hydrogen flow passage around the coated tip which would provide a better assessment of coating integrity at the nozzle end. Likewise the labyrinth seal to the cold end of the element both prevented diluting the

corrosion atmosphere by helium leakage into the channels and permitted simulation of pinholing pressure conditions. Tests made utilizing these design changes were able to demonstrate pinholing (i.e. tests 1760 through 1772) and end corrosion (i.e. tests 1683 through 1690) behavior similar to that found in the NRX-A3 reactor.

The replacement of graphite radiant heat shields with three fifteen inch long molybdenum shields have also had several subtle effects on the temperature environment. As can be seen from the experimental data plotted in Figures 10 and 11 the reduction in radiation heat loss resulting from use of low emissivity shields raised the element surface temperature over the last 17 inches and reduced the radial temperature gradient to half the amount obtained with graphite shields. This change in temperature distribution helped eliminate test difficulties caused by high thermal stresses in the element and provided a better corrosion test by exposing more element material to high temperature. Internal material and gas temperature measurements seemed to indicate that these parameters remained essentially unchanged. A slight shift of about 0.4 inches upstream in the axial temperature profile did, however, result from the cumulative effect of shifting the element 1-1/2 inches toward the hot end, increasing the length of heated element by 0.6 inches (due to changes in the cold chuck grip) and the introduction of the moly shields. The net

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result of these changes on corrosion weight loss* was slight indicating that except for the radial gradient the test remained essentially the same.

A considerable improvement was introduced in furnace operational capabilities by use of the moly shield. Overheating of furnace hardware and the resulting slow cool down almost ceased to be a problem. An indication of the reduction in furnace limitation can be had by observing that 60 minute tests can now be made using only a 10 minute cooldown with no real damage to furnace parts. In addition a high temperature test was recently made (setting 5100°R surface temperature at 48.5 inches) for 10 minutes, again with no signs of damage to test equipment (i.e. test number 1778). Thus the introduction of the redesigned chuck and shield hardware has upgraded the electrical test by improving the test simulation and furnace capability.

* A weight loss study conducted on 20 tests (10 immediately before and 10 immediately after the installation of moly shields) showed an average weight loss of 6.25 grams for LB conditions run for two successive 10 minute cycles and 5.8 grams for LMB conditions run in the same sequence.

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Atomic Energy Act - 1954

Astronuclear
Laboratory

WANL-TME-1381

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