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ISOTOPE KILOWATT PROGRAM QUARTERLY PROGRESS REPORT FOR PERIOD ENDING DECEMBER 31, 1972

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Reactor Division

ISOTOPE KILOWATT PROGRAM QUARTERLY PROGRESS REPORT
FOR PERIOD ENDING DECEMBER 31, 1972

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MAY 1973

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FOREWORD

In 1968 the Oak Ridge National Laboratory started work on a program to evaluate various types of radioisotope energy conversion systems for the production of 1 to 10 kW of electric power for terrestrial and under-sea applications. This program is being carried out for the U. S. Atomic Energy Commission Division of Reactor Development and Technology and the Naval Facilities Engineering Command. The first phase of the program was a parametric and engineering analysis comparing the principal isotope fuels and the principal types of energy conversion system that have been proposed for applications of this sort, and the preparation of a set of conceptual designs for the more attractive systems. That work was completed in the summer of 1969 and was reported in Ref. 1. In October of 1969 ORNL was asked to proceed with a detailed engineering study of the three most promising systems selected from those covered in Phase I of the program. These three systems now under study are a 2-kW(e) thermoelectric system, a 3-kW(e) steam Rankine cycle system, and a 5-kW(e) organic Rankine cycle system.

The first step in the effort was to evolve a program plan for a three-year effort to be carried out in calendar years 1970, 1971, and 1972. The conceptual designs presented in Task I were reexamined and possible improvements were considered with particular attention to the difficult development problems. A variety of engineering tests was considered as a means of evaluating the technology, solving the principal technical problems, and investigating engineering uncertainties that should be resolved before settling on the design of a prototype power plant. In view of the limited funds and the desirability of narrowing the field to a single Rankine cycle system, particular attention was given to the relative merits of the steam and organic Rankine cycle systems.

The first quarter of 1970 was devoted to firming up reference designs for the three types of system, selecting the most crucial experiments required to evaluate the technology, and settling on a program plan for the three-year effort.² With this first quarter's work as a foundation, the second quarter was then devoted to firming up the details of the reference designs, firming up details of the experiments to be conducted, and preparation of topical reports covering the three reference designs with their

associated experiments.³ The subsequent quarters have been devoted to the design and construction of the most urgent experiments.⁴⁻¹² The objective is to establish as well as possible by June 1973 the design bases for prototype isotope power plants with a clear delineation of the development program required in each case including firm estimates of the cost and time for the various programmatic steps.

This is the twelfth in a series of quarterly progress reports. Topical reports present the work carried out in particular areas when key tasks are completed. When a topical report is issued essentially concurrently with a quarterly report, to avoid duplication only a very brief summary of its contents is included in the quarterly.

ISOTOPE KILOWATT PROGRAM QUARTERLY PROGRESS REPORT
FOR PERIOD ENDING DECEMBER 31, 1972

1.0 SUMMARY

Gas samples were taken from all but one of the organic fluid glass capsules. The volume of the gas ranged from 0.007 to 0.03 cc/g of liquid. Partial analysis of the gas phase indicated the major component to be hydrogen in the range of 50% by volume. Analysis of the liquid portion indicated that benzene is the major impurity, the amount running from 30 to 150 ppm.

Operation of the 1/4-scale organic fluid decomposition test loop has been interrupted by a series of difficulties with increases in the condenser pressure as a consequence of the accumulation of noncondensables. The first arose as a consequence of a pump failure, the second was thought to be a leak in a soft soldered joint at a flowmeter, but the system was found to be vacuum-tight after the third rise in pressure, hence this seems to be accountable only on the basis of evolution of noncondensables from the fluid as a consequence of thermal decompositions. The test conditions have been changed so that the loop is operating on simple thermal convection without a pump to see if a hot spot in the pump might have been responsible.

Fabrication of components for the Phase II heat block-shield test with heat pipes has been completed. The temperature instrumentation and heaters have been installed on the test block for the Phase II heat pipe tests. Installation in the test stand should be completed by mid-January.

All experimental work on the 1/4-scale aluminum insulation test with the block horizontal was completed. The thermal conductivity in argon at 15.4 psia was approximately 25% higher than that found in the vertical test. When the insulation was melted, the upper side of the block reached a maximum temperature of 1640°F and the lower side 1517°F. The most interesting result of the test was that none of the molten aluminum ran or dripped onto the heat block. The aluminum on melting flowed around the remaining screen and accumulated in the lower part of the insulation. The first draft of the final report on the insulation program has been written and internal review should be completed by February.

Fabrication and assembly of components for the full-scale fusible insulation evaluation test should be completed in January.

Fabrication of the dummy fuel capsules was completed. Dimensional inspection and heat treatment are scheduled for the first week of January. Capsule 1 will be shipped to David Taylor Model Basin for pressure testing at the end of the first week in January.

2.0 ORGANIC FLUID EVALUATION

Organic Fluid Capsule Decomposition Test

Fourteen of the 30 samples removed from the heat block-shield in September have been opened to measure the amount of gas evolved. This was accomplished on 13 of the 14 samples; one gas sample was lost when the sample tube was broken during the time of sample evacuation. The gas volume was obtained by freezing the sample with liquid nitrogen and then pumping off and measuring the gas. After removing the gas, the sample was allowed to thaw and an analysis was obtained on the liquid phase. The only measurable component found in the liquid phase was benzene and the values shown in Table 1 are the average of two analyses on each sample. Analysis of the gas phase was also completed on some of the samples and the data are reported in Table 1. The preliminary results show the volume of gas to vary between 0.007 and 0.03 cm³/g of liquid in the tube. The higher value is approximately twice the amount (0.01 to 0.015 cm³/g) obtained from the first four samples removed after 7000 hr of operation. Inasmuch as the operating time on the second set of capsules was 14,200 hr, this indicates that the amount of decomposition increases linearly with exposure time.

Organic Fluid Decomposition Test Facility

A test started September 21, 1972 was operated until October 2, 1972 when it was terminated owing to the continued steady increase in the condenser pressure. At the time of shutdown, the condenser pressure was showing 0.67 psia. Figure 1 shows a plot of the condenser pressure as a function of time for the 260 hr run. After the heat block was cooled below 600°F to prevent the liquid in the boiler tubes from overheating, the

Table 1. Results from Analyses of the Organic Fluid from
the Organic Fluid Capsule Decomposition Test

Type of Capsule	Distance From SrTiO ₃ Source in.	Sample No.	Amount of Liquid grams	Liquid Phase Analysis			Gas Volume cc	Gas Phase Analysis - % by Volume										
				Biphenyl %	Phenyl Ether %	Benzene ppm		H ₂	CH ₄	H ₂ O	HC	N ₂ + CO	O ₂	A	CO ₂	Benzene		
Glass Containing Dowtherm	4.0	1	4.9890	27.1	72.9	35	0.045											
	8.0	2	5.0765	27.0	73.0	40	0.049											
	6.0	3	4.9997	27.5	72.5	30	0.083											
	4.0	4	5.2080	26.9	73.1	45	0.047											
	2.5	5	5.2180	27.5	72.5	35	0.026	3.3	27.1	7.8	4.5	52.1	0.2	<0.01	3.3	1.7		
	2.5	6	5.1510	27.5	72.5	40	0.050											
	1.75	7	5.1816	27.4	72.6	100	0.067	1.5	31.6	3.1	1.2	57.6	0.1	<0.1	1.8	3.1		
	1.25	8	5.1666	27.2	72.8	90	0.070											
Glass Containing Dowtherm and Stainless Steel Wires	4.0	11	5.1473	27.1	72.9	100	0.046	38.2	10.3	2.3	8.4	21.3	0.2	<0.04	17.5	1.8		
	8.0	13	5.1899	26.9	73.1	75	0.133	25.9	23.2	2.0	8.3	20.0	<0.05	<0.04	17.4	3.2		
	2.5	14	5.1963	27.2	72.8	65	0.043											
	8.0	16	5.1728	27.0	73.0	75	0.146	41.6	3.7	0.4	5.8	31.8	5.5	<0.04	8.5	2.7		
	6.0	17	5.1878	27.0	73.0	75	0.047	51.0	8.9	1.1	6.1	18.9	<0.1	<0.2	11.2	2.9		
	6.0	18	5.2109	26.9	73.1	145	0.035											
	1.75	21	5.2652	27.0	73.0	100	0.045	30.7	12.2	2.6	9.7	23.0	0.06	<0.04	15.5	2.3		
	1.75	22	5.1996	26.9	73.1	125	0.037											
	2.5	24	5.2038	26.7	73.3	90	0.041											
	4.0	25	5.1975	26.8	73.2	90	0.058	40.0	12.8	1.7	8.9	18.3	0.1	<0.04	16.8	1.3		
	1.75	26	5.2425	27.2	72.8	80	0.057	29.9	9.6	10.5	9.4	20.3	0.1	<0.04	19.3	0.9		
	8.0	28	5.1850	27.2	72.8	75	0.053	Sample Vial Leaked										
	1.25	29	5.1979	26.9	73.1	130	0.040											
	8.0	55	5.2346	27.4	72.6	40	0.110	47.4	5.4	0.8	8.1	12.0	<0.1	<0.5	23.8	2.4		
	1.25	56	5.2124	Sample Broke During Thawing			0.114	45.7	6.4	0.6	7.1	15.2	<0.1	<0.04	23.7	1.3		
	1.25	57	5.2007	Sample Broke During Thawing			0.100											
	8.0	59	5.1903	Sample Broken During Freezing Process														

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Fig. 1. Condenser pressure during the second test run, September 21 to October 2, 1972.

condenser was isolated from the boiler and allowed to cool to ambient conditions. A sample of gas was then taken from the sample tap at the condenser outlet. Results of the analysis are presented in Table 2.

The condenser and vapor line back to the valve downstream of the boiler separator were then evacuated until the pressure was in the order of 0.003 psia before restarting the test on October 6, 1972. During startup, some difficulty was experienced in trying to get pump No. 1 to maintain the desired flow rate to the boiler. The boiler feed supply was switched to the No. 2 pump in order to continue the test while partially disassembling and examining pump No. 1. Inspection revealed that one of the brushes used to conduct dc current to the electromagnets in the driver assembly was binding in the brush holder. This prevented good contact with the slip ring and consequently reduced the efficiency of the magnetic clutch. After sanding the brush to remove several rough spots, it was reinstalled in the holder and the pump restarted. A check on the performance of the pump showed that it would deliver the necessary head and flow, so the pump was put in the standby condition.

In the meantime, the test facility had operated approximately 70 hr and the condenser pressure had risen to a value about 0.2 psia higher than the pressure experienced after a comparable running time in the previous test. Operating conditions were essentially the same except that pump No. 2 was being used instead of pump No. 1. Although pump No. 2 had been operated previously for short periods of time, it was possible that contaminants could have been trapped in the pump and were now being introduced into the system. A sample of the liquid was taken from the pump recirculation line and the test continued to see if the rate of pressure rise in the condenser would decrease with time.

Approximately 30 hr later while the test facility was being remotely monitored, an alarm was received indicating operating difficulties. Investigation of the alarm showed the following:

1. The flow to the boiler had fallen slowly and set off the low flow alarm even though the No. 2 pump was still operating;
2. The drop in flow rate had continued, and approximately 30 sec later an automatic switch-over to pump No. 1 occurred;

Table 2. Report of Mass Spectrometer Analysis of
Gas Samples Removed from the Condenser of the
1/4-Scale Organic Fluid Decomposition Test

Compound	End of Second Test (%)	End of Third Test (%)
H ₂	82.7	44.3
He	< 0.05	< 0.05
CH ₄	1.2	3.3
H ₂ O	0.6	-
HC (mass 27, 39, 41)	2.0	1.8
N ₂ + CO	8.1	34.6
O ₂	< 0.01	3.7
CO ₂	5.3	1.9
Mass 78 (benzene)	0.1	10.5

3. Although flow to the boiler was reestablished, a shift in system inventory had occurred and there was an excess of liquid in the pump suction line while the liquid level in the boiler vapor separator had been reduced;
4. Approximately 4 hr before the alarm was received the condenser pressure had risen sharply, and, during the 4 hr period, had risen from 0.65 psia to 0.83 psia. A plot of the condenser pressure as a function of time is presented in Fig. 2;
5. When pump No. 2 was restarted, it was very noisy in the front bearing area of the driver assembly.

Inasmuch as the condenser pressure was approaching the upper limit of the pressure transmitter range (1.0 psia) and there was obvious difficulty with pump No. 2, the decision was made to interrupt the test, isolate the condenser from the rest of the system, and investigate the pump problem as well as the sudden increase in condenser pressure.

Inspection of the pump revealed a bad bearing in the motor used to turn the driver assembly and some damage to the hermetically sealed containment can which housed the pump rotary element. The containment can, approximately 9 in. long by 3 1/2 in. in diameter and fabricated from 0.040-in.-thick stainless steel, was found to be scored over several circumferential areas on the can cylindrical surface. Traces of metal were found to be embedded in the driver magnets as well as magnetically attached. Also noted was the bluish discoloration of the stainless steel in the scored areas, which indicated local heating of the metal to the range of 800 to 1000°F. Measurements taken on the containment can showed a maximum of 0.015 to 0.018 in. of material had been removed in the scored areas.

Further examination for the cause of the rubbing showed markings on the recessed face of the adapter flange as well as a bad bearing in the rear of the driver assembly. Play in the bearing, however, was not sufficient to cause the scoring of the containment can, and attention was focused on the cause of the markings on the face of the adapter flange. Further investigation revealed that the weldment joining the containment can to the pump casing was different from the design originally approved, and the lip of the

Fig. 2. Condenser pressure during the third test run, October 6-10, 1972.

containment can extended 0.053 in. above the shoulder on the face of the pump casing flange as shown in Fig. 3. Consequently, the adapter had been resting on the lip of the containment can and had never been properly aligned or seated on the flange of the pump casing.

The pump had been operated by the manufacturer in a water test facility and head-flow data obtained. These data showed the pump to be functional as well as having operating characteristics similar to those of pump No. 1. The small gap between the flanges was not obvious during visual inspection of the unit, and hence the pump and motor assembly had been installed in the test facility in the "as received" condition. During the performance testing of the pump by the manufacturer as well as during the initial check out and test facility operation, the bolts held the adapter in place against the approximately 1/16-in.-thick lip on the containment can and the misalignment was not bad enough to cause trouble. However, when the bearing in the rear of the motor began to fail, the vibration plus the loose fit between the bolts and bolt holes in the adapter flange allowed the adapter, driver assembly, and motor unit to slip and let the driver assembly contact the containment can. The rubbing of the parts not only reduced the pump efficiency but caused local heating of the can and boiling of the liquid in these areas. This latter condition could account for the rapid buildup of non-condensables in the condenser and for the increase in the benzene concentration found in a sample of gas taken from the condenser. A detailed analysis of this gas sample is also shown in Table 2.

In order to avoid opening the Dowtherm portion of the system and to make the minimum alterations that would permit a check to determine whether the damage had occurred to the bearings and/or the rotary element inside the containment can, the inner face of the adapter was machined to relieve it by approximately 1/16 in. This allowed proper alignment and seating of the adapter and driver assembly on the pump casing. A check on the clearance between the containment can and the driver during reinstallation showed it to be between 0.015 in. and 0.020 in.

A performance test of the pump was then undertaken. With the heat block maintaining the boiler tubes around 590°F, the valve in the vapor line downstream of the boiler-separator was opened slightly and vapor flow started to the condenser. The repaired pump (pump No. 2) was then started and the

ORNL DWG 73-1861

Fig. 3. Actual weldment and assembly of pump as received from the manufacturer. This shows how the weld prevented proper seating and alignment of the driver assembly.

valve in the liquid line upstream of the flowmeter opened to allow liquid flow to the boiler. For approximately one minute the pump provided a flow of 0.15 gpm to the boiler. The flow rate then started to drop and within a matter of seconds the indicated flow fell to zero and then rose to around 0.2 gpm. At the same time, even though the pump was still running, temperatures along the boiler feed line rose sharply starting at the boiler inlet and progressing back to the pump. The block valve in the liquid line was then closed and the pump No. 2 was turned off. Investigation also showed the temperature at the pump discharge had increased indicating that the liquid was being heated in the pump.

The failure of pump No. 2 to supply the necessary head to deliver feed to the boiler indicated damage had occurred inside the containment can and we were faced with the decision to: (1) operate the system with the remaining pump, or (2) open the pump and attempt to repair the damage. Contact with the pump manufacturer indicated the possibility of a minimum of 12 weeks to obtain the necessary containment can and any other parts that might be needed.

The two alternatives were presented to the Navy and AEC representatives in a meeting on November 9, 1972. At this time we were told to wait until an "Incident Report" which had been sent to RDT in Washington on November 6, 1972, could be reviewed and a decision made. On November 27, 1972, word was received from the AEC in Washington that we were to operate the system on the remaining pump. However, before starting the system, pump No. 1 was to be inspected to assure that the same difficulty did not exist in this pump. Also a letter was to be written to the pump manufacturer informing him of his failure to make the pump according to the approved design. Although pump No. 1 had been examined previously, the adapter driver assembly and motor were removed and the containment can-to-pump casing weldment re-inspected. This weldment was found to be made according to the approved design.

On November 30, 1972, the vapor lines and condenser were again evacuated, and the system restarted with the boiler at 590°F. The block valve downstream of the boiler-separator was opened, the boiler feed pump started, and the throttling valve between the pump and boiler adjusted to provide a flow of approximately 0.15 gpm. Within 5 min after the above conditions

were established, the distinctive odor of Dowtherm was noted and an inspection of the high pressure part of the system was made to check for a leak. When insulation was removed from around the flowmeter a leak was found in the soft soldered joint downstream of the flowmeter. There was also evidence of soft solder on the insulation removed from around the flowmeter. The leak, although small (of the order of $0.5 \text{ cm}^3/\text{hr}$ at operating conditions), was large enough that a long term test could not be undertaken safely, and the system was again shut down to try and determine the cause for the leak as well as determine a method for repairing the leak. Power to the heat block-shield was also reduced to lower the pressure in the boiler and boiler feed line and thus reduce the amount of leakage.

Soft soldered joints, one on either end of the flowmeter, were found to be the source of the leak. These joints were used because no vendor could be found who would provide a flowmeter in the range of 0 to 1.0 gpm with other than flanged or screwed ends. Also, the flowmeter obtained had material which, according to the sales representative, should not be heated above 575°F .

A sample of the soft solder used on the flowmeter assembly was obtained from the fabrication shop and although the manufacturer's data showed the melting range was 360°F to 420°F , our tests showed the solder would flow on a vertical surface, due to gravity, when the temperature reached 200°F to 220°F . As a result of this test, a review was made of the operating conditions when during the check out of the No. 2 boiler feed pump a backflow of liquid was observed from the boiler. Although a thermocouple was not attached to the flowmeter assembly, evidence from other thermocouples located on the boiler feed line indicate the temperature would have reached 250°F and would have remained at this temperature for several minutes after the valves were closed and flow of the liquid stopped. This information along with the test data on the soft solder has led to the conclusion that the leak was caused by the condition which occurred while the test was being made on the No. 2 boiler feed pump.

Repair of the leak with the flowmeter assembly in place was not practicable, hence it was decided to remove the assembly and make the repairs using a higher temperature soft solder. In an effort to minimize the amount of air introduced into the system, the boiler pressure was reduced

and the flowmeter assembly isolated from the remainder of the system by a valve upstream of the assembly and by freezing the line with liquid nitrogen downstream of the assembly. Following the removal of the flowmeter assembly, the ID of the tubing for approximately 6 in. on either side of the cut was cleaned with alcohol and clean swabs to prepare for welding the repaired assembly back into the system.

After removing the pipe extensions from the ends of the flowmeter, all parts were thoroughly cleaned with alcohol before attempting to make any repairs. The threaded ends of the flowmeter extensions (1/2 sch. 40 pipe) were then tinned with a 50-50 soft solder (457-550°F melting point). The flowmeter was placed between copper chill blocks and the threaded ends also coated with the same soft solder. Inspection of the flowmeter after this step revealed no obvious difficulty with the bearings and the pipe extensions were screwed onto the flowmeter. The flowmeter was again placed between the copper chill blocks and the joints heated to melt the solder. After cooling and recleaning, the entire assembly was then helium leak-checked before the assembly was reinstalled in the system.

The amount of air introduced into the system while making the repair was small. However, when the boiler temperature was again brought to 600°F and flow was established, the condenser pressure rose rapidly and within 3 hr had risen from 0.03 psia to about 1.0 psia. The boiler was isolated and the rest of the system cooled to enable the condenser to be evacuated. A second attempt to operate the system again showed an increase in the condenser pressure but the rate was somewhat slower.

The boiler temperature was then decreased to establish natural convection operation of the system for the period of December 22, 1972 through January 1, 1973 to see if a continued increase in the condenser pressure would occur under these conditions.

3.0 THERMOELECTRIC SYSTEM

Thermoelectric Module

The final report on this phase of the program has been written, reviewed internally, and submitted to Washington for final review.

Phase II Heat Pipe Test

Fabrication of parts for the Phase II heat pipe test has been completed.

The three heat pipes scheduled to be tested before the full-scale meltdown test were given a preliminary treatment to activate the internal potassium purification systems. Each pipe was operated at about 1240°F for 117 hours. After the preliminary treatment, the temporary cleanup systems, located in the heat pipe fill tubes, were removed and the fill tubes sealed and welded.

The instrumentation and heaters have been installed on the test block for the Phase II heat pipe tests. The installation should be completed early in the next quarter.

4.0 THERMAL FUSE AND INSULATION

The assembly of the 1/4-scale insulation test rig was completed in October and the system was heated and purged with argon in preparation for testing. The heat block was heated to about 200°F and held there while the system was pumped by a vacuum pump for 26 hr and then purged for 32 hr with argon with a pressure of 6 psig in the tank. The moisture content was measured at this point and was found to be 23 ppm with the block at 200°F. A gas sample was taken for analysis and the oxygen content was found to be < 1 ppm. The gas composition was considered satisfactory to begin heating to a temperature of about 800°F for the first point of the thermal conductivity test.

Tests of the aluminum insulation specimen in the horizontal position in the 1/4-scale insulation test rig were conducted in November. Thermal conductivity measurements were taken at two temperature levels in argon at 15.4 psia. The results of the tests are shown in Fig. 4. The data for the horizontal test is about 25% higher than for the vertical test. This is thought to be largely due to a difference in the assembly procedure for the test specimen. The expanded stainless steel sheet on the outside of the horizontal test specimen was pulled down tighter on the aluminum screen than before, causing wrinkling of the screen material and compaction of the insulation matrix.

Fig. 4. Thermal conductivity as a function of the mean insulation temperature for the combined aluminum foil-screen insulation in Argon at 15.4 psia.

Block surface temperatures taken during the meltdown test are shown in Fig. 5. The upper side of the block reached a maximum temperature of 1640°F and the lower side reached 1517°F . The central fuel element in the full-scale heat block would probably be affected by an average of these temperatures, or about 1580°F . This should yield a surface temperature of about 2150°F on the central fuel element for the loss-of-cooling accident in the horizontal position.

The meltdown test was terminated after 19 hr by a heater failure which shorted out one entire circuit of two heaters so that the load could not be shifted from the failed heater to the other in its circuit. The block temperatures had reached a maximum value before the failure, however, so that only slightly lower temperatures would have occurred at longer times.

The vacuum tank was opened and the insulation specimen was removed for examination. The most interesting result was that none of the molten aluminum from the upper half of the insulation had run down on the heat block. Instead it ran around the inner circumference of the remaining insulation material and accumulated in the lower half of the specimen. The molten aluminum formed a puddle that was slightly above the inner liner of expanded stainless steel on the lower side. The higher temperatures measured on the upper side of the heat block probably resulted from the unmelted debris of aluminum oxide that was left behind on the expanded stainless steel liner after the molten aluminum ran around the screen to the lower side. The lower side of the heat block apparently ran cooler because the molten aluminum provided a path for heat removal with a higher thermal conductivity than that of the unmelted debris left behind on the upper side.

The appearance of the unmelted material was very similar to that found in the previous test, therefore material from this test was not subjected to a chemical analysis.

The first draft of the final report on the insulation development program has been written and internal review should be completed early in 1973.

5.0 FULL-SCALE FUSIBLE INSULATION EVALUATION TEST

The bottom extension plate and the deflector were added to the heat block-shield. To protect the block and the support skirt from molten

Fig. 5. Block surface temperature vs. time for the horizontal meltdown test.

aluminum, the heat block-shield including the skirt and the deflector was painted with a silicone base ceramic paint, PT-404-A, obtained from Product Techniques, Inc.

After the paint was applied, the heat block-shield was heated with 34 kW to bake out the coating. The temperatures of the system were measured during this process. The measured values of the radial temperature distribution compared to the values obtained before painting are shown in Fig. 6. The surface temperature decreased approximately 30°F as a result of the improvement in the surface emissivity resulting from the high emissivity of the paint. The peak surface temperature of the heater can decreased approximately 80°F. The decrease stems from two major factors. First, approximately 35°F can be attributed to the decrease in surface temperature, and, secondly, approximately 45°F is attributed to an approximately 0.005 in. decrease in the hole diameter attributed to stress shrinkage resulting from the previously performed loss-of-coolant accident test.

The wrapping of the aluminum screen and foil onto the inner expanded metal liner was completed during the month. The assembly of the insulation should be completed by the second week in January.

6.0 FUEL CAPSULE TESTS

The welding and loading operations on the dummy fuel capsules being fabricated for acceptance tests were completed. The capsules will undergo initial dimensional inspection and heat treatment during the first week of January. Capsule 1 will be shipped to David Taylor Model Basin at the end of the first week in January.

Fig. 6. Comparison of heat block-shield radial temperature distribution before and after painting of the surface with PT-404-A silicone base ceramic paint.

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