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Advanced Energy Systems Division

Spent Fuel Dry Storage Technology Development: THERMAL EVALUATION OF SEALED STORAGE CASK CONTAINING SPENT FUEL

P.F. Schmitten
J.B. Wright

Prepared For
THE UNITED STATES DEPARTMENT OF ENERGY
Contract No. DE-AC08-76NVOO597

AUGUST 1980

Westinghouse Electric Corporation
Advanced Energy Systems Division
P.O. Box 10864
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C.A. Holder P.S. Sherba
W.L. Lundberg R.Unterzuber

ABSTRACT

The spent fuel Sealed Storage Cask (SSC) Test is presently being conducted at the Engine-Maintenance, Assembly and Disassembly (E-MAD) facility on the Nevada Test Site. A pressurized water reactor spent fuel assembly was encapsulated inside the E-MAD Hot Bay and placed in a instrumented above surface storage cell during December 1978 for thermal testing. The fuel assembly was sealed inside a stainless steel canister and attached to a concrete filled steel shield plug. The canister assembly was then placed in a carbon steel liner which is encased in a reinforced concrete shield cask. The SSC was then transferred outside to a foundation pad adjacent to E-MAD.

Instrumentation provided to measure canister, liner and concrete temperatures consisted of thermocouples which were inserted into tubes on the outside of the canister and liner and in three radial positions in the concrete. Temperatures from the SSC test assembly have been recorded throughout the past 16 months. Canister and liner temperatures have reached their peak values of 200°F and 140°F, respectively.

A computer model was developed to predict the thermal response of the test configuration. Computer predictions of the transient and steady-state temperatures of the SSC components and surrounding concrete are presented and they show good agreement with the test data.

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1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

The purpose of this report is to provide a test description, test results, and the conclusions for the spent fuel Sealed Storage Cask (SSC) Test performed at the E-MAD facility on the Nevada Test Site. This test was conducted as part of the Spent Fuel Handling and Packaging Program (SFHPP) 1978 Demonstration (further discussed in Section 1.3). The primary test objective was to confirm by actual testing that commercial reactor spent fuel could be passively stored in an above ground storage cell at the Nevada Test Site.

The SSC Test was begun on December 7, 1978 when a pressurized water reactor (PWR) spent fuel assembly was placed into an SSC and transferred to a storage pad near the E-MAD facility. The test hardware (shown in Figure 1) consisted of an instrumented carbon steel liner, an instrumented stainless steel canister (containing the spent PWR fuel assembly), a concrete-filled shield plug which supported the canister from the top of the liner and an instrumented reinforced concrete shield. Throughout the test period, temperature readings from thermocouples on the canister, liner and in the concrete were recorded. Strain gages were also embedded in the concrete shield and were recorded during the test period. Interpretation of the strain gage data is not included in this report. A finite difference computer model (described in Section 6.0) was developed to predict SSC and canister transient and long term temperatures. Comparisons of the analytical predictions with the test data are presented in Section 7.0.

1.2 ORGANIZATION OF REPORT

This report is organized to present the SSC Test and its results in the following order:

- Introduction (including background of Spent Fuel Handling and Packaging Program 1978 Demonstration)

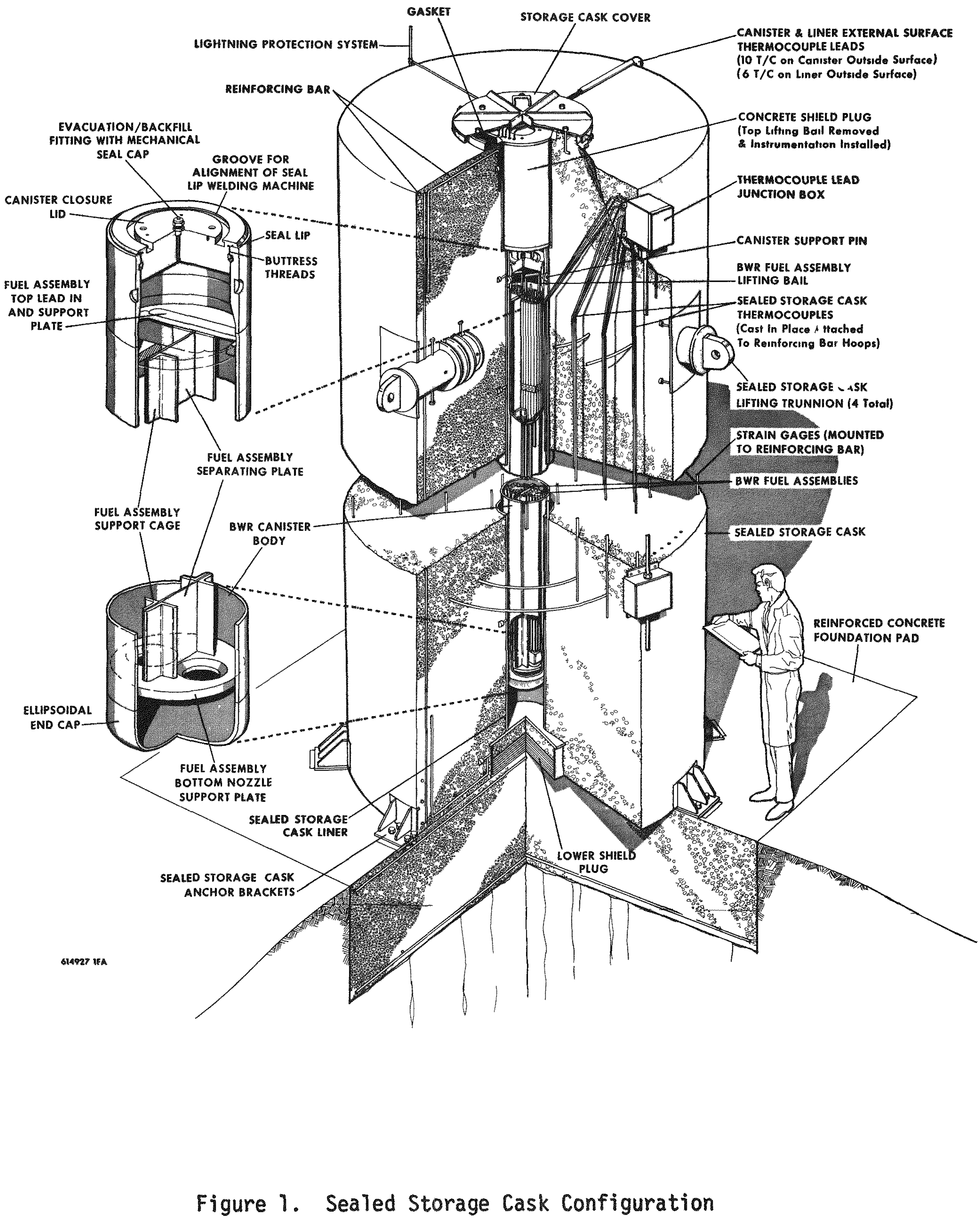

Figure 1. Sealed Storage Cask Configuration

- Conclusions drawn from the test results
- Test objectives
- Test hardware description
- Test operation and results
- Thermal model description
- Comparison of test results with model predictions

1.3 BACKGROUND

The SSC Test described in this report is being conducted as part of the Spent Fuel Handling and Packaging Program (SFHPP) 1978 Demonstration. The objective of the SFHPP 1978 Demonstration was to develop the capability to encapsulate typical spent fuel assemblies from commercial nuclear power plants and to establish by testing the suitability of one or more surface and near-surface concepts for the interim dry storage of the encapsulated fuel assemblies.

The E-MAD (Engine-Maintenance, Assembly, and Disassembly) facility, constructed at the Nevada Test Site as part of the Nuclear Rocket Development Station, was chosen as the location for this demonstration because of its extensive existing capabilities for handling highly radioactive components and because of the desirable site characteristics for the proposed storage concepts. The E-MAD facility, operated for the Department of Energy by the Advanced Energy Systems Division of the Westinghouse Electric Corporation, is described in more detail in Reference 1.

Near surface and above surface storage concepts were chosen for testing during the SFHPP 1978 Demonstration. Each storage cell is designed to accommodate one canister, and the canister is designed to contain either one PWR fuel assembly or two boiling water reactor (BWR) fuel assemblies. The near surface storage concept or drywell, Reference 2, consists of a steel liner grouted into a shallow hole drilled in the alluvial soil at the E-MAD facility. A sealed canister containing the fuel assembly in a helium atmosphere is suspended from a shield plug which in turn is supported by a step in the liner. The above ground storage concept, Sealed Storage Cask (SSC), is shown in Figure 1. A steel liner similar to that used in the drywell is encased in a reinforced concrete silo, and the canister/shield plug package is supported in the liner in the same manner as in the drywell. In both of these storage systems, the decay heat of the fuel assembly is passively dissipated to the environment. Encapsulation of the fuel assemblies was performed inside the shielded Hot Bay of the E-MAD facility. The drywell and SSC storage cells were constructed in an area adjacent to the facility.

An overriding requirement for the SFHPP 1978 Demonstration Program was that the spent fuel storage system and associated activities not result in an undue risk to the public, property, environment, or site employees. One means of assuring that this requirement would be met was to maintain the leak tight integrity of the fuel cladding and the canister. Because high temperature can affect the long term integrity of both of these barriers to fission product release, thermal considerations were an important concern in the design of the storage cells. Preliminary analyses performed by the Hanford Engineering Development laboratory (HEDL) established 715°F (380°C) as the fuel cladding temperature limit below which fuel cladding integrity would be maintained in a helium environment for long storage times (100 years). Scoping thermal analysis of the storage cell concepts indicated that cladding temperatures reached in the SSC would be well below the limit for the fuel assembly decay heat levels being considered.

The storage cell experiments consisted of encapsulating spent fuel assemblies and placing them in storage with thermocouple instrumentation on the exterior of the fuel storage canister and throughout the storage cell. The fuel assemblies selected were characteristic of high burnup (25,000 MWD/MTU) fuel assemblies approximately three years out of the reactor with a thermal power level of approximately 1.25 kW. Fuel encapsulations were performed at E-MAD during December 1978 and January 1979. An encapsulated PWR assembly was placed in a Sealed Storage Cask on December 7, 1978 and two other encapsulated PWR fuel assemblies were placed in drywells on January 12 and 24, 1979. These experiments are still in progress. The on-going SSC test is the subject of this report.

2.0 CONCLUSIONS

The following conclusions can be drawn from the results of the SSC test:

1. The peak measured canister temperature for an encapsulated PWR spent fuel assembly with an initial decay heat level of 1.1 kW stored in an SSC configuration at the Nevada Test Site was 201°F. The peak concrete temperature adjacent to the liner was 141°F.

2. Seasonal variations in ambient air temperatures and solar radiation have a significant effect on the canister temperature. The peak canister temperature is in the order of 115°F above the average monthly ambient temperature (yearly range is 37°F to 83°F).

3. Day-night variations in ambient air temperature are essentially damped out within the first 15 inches of concrete.

4. The computer thermal model provides predictions of the concrete temperature distribution in close agreement with the test data.

3.0 TEST OBJECTIVES

As originally planned, the objectives of the spent fuel SSC Test were 1) to verify that spent fuel assemblies can be safely stored with passive cooling and 2) to determine storage cell thermal properties and interface and boundary conditions to calibrate and verify thermal models.

The test objectives would be met by a combination of actual test results and calibrated computer model predictions. An encapsulated spent fuel assembly would be installed into an SSC and the temperatures in the canister, liner and surrounding concrete recorded. In addition, a computer model of the SSC would be prepared for comparison with the test results. The SSC model and an existing fuel rod thermal model would be used to evaluate SSC performance beyond the limits of the test. The maximum canister temperature level attained would be compared with predicted peak canister and peak fuel cladding temperatures to evaluate SSC performance.

Transient test results would be compared to computer code predictions using the thermal power versus time predicted for the actual spent fuel assembly as input. Computer model thermal property and heat transfer correlation revisions would be made as necessary to update the model for good model/test agreement. Good agreement between computer model predictions and test data will qualify the computer model for use in evaluation of storage of various power decay heat level fuel assemblies.

4.0 TEST HARDWARE DESCRIPTION

4.1 TEST ARRANGEMENT

The SSC Test hardware arrangement is shown in Figures 1, 2 and 3. The test hardware consists of 1) a carbon steel liner encased in a transportable reinforced concrete shield, 8 feet 8 inches in diameter and 21 feet high, 2) a 16 by 16 feet by 3 feet 10 inches deep reinforced concrete foundation pad, 3) a canister assembly consisting of a canister body, closure lid and a concrete filled shield plug which supports the canister from the top section of the liner, 4) a spent fuel assembly, 5) an array of thermocouple instrumentation to measure temperature response and 6) a data acquisition system to record the thermocouple data. Photographs of the SSC Test hardware and its construction are shown in Figures 4, 5 and 6.

4.2 SSC LINER

The SSC liner is illustrated in Figure 2 and 3. The liner consists of three sections. The center section of the liner consists of a 17 foot long section of 18 inch diameter by 0.375 inch wall pipe. The upper section of the liner is manufactured from a 34 inch long, 22 inch diameter, 0.75 inch wall pipe. The upper and center sections of the liner are positioned concentrically to one another and welded to opposite sides of a 22 inch outside diameter, 17.25 inch inside diameter, 0.50 inch thick ring. This ring forms the ledge on which the 20 inch diameter shield plug (which is connected to the canister assembly) is supported. The lower section is 44 inches in diameter and 14 inches long. This section provides added protection as the cask is transported and contains 7 inches of steel plate and 6 inches of concrete. Welded to the upper section is a tapered entry flange which is notched at two opposite places for routing of canister instrumentation to the SSC external junction boxes. The liner material is carbon steel.

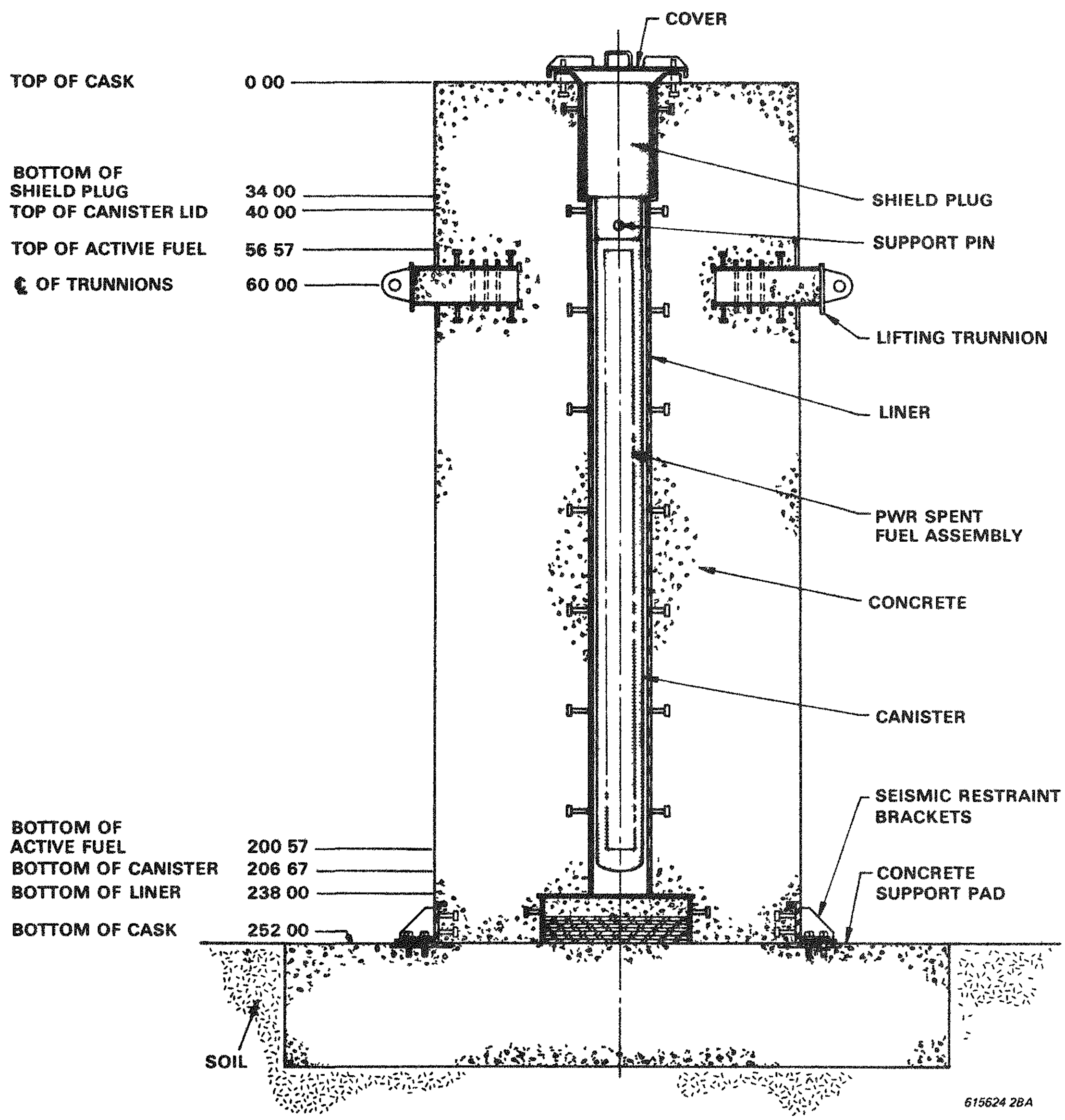

Figure 2. SSC Schematic

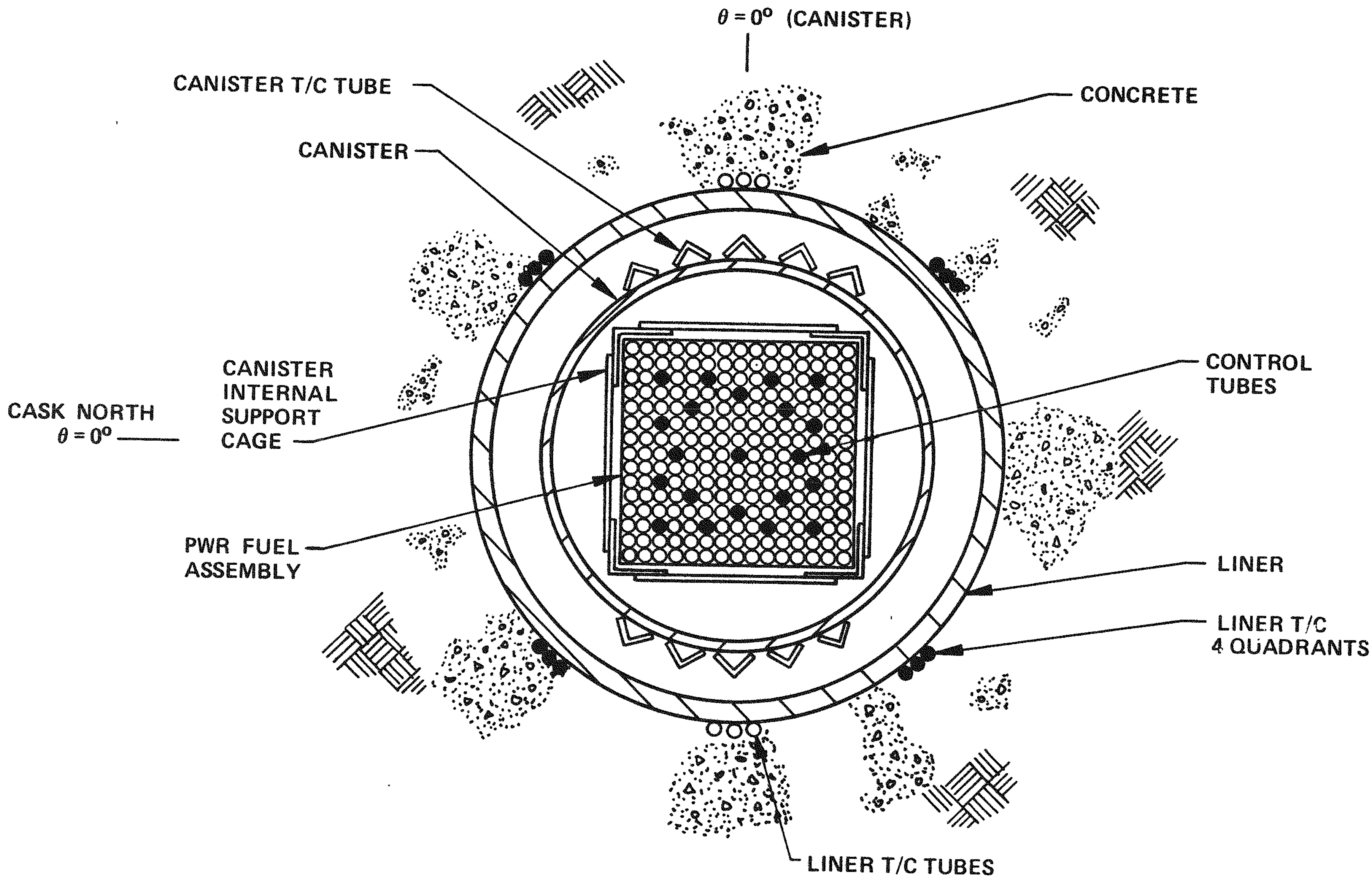

Figure 3. SSC Liner Section View

4.2.1 INSTRUMENTATION

Six tubes, 0.156 inch outside diameter and 0.086 inch inside diameter are attached to the outside of the liner and serve as thermocouple wells. The six tubes extend from the top of the liner to about 2 inches from the lower section of the liner. The tubes are clamped onto the liner by 11 large adjustable band clamps.

The thermocouple tubes are oriented around the liner in two groups as shown in Figures 3. The two groups each contain three tubes that are spaced 180° apart. The tubes allow thermocouple installation at any elevation. The ends of the tubes are swaged and tackwelded to prevent concrete from filling the tubes during SSC construction. The installed elevation of the thermocouples in the tubes is controlled by the thermocouple length. The thermocouples are inserted until the transition boot between thermocouple and extension lead (see Section 4.7) contacts the top of the tube thus controlling the position of the thermocouple tip. The thermocouples are installed in each group of tubes so that there is one positioned at the middle of the PWR fuel assembly active fuel length, another one foot above the bottom of the active fuel and the other one foot below the top of the active fuel. These thermocouple positions line up with thermocouple positions on the canister. During the construction phase of the SSC, twelve additional thermocouples were attached to the outside of the liner with epoxy cement and banding straps. The thermocouples are oriented around the liner in four equally spaced groups as shown in Figure 3. The elevations of the thermocouples are the same as described above. Table 1 provides depth and angular position data for the installed liner thermocouples.

4.2.2 LINER INSTALLATION

The liner is an integral part of the SSC concrete shield. Four peripheral Nelson studs equally spaced at 8 elevations assure interface integrity with the concrete. The liner is shown in Figure 4 prior to shipment and during placement of surrounding re-inforcing bar in Figures 5 and 6.

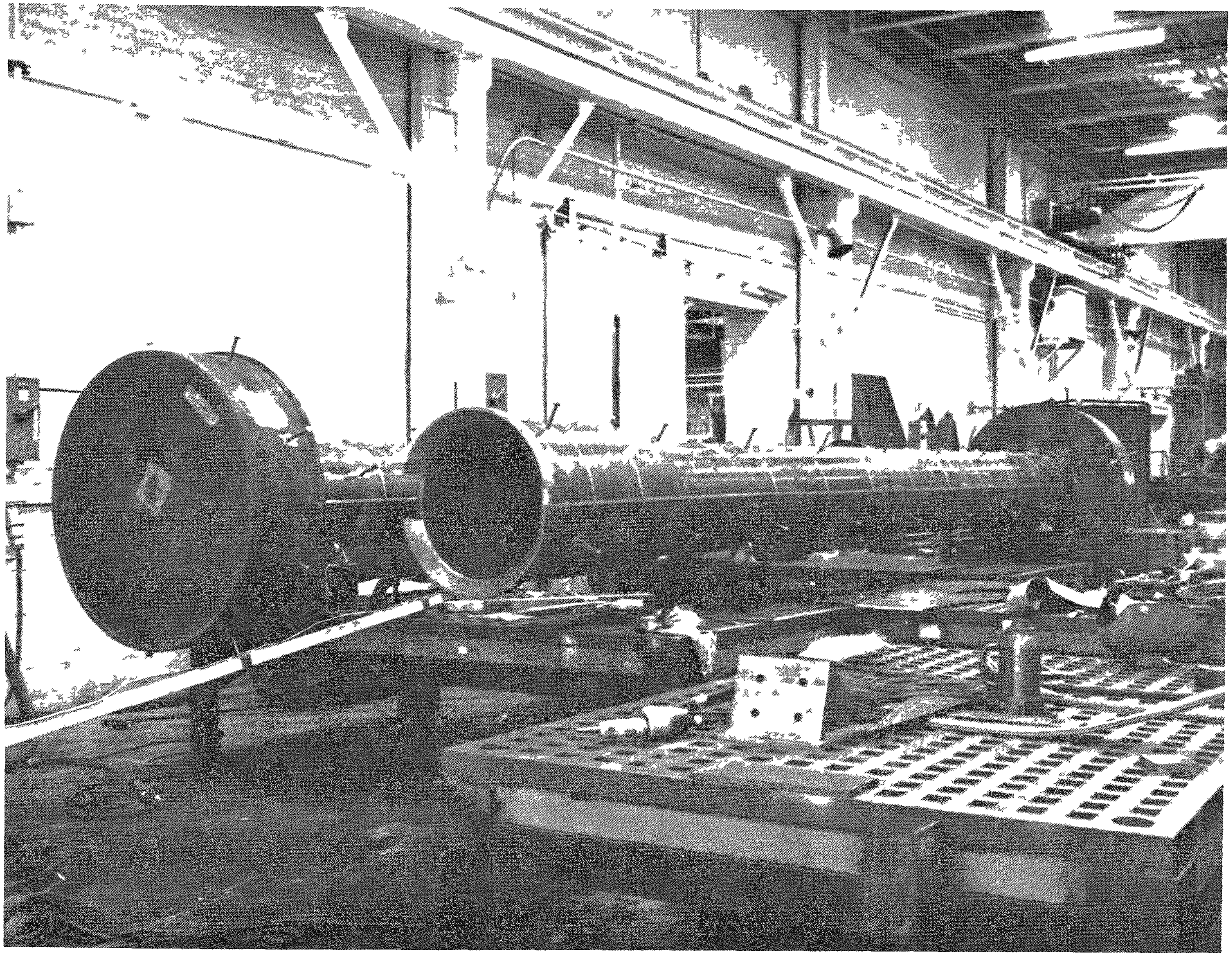

Figure 4. Sealed Storage Cask Liners Prior to Shipping

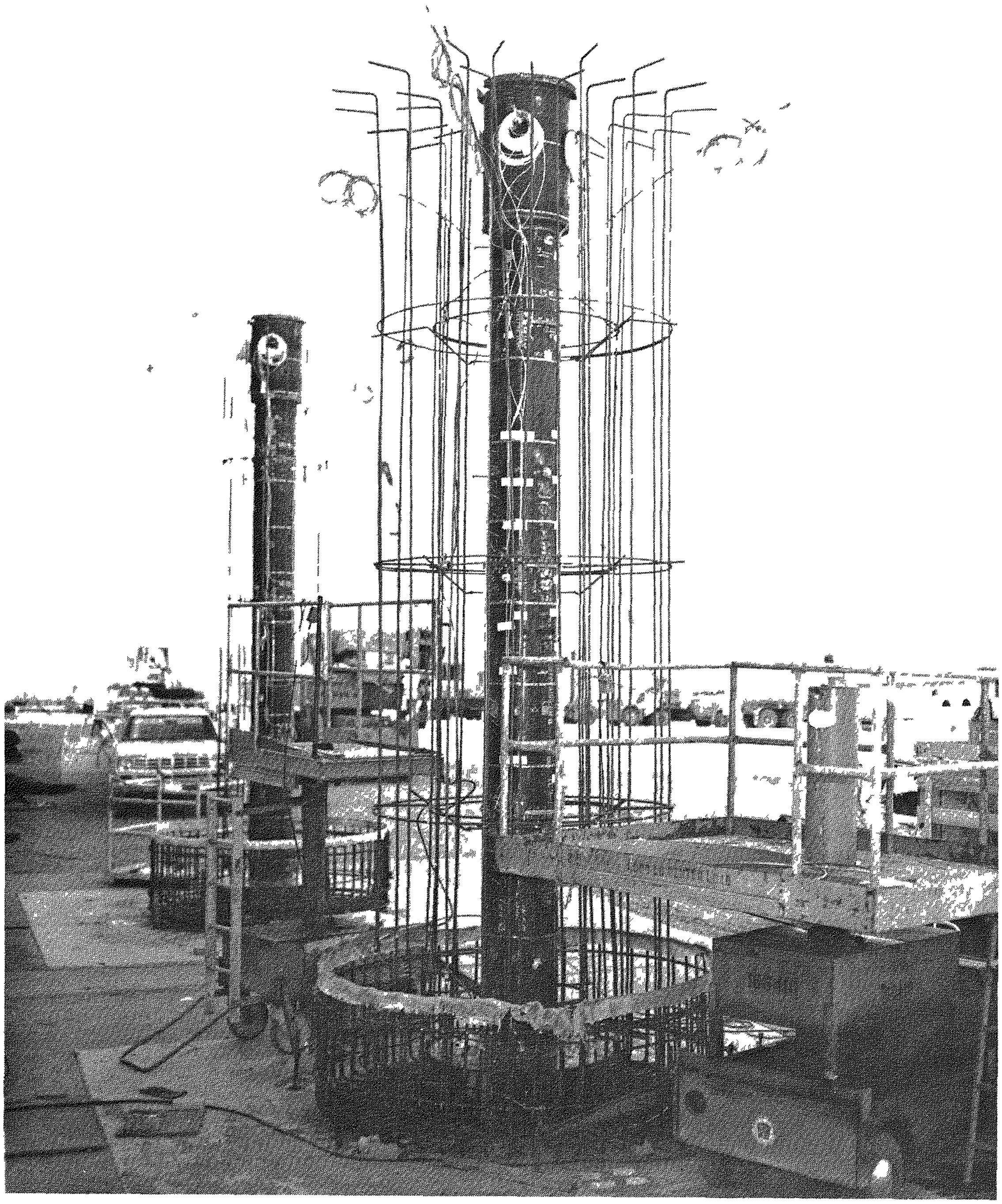

Figure 5. Sealed Storage Cask Liners on Pads During Rebar Installation

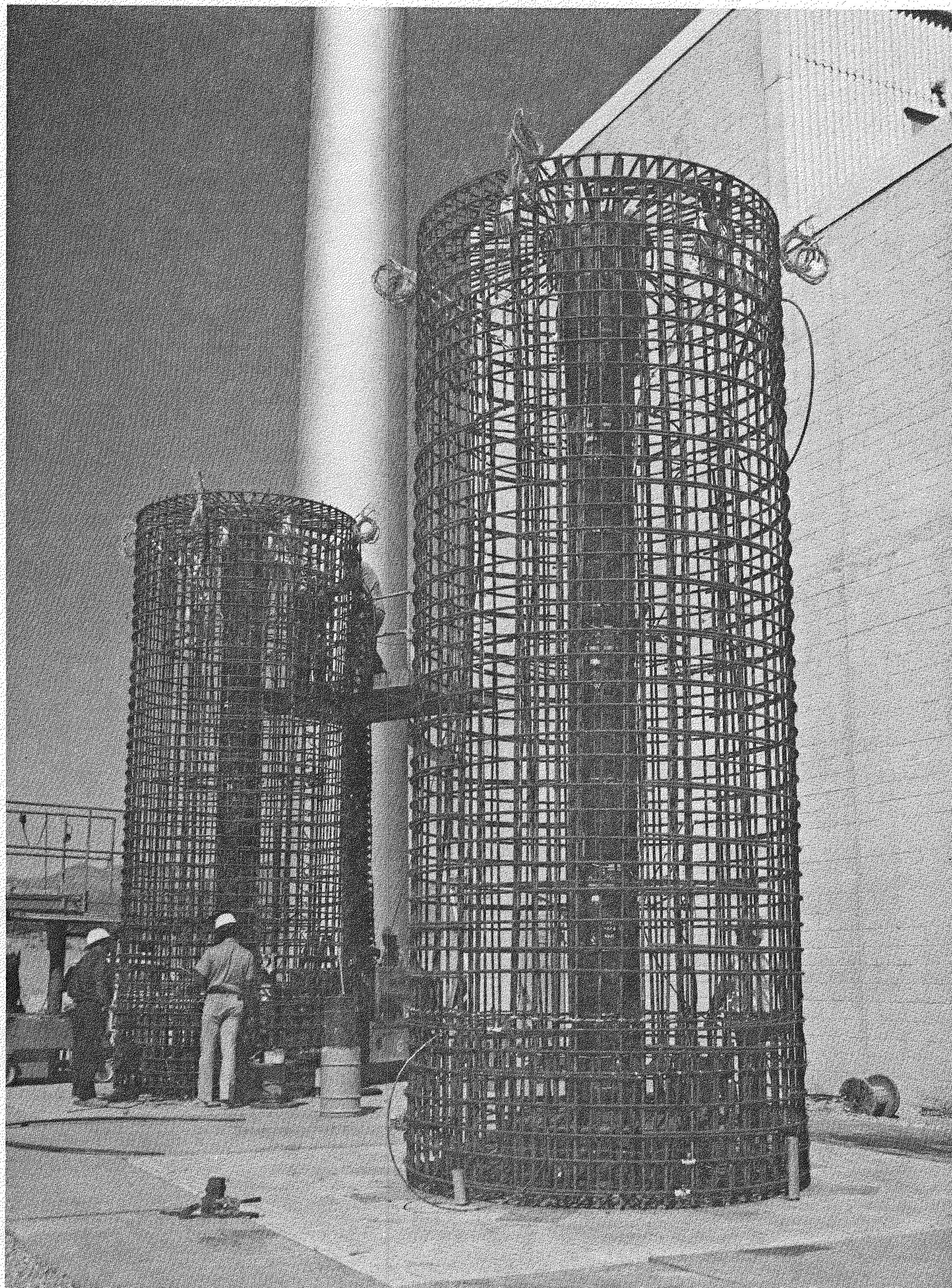

Figure 6. Sealed Storage Cask Rebar Installation Completed Prior to Concrete Pouring

TABLE 1

SSC-2 THERMOCOUPLE LOCATIONS

T/C No.	Distance Below Top of SSC (in.)	Radius (in.)	Orientation* (Degrees)	Location
620	68.5	9	45	Liner
621	68.5	23	45	Cask Concrete
622	68.5	37	45	Cask Concrete
623	68.5	50	45	Cask Concrete
624	128.5	9	45	Liner
625	128.5	23	45	Cask Concrete
626	128.5	37	45	Cask Concrete
627	128.5	50	45	Cask Concrete
628	188.5	9	45	Liner
629	188.5	23	45	Cask Concrete
630	188.5	37	45	Cask Concrete
631	188.5	50	45	Cask Concrete
632	68.5	9	135	Liner
633	68.5	23	135	Cask Concrete
634	68.5	37	135	Cask Concrete
635	68.5	50	135	Cask Concrete
636	128.5	9	135	Liner
637	128.5	23	135	Cask Concrete
638	128.5	37	135	Cask Concrete
639	128.5	50	135	Cask Concrete
640	188.5	9	135	Liner
641	188.5	23	135	Cask Concrete
642	188.5	50	135	Cask Concrete

*Azimuth orientation is from North = 0° clockwise

TABLE 1 (CONTINUED)

SSC-2 THERMOCOUPLE LOCATIONS

T/C No.	Distance Below Top of SSC (in.)	Radius (in.)	Orientation* (Degrees)	Location
643	188.5	37	135	Cask Concrete
644	68.5	9	225	Liner
645	68.5	23	225	Cask Concrete
646	68.5	37	225	Cask Concrete
647	68.5	50	225	Cask Concrete
648	128.5	9	225	Liner
649	128.5	23	225	Cask Concrete
650	128.5	37	225	Cask Concrete
651	128.5	50	225	Cask Concrete
652	188.5	9	225	Liner
653	188.5	23	225	Cask Concrete
654	188.5	37	225	Cask Concrete
655	188.5	50	225	Cask Concrete
656	68.5	9	315	Liner
657	68.5	23	315	Cask Concrete
658	68.5	37	315	Cask Concrete
659	68.5	50	315	Cask Concrete
660	128.5	9	315	Liner
661	128.5	23	315	Cask Concrete
662	128.5	37	315	Cask Concrete
663	128.5	50	315	Cask Concrete
664	188.5	9	315	Liner
665	188.5	23	315	Cask Concrete
666	188.5	37	315	Cask Concrete
667	188.5	50	315	Cask Concrete

TABLE 1 (CONTINUED)

SSC-2 THERMOCOUPLE LOCATIONS

T/C No.	Distance Below Top of SSC (in.)	Radius (in.)	Orientation* (Degrees)	Location
668	68.0	9	270	Liner
669	68.0	9	90	Liner
670	128.0	9	270	Liner
671	128.0	9	90	Liner
672	188.0	9	270	Liner
673	188.0	9	90	Liner
674	68.0	7	240	Canister
675	68.0	7	60	Canister
676	98.0	7	255	Canister
677	98.0	7	75	Canister
678	128.0	7	270	Canister
679	128.0	7	90	Canister
680	158.0	7	285	Canister
681	158.0	7	105	Canister
682	188.0	7	300	Canister
683	188.0	7	120	Canister

4.3 CANISTER ASSEMBLY

The canister assembly consists of a canister body, closure lid and a shield plug. An illustration of the details of the canister assembly is shown in Figure 7, an illustration of the closure lid is shown in Figure 8, and illustrations of the shield plug and its attachment to the canister body are shown in Figures 9 and 10. The canister described below was designed to accommodate one Turkey Point Reactor PWR spent fuel assembly.

4.3.1 CANISTER BODY

The main body of a PWR canister is a standard 14 inch outside diameter, 0.375 inch wall, 154 inches long 304 stainless steel pipe. Welded to the bottom of this pipe is a standard 14 inch diameter, 6.5 inch high ellipsoidal end cap. This end cap has welded into it a cruciform formed of 0.75 inch 304 stainless steel plate. This cruciform supports the bottom of a PWR fuel assembly and acts as a loosely toleranced keyed assembly for the fuel assembly bottom nozzle.

The top of the PWR canister body consists of a section of 14 inch outside diameter, 0.937 inch wall, 304 stainless steel pipe approximately 9 inches long. This section is welded to the 0.375 inch thick main body pipe and contains machined threads which mate with the closure lid. The outside upper surface of the canister body contains 4 blind holes equally spaced around the pipe circumference for the attachment of the shield plug. Two 0.75 inch square bars (keys) are welded to the outside of the canister body to support the canister during remote operations and to align the shield plug so that instrumentation tubes are in the proper orientation.

Welded to the inside of the PWR canister body is a fuel assembly support cage formed of standard 2.0 inch by 2.0 inch by 0.18 inch thick 304 stainless steel angles tied together on four sides at six elevations by thin plates. This cage provides lateral support for the entire length of the PWR fuel assembly.

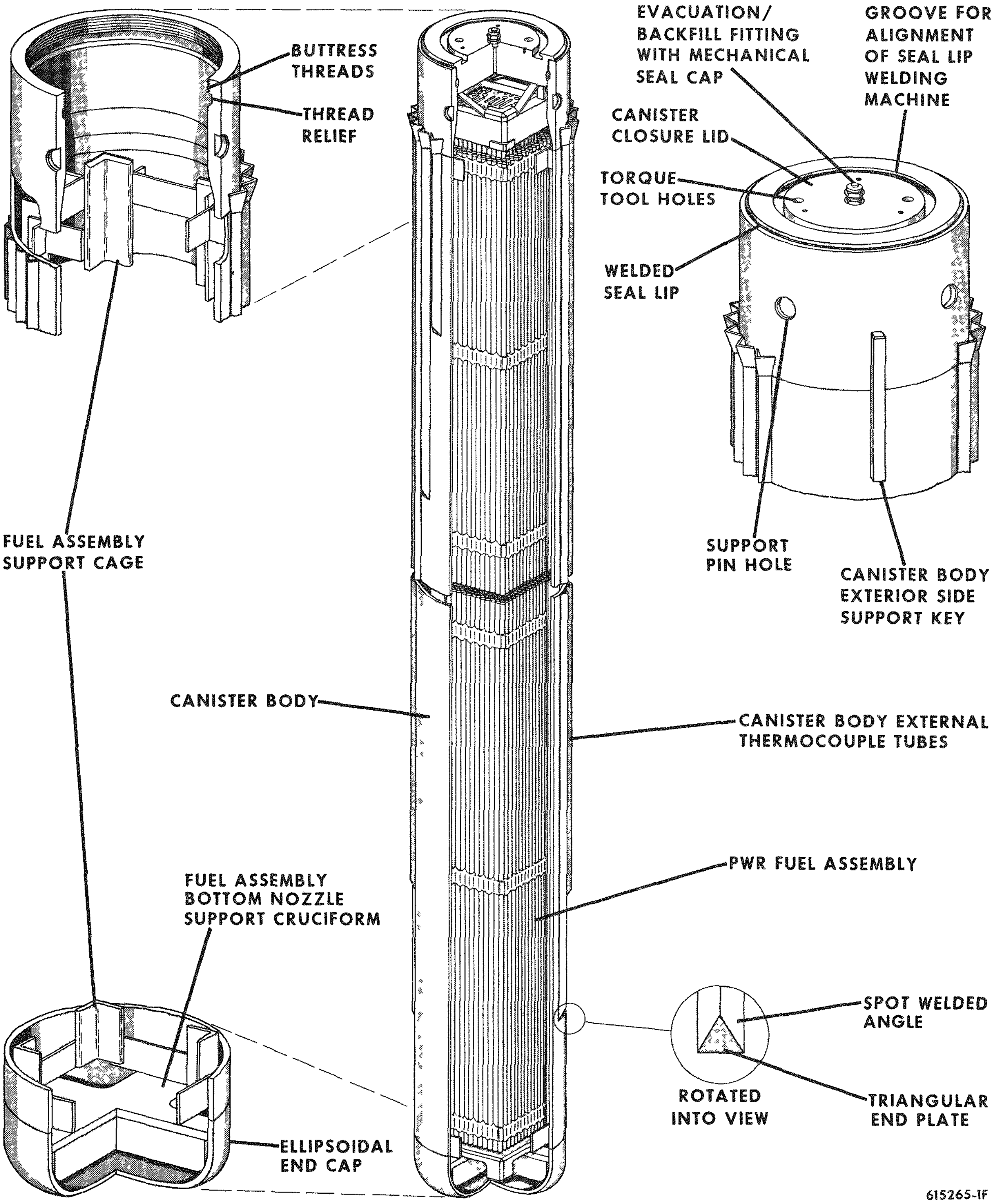

Figure 7. Canister Configuration

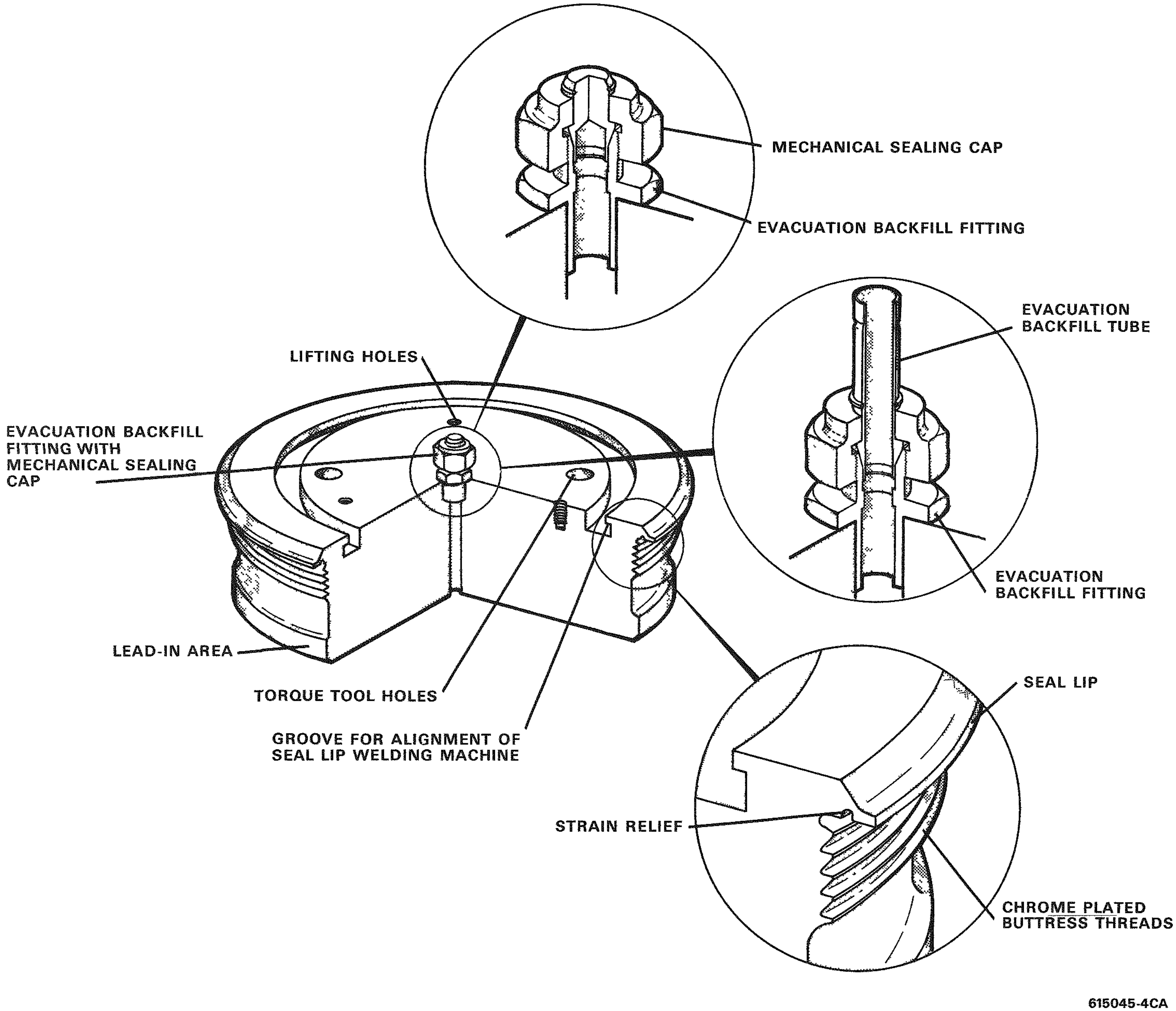

Figure 8. Canister Closure Lid Configuration

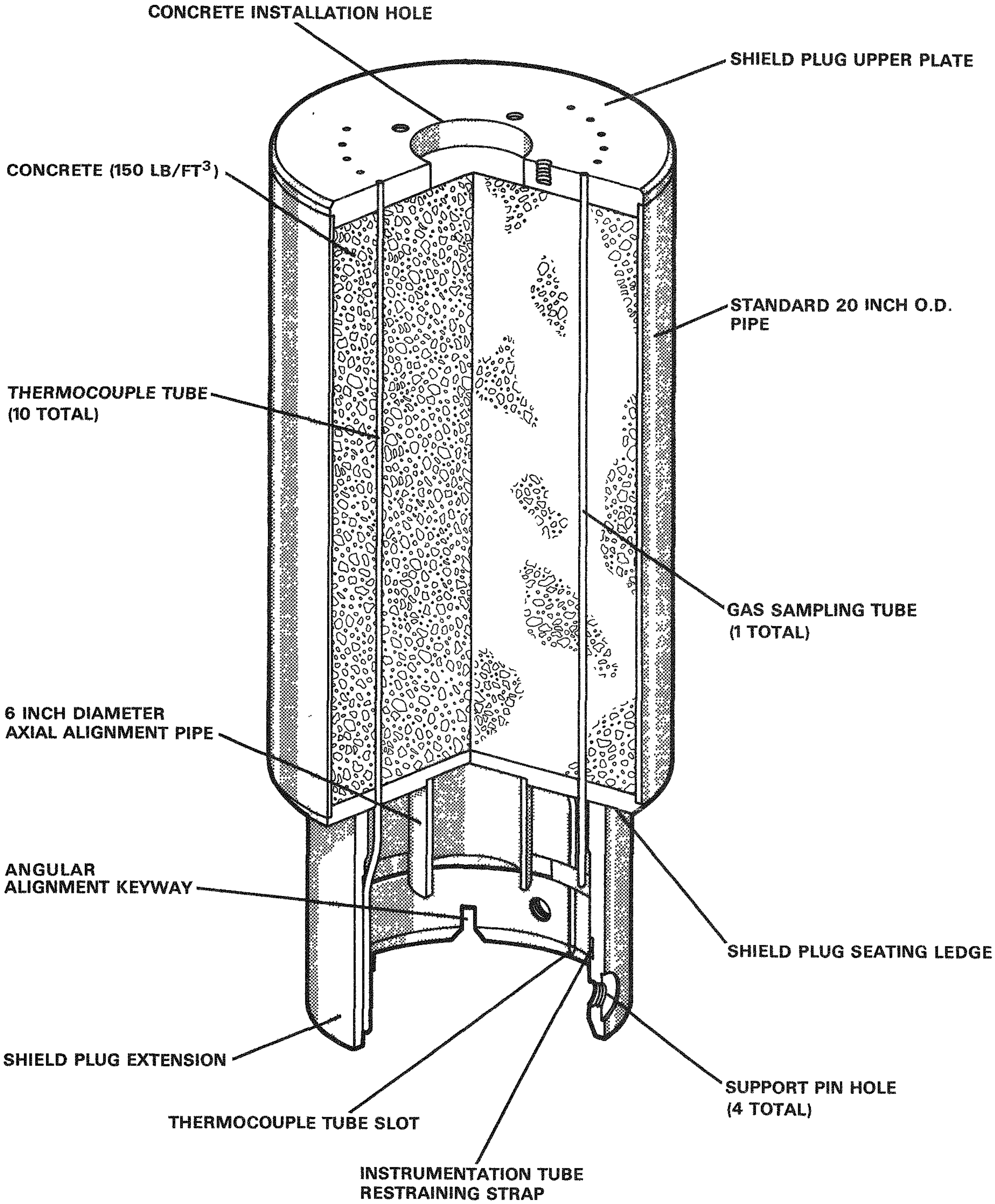

Figure 9. Shield Plug Configuration

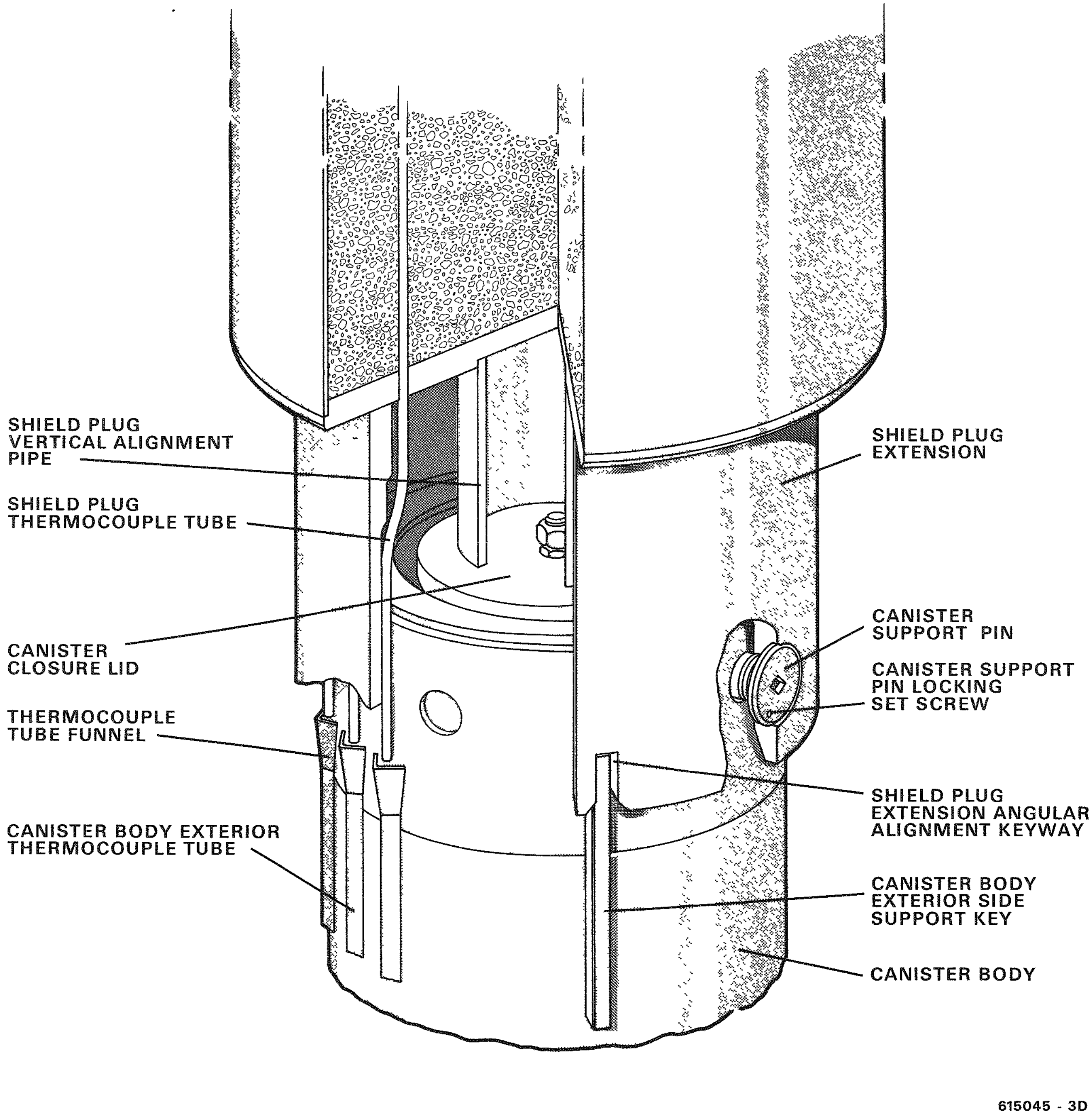

Figure 10. Canister and Concrete Shield Plug Mating

4.3.2 INSTRUMENTATION

The canister contains ten thermocouple tubes for insertion of thermocouples after emplacement in an SSC. The thermocouple tubes consist of inverted 0.75 inch by 0.75 inch by 0.12 inch thick angles tack welded to the outside of the canister body. A funnel is formed at the top of each tube by a 1.25 inch by 1.25 inch angle cut to match the smaller angle and welded to the top of the tubes (see Figure 7). The funnel is provided to allow for potential radial and azimuthal mismatch between shield plug and canister body instrumentation tubes and to assure proper thermocouple installation. An angled triangular plate is welded to the bottom of each tube. It is mounted at a relatively steep angle to promote contact between thermocouple junction and canister wall (see Figure 7).

Five thermocouple tubes are located on opposite sides of the canister with the center tubes of each group being 180° apart. The five tubes in each group are spaced 15° apart and extend down the canister to lengths matching the PWR fuel assembly active fuel middle, 2.5 feet above and below the active fuel middle and 1.0 foot from each end of the active fuel. The thermocouples are installed through tubes in the shield plug until the transition boot is 6.0 inches above the top of the shield plug.

The thermocouples when installed measure temperatures at five different elevations on both sides of the canister to determine the axial canister temperature profile. The uppermost, middle and lowermost of thermocouples are located at the same elevations as those in the SSC liner. Table 1 identifies the thermocouples installed in the canister and the SSC.

4.3.3 CLOSURE LID

The closure lid as shown in Figure 8 is a flat disc, 3.5 inches thick and 12.5 inches in diameter. The disc has approximately 1.0 inch of buttress threads machined near the top which mate with threads machined into the thicker section of 14 inch diameter pipe at the top of the canister body. The top outside surface of the closure lid is machined to form a seal lip for seal welding of the canister after the fuel assembly is installed. Features on the top surface of the closure lid include a machined groove for alignment of the seal welding machine with the machine seal lip, provisions for the lifting and torquing fixture, and a fitting with a mechanically sealed cap through which helium is introduced into the canister. The bottom 1.0 inch of the closure lid serves as a lead-in for the installation of the lid into the canister body.

The seal lip on the canister closure lid is welded to the canister body to complete the containment boundary. The gas fitting on top of the closure lid is used to evacuate the canister and backfill with helium. The helium serves to provide an indicator for initial leak checking of the closure lid seal weld and the gas fitting mechanical seal, to stabilize the fuel assembly in an inert atmosphere, and to enhance conductive heat transfer to the canister.

4.3.4 SHIELD PLUG

The canister is attached to a shield plug before emplacement into storage. The shield plug shown in Figure 9 is a 20 inch outside diameter, 0.25 inch wall carbon steel pipe approximately 34 inches long with a 1.0 inch thick plate welded to the top and bottom. The volume between the two end plates is filled with concrete for shielding. Extending from the bottom plate of the assembly is a 16 inch outside diameter, 1.031 inch wall, carbon steel pipe approximately 13.5 inches long. This pipe extension contains 4 tapped holes 90^{0} apart which accept the canister support pins. It is through these pins that the canister is secured to the shield plug. The shield plug is lowered over the canister body (which fits inside of the 16 inch diameter extension) and the support pins are threaded into the shield plug extension as shown in Figure 10. The pins protrude from the inside of the extension into 4 flat-bottom holes in the upper portion of the canister.

The shield plug has eleven 0.086 inch inside diameter tubes which extend from the upper plate, through the lower plate down to the bottom of the shield plug extension, 10 for routing thermocouples to the canister and one for sampling the atmosphere above the canister lid. The ten thermocouple tubes are routed through slots in the bottom portion of the extension so as not to interfere with canister body. The tubes are secured to the extension by spot welded straps. The shield plug has two sets of 5 tubes with 15° spacing between tubes. The tubes are oriented with respect to the thermocouple tubes on the canister by an alignment keyway in the shield plug extension and a bar (key) on the outside of the canister.

4.4 PWR SPENT FUEL ASSEMBLY

The specific spent fuel assemblies selected for the SFHPP 1978 Demonstration were four spent PWR fuel assemblies from the Turkey Point Reactor located in Southern Florida. A representative Turkey Point fuel assembly is shown schematically in Figure 11. The selected assemblies are 161.3 inches long (prior to irradiation) with a square cross section having a maximum distance across flats of 8.47 inches. The overall length is made up of a top nozzle, the fuel rods, and the bottom nozzle. The 204 fuel rods and 21 control tubes are arranged in a 15 x 15 array as shown in Figure 3. The fuel rods are 0.422 inch diameter zircaloy cladding around UO_2 pellets with a square pitch of 0.563 inches. The active fuel length is 144 inches. The fuel rods are laterally constrained by a series of 7 grids located along the length of the rods. The PWR fuel assemblies are supported by the bottom nozzle when in the vertical position. The bottom nozzle has four square feet located at the corners of the assembly. These feet interface with the cruciform in the bottom of the canister. A PWR fuel assembly weighs approximately 1500 pounds.

The specific PWR fuel assemblies were chosen based on their burnup (25,000 MWD/MTU) and their decay time (time out of reactor). Initial model predictions indicated that maximum decay heat levels for spent fuel should be limited to less than 1.25 kW. The four Turkey Point fuel assemblies (Serial Numbers B02, B03, B41, and B43) were chosen based on an estimated decay heat level slightly less than 1.25 kW at the earliest SSC emplacement date (November 1978). This decay heat level was based on the predicted decay heat curve (Figure 12) and the October 1975 discharge date for the four assemblies. Specific data (operating statistics, dimensional measurements, weight data, flux and gamma

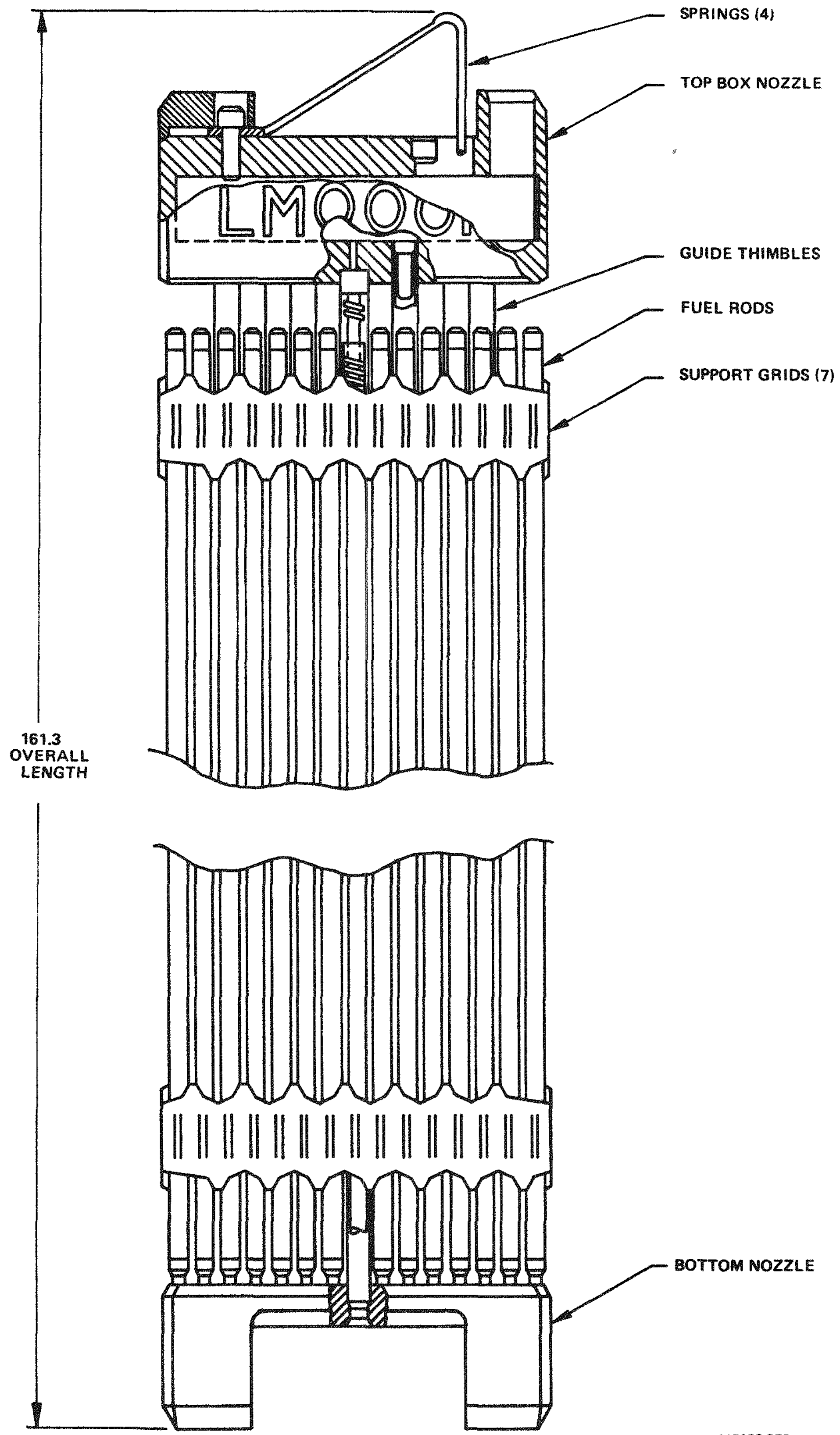

Figure 11. PWR Fuel Assembly Configuration

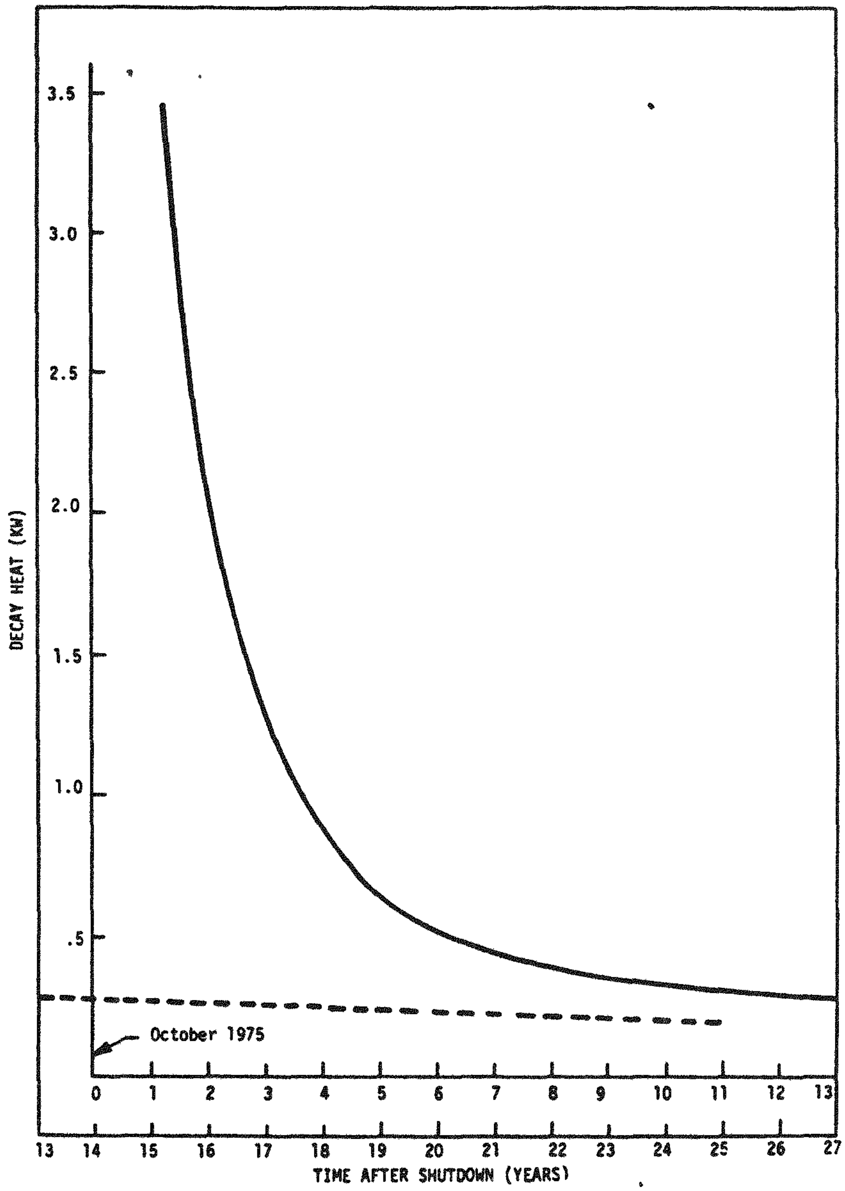

Figure 12. Predicted Decay Heat After Shutdown for Turkey Point PWR Spent Fuel Assemblies

scan data, etc.) concerning the spent fuel assemblies was collected prior to their shipment to E-MAD and is reported in Reference 3. Figure 13 shows a spent fuel assembly being lowered into a canister.

4.5 STORAGE SITE

The storage site for the two SSC's is located on the west side of the E-MAD building within the security fenced area surrounding the E-MAD complex as shown in Figure 14. The area west of the E-MAD building was chosen as the storage site since it is fairly level and would require a minimum of site modifications.

The site was prepared by excavating a 20 by 46 foot hole to a depth of 9 feet. The hole was then filled to a depth of 6 feet with lean concrete. Two 16 by 16 by 3 foot reinforced concrete foundation pads were then constructed on this subfoundation. The SSC storage area construction (shown in Figures 15 and 16) was completed in September, 1978. The storage area concrete pads were emplaced 26 feet apart for two SSC's. The first SSC (#2) is placed 27 feet south and 22 feet east of the NE corner of E-MAD. This location was selected to permit access for the SSC transporter and mobile crane. Eight embedment plates in the pad are utilized to permit bolting the SSC to the pad.

Underground conduit was laid to allow for instrumentation routing for the two casks. Four lines of 2 inch diameter PVC pipe were installed approximately 2 feet below ground level running from the instrumentation shed to an enclosure between the casks. Vertical sections of steel pipe were installed at the end of each pipe to attach the large waterproof, dustproof electrical enclosure. The instrumentation conduit is connected to an environmentally controlled instrumentation shed located outside the E-MAD building. Flexible conduit routed the instrumentation from the large enclosure to junction boxes mounted on the casks.

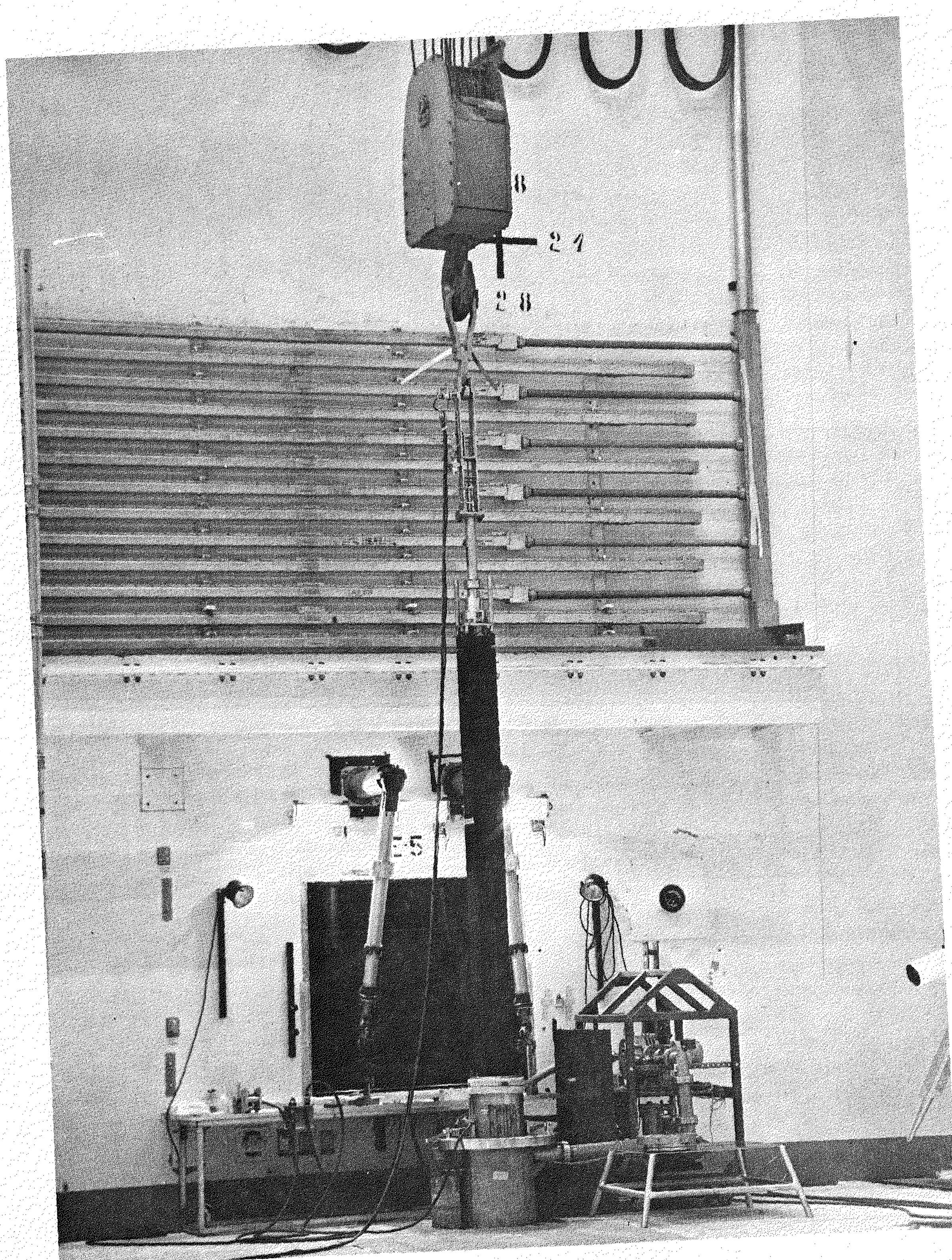

Figure 13. PWR Fuel Assembly Being Installed Into Canister

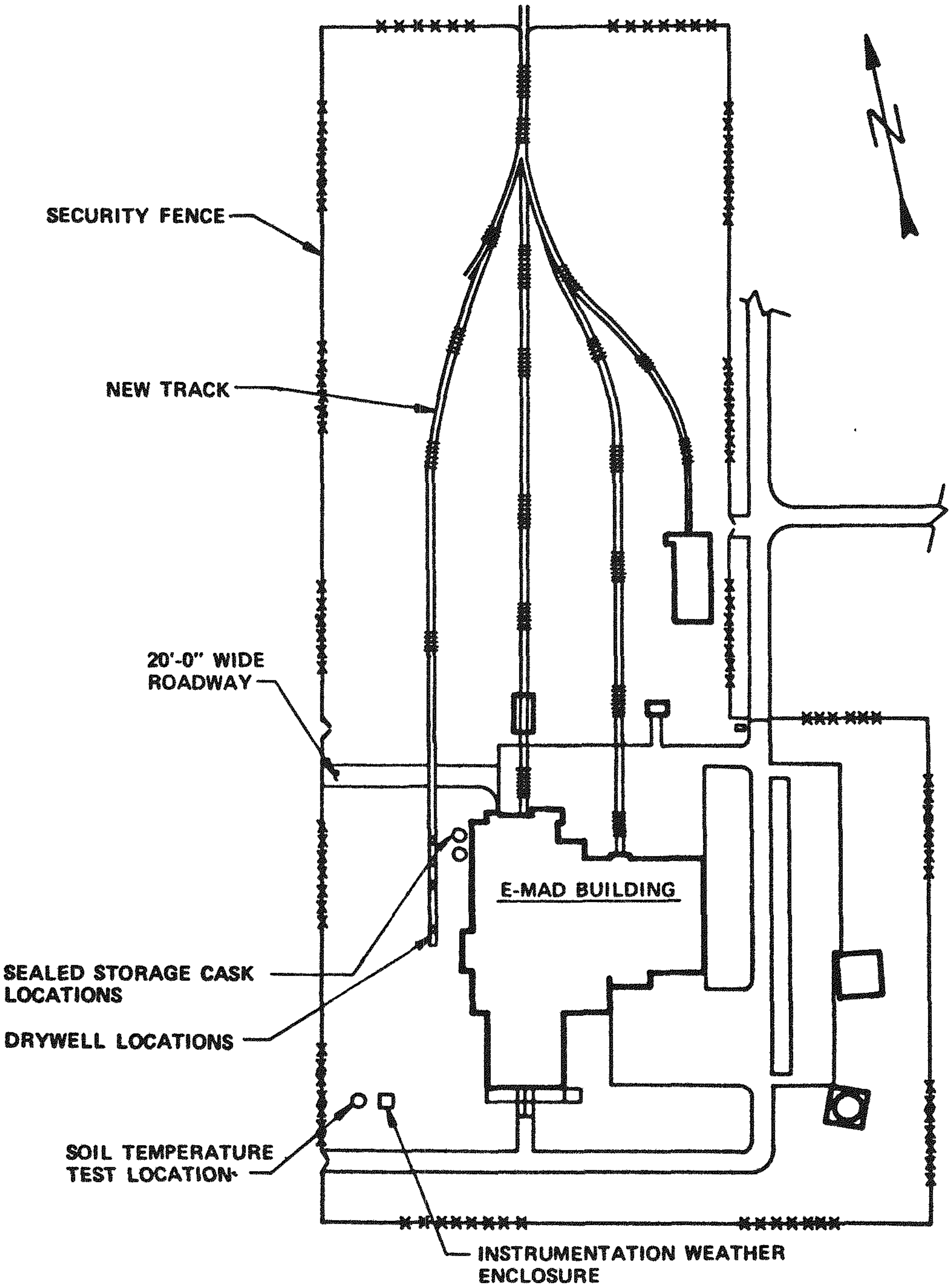

Figure 14. E-MAD Storage Site Configuration

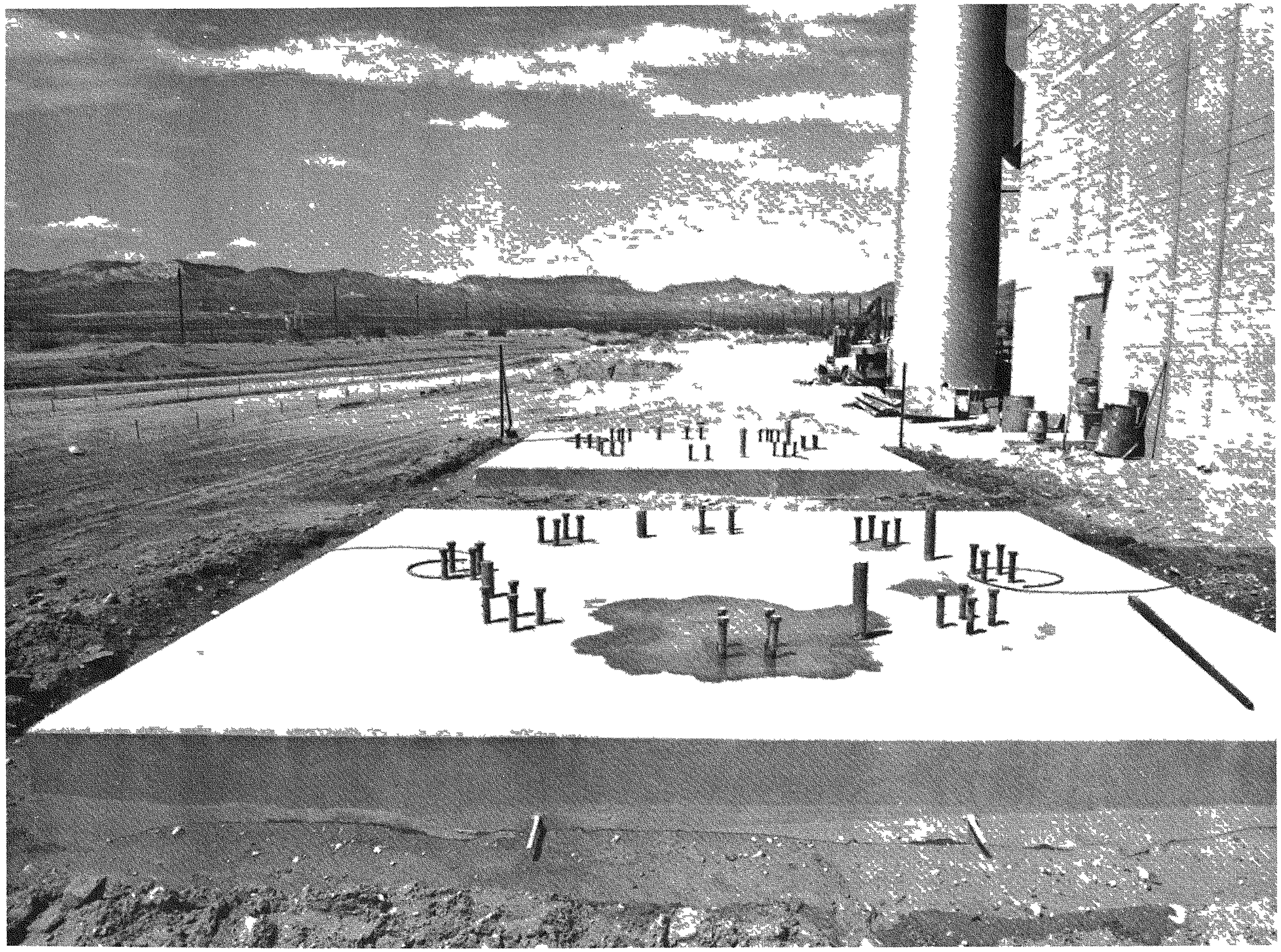

Figure 15. Sealed Storage Cask Foundation

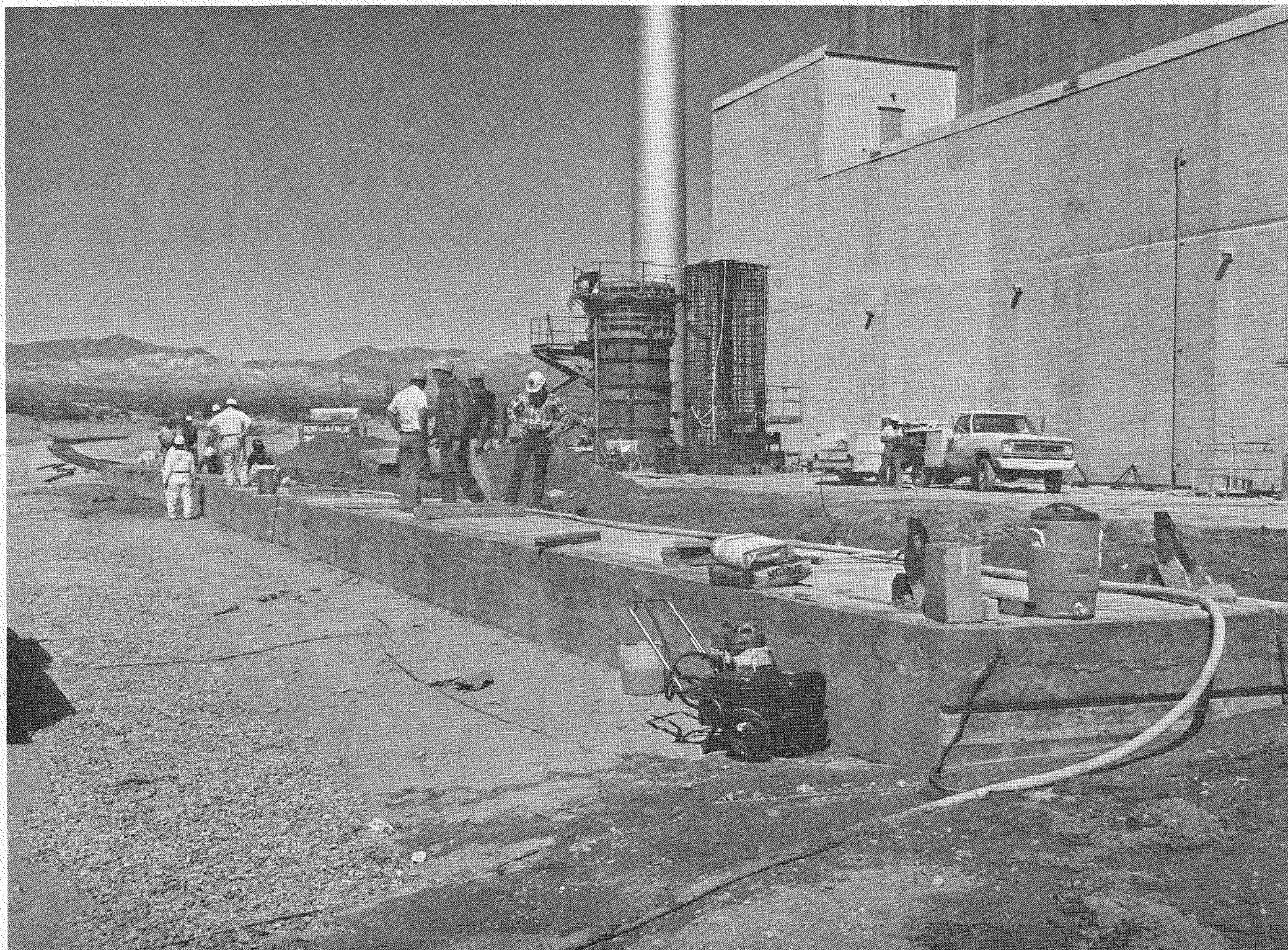

Figure 16. SSC and Drywell Storage Area Construction

4.6 SEALED STORAGE CASK ASSEMBLY

4.6.1 SSC CONSTRUCTION

The SSC is a reinforced concrete shielded container constructed on its foundation pad as shown in Figures 5, 6 and 16. The finished size is 252 inches high and 104 inches in diameter. Three rings of reinforcing bar surround the liner. The outer ring at a 50 inch radius has 0.75 inch diameter bars placed vertically and circumferentially on 6 inch centers. At the top and bottom of the cask there are formed radial extensions between the liner and outer ring. The two inner rings at radii 23 and 37 inches have 12 symmetrically placed vertical bars 0.625 inch in diameter, and 3 hoops 0.5 inch in diameter. The purpose of these rings is to position and support the thermocouples that extend down from the top of the cask.

Embedded within the periphery of the outer reinforcing ring are four handling trunnions of which only two are required to handle the assembled cask weight of approximately 95 tons. The trunnions are fabricated from 10 inch SCH. 140 pipe, capped at the outer end and filled with grout. The pipe is 30 inches long and extends 6 inches past the cask surface. Welded to the pipe at this interface is a 24 inch square by 0.75 inch thick plate. Also welded to the embedded portion of the pipe are three 15 inch diameter rings on 4 inch centers. Twenty Nelson studs welded to the plate and pipe periphery assure interface integrity with the concrete.

At the base of the cask are eight welded brackets embedded in the SSC by 8 Nelson studs. The brackets are bolted to embedments in the foundation pad. The vertical plate of the bracket is 12 inches by 20 inches long by 0.75 inch thick rolled to a 52 inch outside radius. The horizontal plate is 12.5 inches wide by 18 inches long by 0.75 inch thick. Three 0.75 thick gusset plates are welded to the two plates. This method of attaching the cask to the pad prevents cask overturning from a horizontal seismic loading of 0.25 g.

Following the assembly of the reinforcing bar, thermocouples, trunnions and brackets, a circular concrete form is placed around the structure and the concrete placement is completed in a single continuous pour.

Other components of the SSC are a cask cover and a special handling sling. The cask cover plate with a neoprene gasket is bolted to the top of the cask to seal the interior. The cover is 38 inches in diameter by 0.5 inch thick steel plate. Six radial ribs, 2.0 inch high, strengthen the plate. The plate is attached by six 0.5 inch concrete anchor studs. The handling sling for the SSC has a rated capacity of 110 tons. The sling has two legs approximately 23 feet long. Each sling leg is a two part 2.25 inch diameter wire rope equalizing strand-laid grommet construction sling of improved plow steel. The endless strand has equalizing thimbles at both ends. The two legs are attached to a pear ring with a 137.5 ton minimum rating. A 10 inch SCH. 60 pipe spreads the two legs 9 feet apart about 8 feet above the bottom of the legs.

4.6.2 INSTRUMENTATION

The temperature characteristics of the SSC are measured using thermocouples located throughout the SSC. In addition to instrumentation described in Section 4.2 and 4.3 for the liner and canister, an additional 36 thermocouples are embedded in the concrete. This instrumentation has compass azimuthal orientations of 45°, 135°, 225°, and 315° and is at elevations of 68, 128 and 188 inches measured from the top of the cask. Instrumentation embedded in the concrete have radii of 23, 37 and 50 inches. Four equally spaced pull boxes are located near the top periphery of the cask for collection of the thermocouple lead wires from each cask quadrant. The thermocouple lead wires are then routed through rigid conduit to a second set of terminal boxes located on the outer surface of the cask below the pull boxes. Each thermocouple terminal box contains a special chromel and alumel terminal connector for termination of the thermocouples.

After the cask unit has been loaded with a canister assembly and moved to the storage site, flexible conduit route the lead wires from the 36 thermocouples embedded in the concrete from the terminal boxes to the storage site junction box (Section 4.5). The lead wires from the ten canister thermocouples and six liner thermocouples, contained in thermocouple tubes, are routed through another flexible conduit directly to the storage site junction box. All conduit and junction box fittings are sealed for water tightness.

4.6.3 CANISTER INSTALLATION

The encapsulated fueled canister is installed into the SSC in the E-MAD Hot Bay as shown in Figure 17. The SSC is transported to the Hot Bay on a low bed trailer. A 135 ton capacity mobile crane with the SSC handling sling, shown in Figure 18, is used to load the SSC onto the trailer.

4.6.4 SSC EMPLACEMENT

At the SSC storage site the handling sling is attached to two SSC trunnions and the SSC is off loaded onto the storage pad. Four installation guide pins threaded into the pad bracket embedments guide the SSC during the final 16 inches onto the pad. Preparing the SSC for testing includes the following:

1. The guide pins and slings are removed.
2. The SSC is bolted to the foundation pad embedments.
3. The SSC lightning arrestor is connected to the E-MAD grounding grid.
4. The 10 canister and 6 liner thermocouples are inserted into the thermocouple tubes.
5. Tne thermocouple lead wires are connected as described in Section 4.6.2.
6. The two slots for passage of canister and liner thermocouple lead wires at the top of the cask are filled with RTV silicon rubber.
7. The cask cover plate is bolted to the SSC concrete.

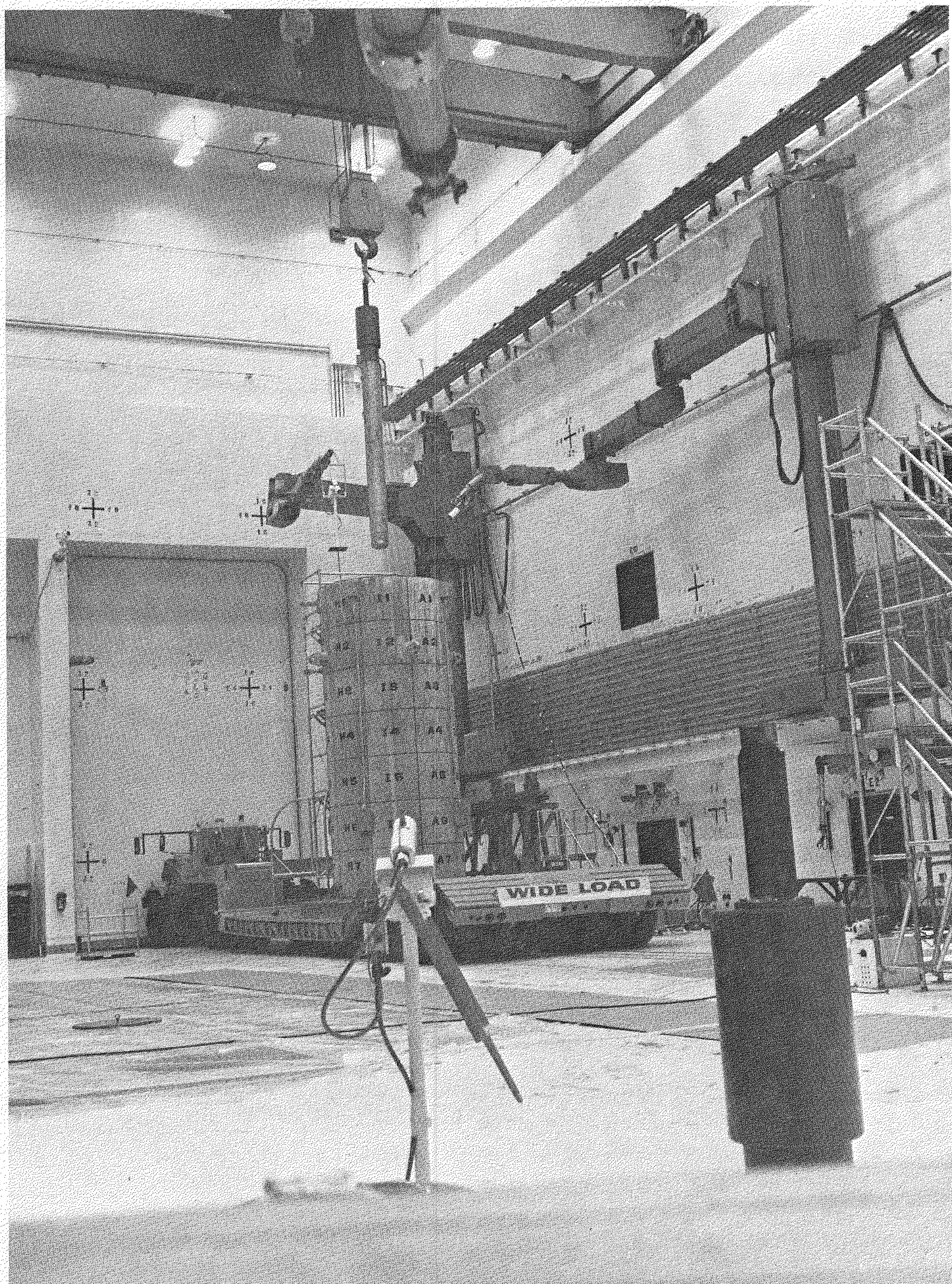

Figure 17. Completed Canister Being Remotely Lowered Into Sealed Storage Cask in Hot Bay

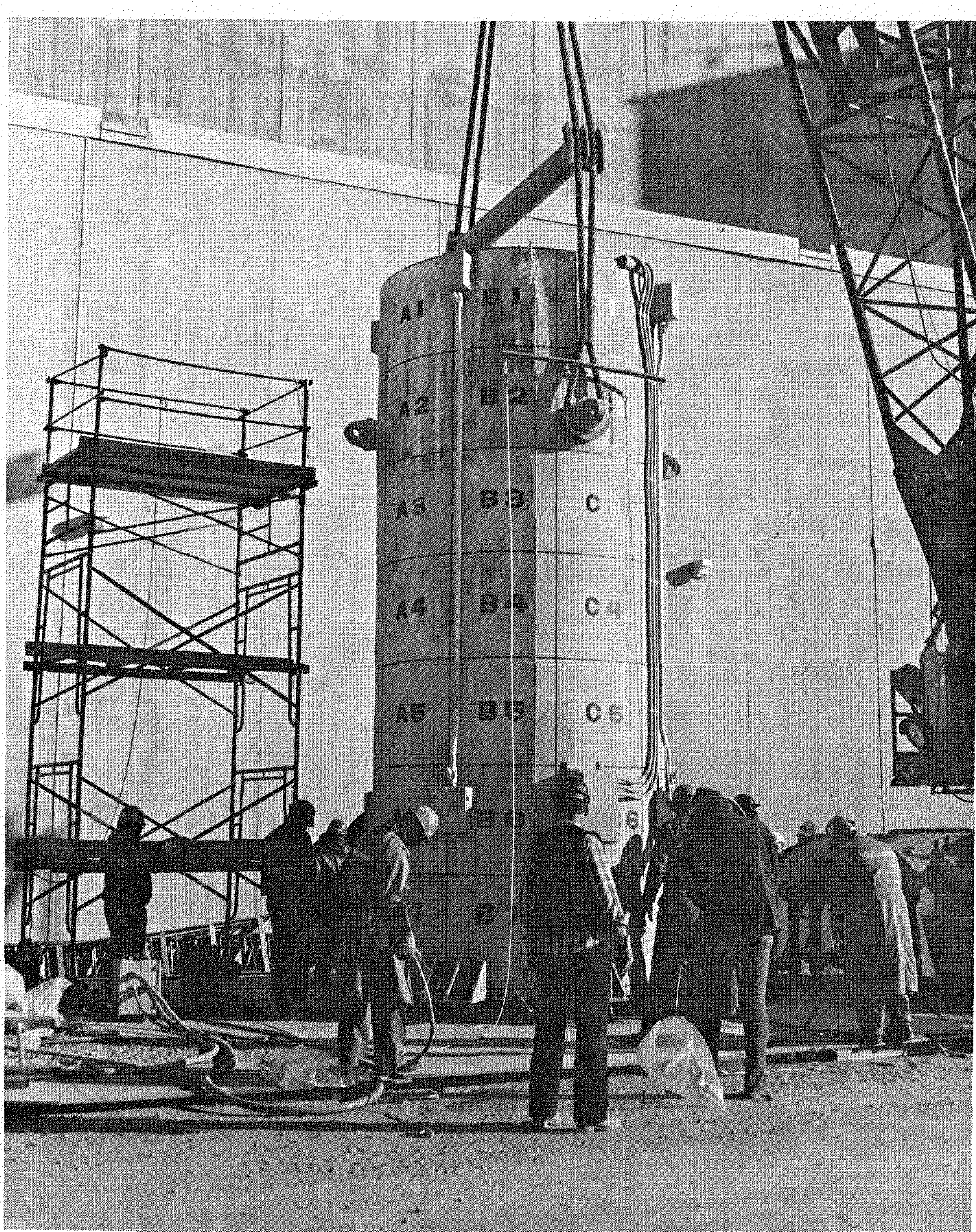

Figure 18. Sealed Storage Cask with Canister Being Lowered Onto Storage Pad

4.7 DATA ACQUISITION SYSTEM

The data acquisition system for the SSC test consists of the array of thermocouples, a data logger, and one remote scanning/multiplexing unit. The thermocouples are attached to the test hardware and the lead wires terminated at the storage site junction box as described earlier in this section of the report. From the storage site junction box the thermocouple leads are routed through rigid underground conduit to the multiplexer unit located in the instrumentation shed outside the E-MAD West Wall. Multiplexer signal cables are routed through underground conduit to the data logger which is located inside the E-MAD building in the West Operator Gallery.

4.7.1 THERMOCOUPLES

All thermocouples used in the SSC test described in the preceding sections consist of Type K, chromel-alumel thermocouple with ungrounded junction enclosed in a 304 stainless steel sheath with magnesium oxide insulation. The 48 thermocouples embedded in the concrete have a 0.187 inch diameter sheath with two 22 gauge Type K extension wires brazed to the thermocouple wires. The wires are enclosed in a 0.250 inch diameter by 0.028 wall by 2.75 inches long stainless steel transition boot which is crimped onto the end of the thermocouple sheath and filled with epoxy. The 16 thermocouples for the canister and liner thermocouple tubes are of similar construction and have 0.062 inch diameter sheaths and 24 gauge extension wires. The transition boot is 0.187 inch diameter by 0.010 wall by 2.75 inches long.

4.7.2 DATA LOGGER SYSTEM

An Acurex Autodata IX data logger with one remote scanning/multiplexing unit is used for the SSC Test. The data logger is shown in Figure 19 in its installed configuration. The data logger is also used for other experiments at E-MAD and for monitoring spent fuel temperatures within the E-MAD hot cells. The data logger operates on 120 volt, 60 Hz AC electrical power and is rated for operation in the range of 32°F to 110°F and 0 to 90 percent relative humidity. This data logger system was selected with capabilities to meet the test needs

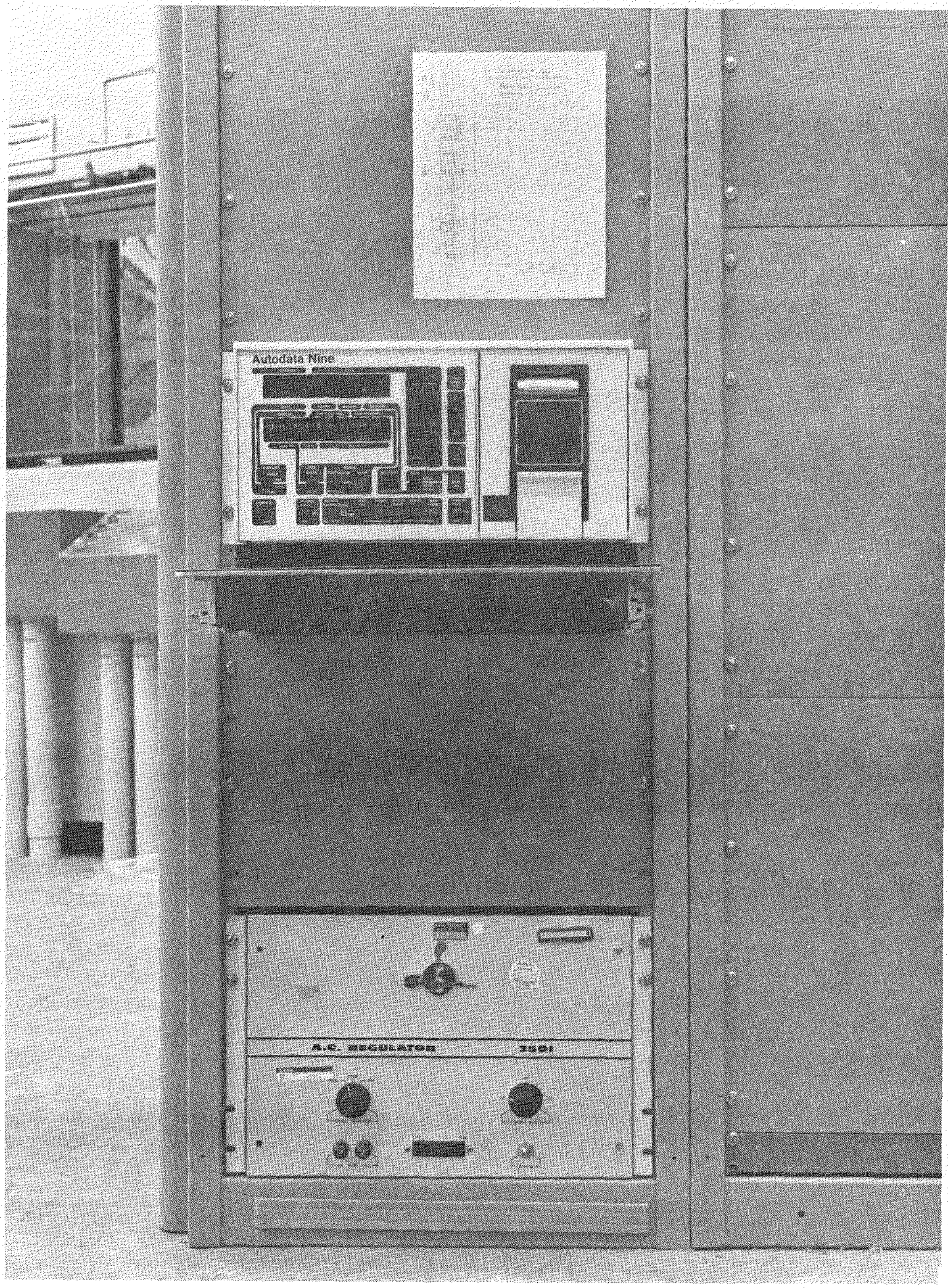

Figure 19. Data Logger Installation in West Gallery

of the SFHPP 1978 Demonstration with considerations for future expansion. Some of the capabilities being utilized for tne SSC Test are as follows:

1. Measurement of Type K thermocouple temperatures from up to 1000 thermocouples.

2. Thermocouple open detection circuit (to determine failures).

3. Remote signal conditioning and multiplexing for remote instrumentation up to 5000 feet from data logger mainframe.

4. Console digital readout in identified engineering units (selectable on the front panel).

5. Printer for output data with header and engineering unit identification.

6. Variable scan modes (single, continuous, and intervals) with adjustable scan intervals.

7. High performance analog to digital conversion.

5.0 TEST OPERATIONS AND RESULTS

5.1 TEST OPERATIONS

The initial plan for the SFHPP 1978 Demonstration Storage Cell experiments was to place one canister containing one PWR fuel in one SSC and a second canister containing two BWR fuel assemblies in the other SSC. Delays in procurement of BWR fuel assemblies prevented their encapsulation for use in SSC testing.

Spent fuel assembly encapsulation operations for SSC emplacement occurred during the first week of December, 1978. The spent fuel canister was installed in SSC Number 2 on December 7, 1978. Thermocouples were installed for this canister and all thermocouple leads were routed to the multiplxer unit in the instrumentation shed. Temperature data from SSC #2 has been monitored from the date of emplacement. Appendix A provides typical mid month data logger printouts of the thermocouple readings. Table 1 provides a listing of thermocouple positions and data logger data channels used to print out the temperature data.

5.2 TEST RESULTS

SSC temperature readings are shown in Figures 20 to 26. In Figure 20, the thermocouple readings of the peak canister and liner temperature are plotted on a weekly interval through March, 1980. The maximum canister temperature (201°F) and liner temperature (141°F) occurred in July, 1979. The cask heatup transient ended after 10 days into the test. Also plotted are the difference in temperature between the canister and liner and between liner and concrete at 23 inches radius. After a year of operation the temperature difference of the canister/liner declined from 75°F to 59°F and the liner/concrete declined from 25°F to 19°F.

Figures 21 and 24 show the midplane (EL. 128") temperatures of the canister, liner and concrete during the intervals of July 24, 1979 to July 27, 1979 and

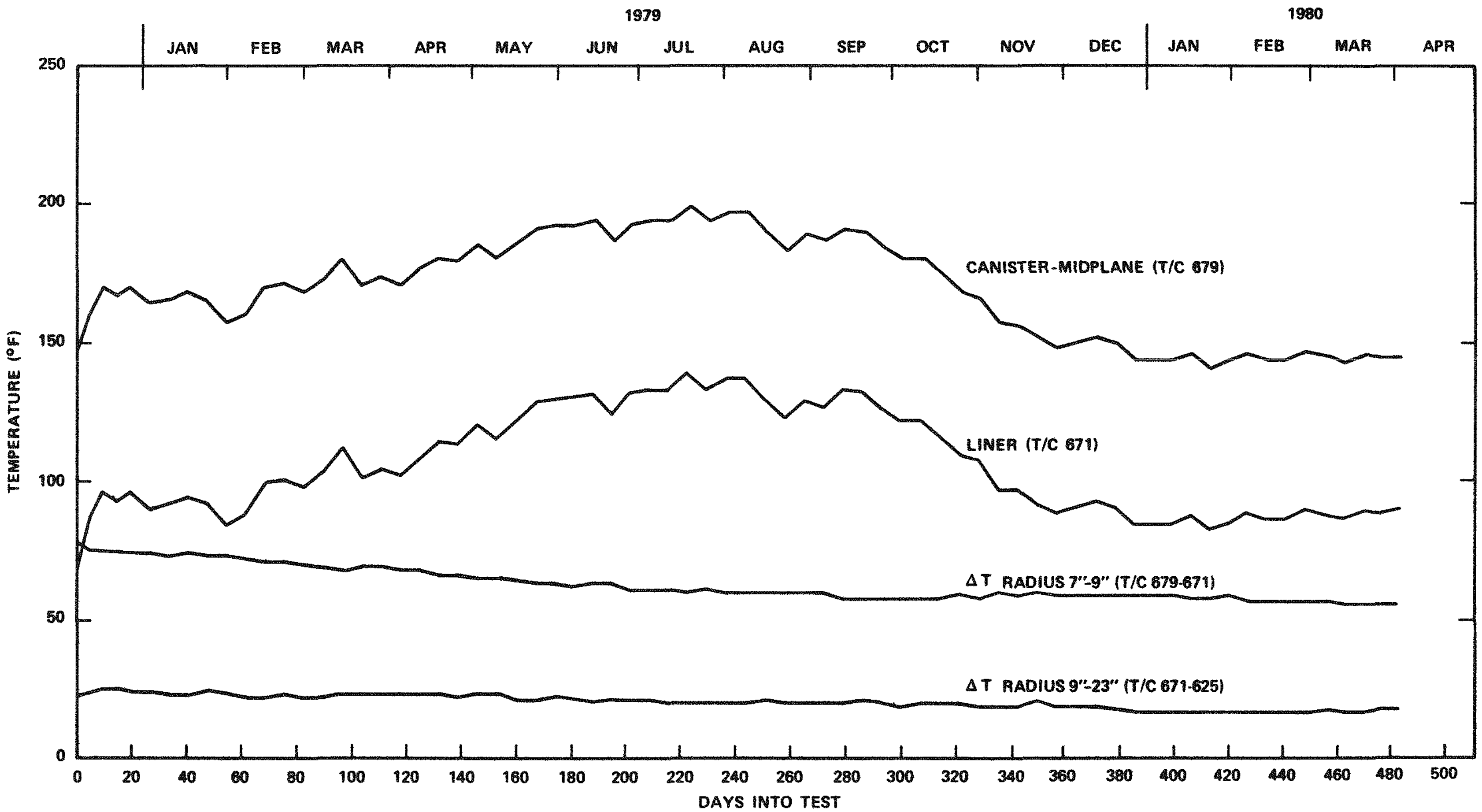

Figure 20. Maximum Temperature Distribution, Weekly Intervals, 45° NE Quadrant, Elevation 128"

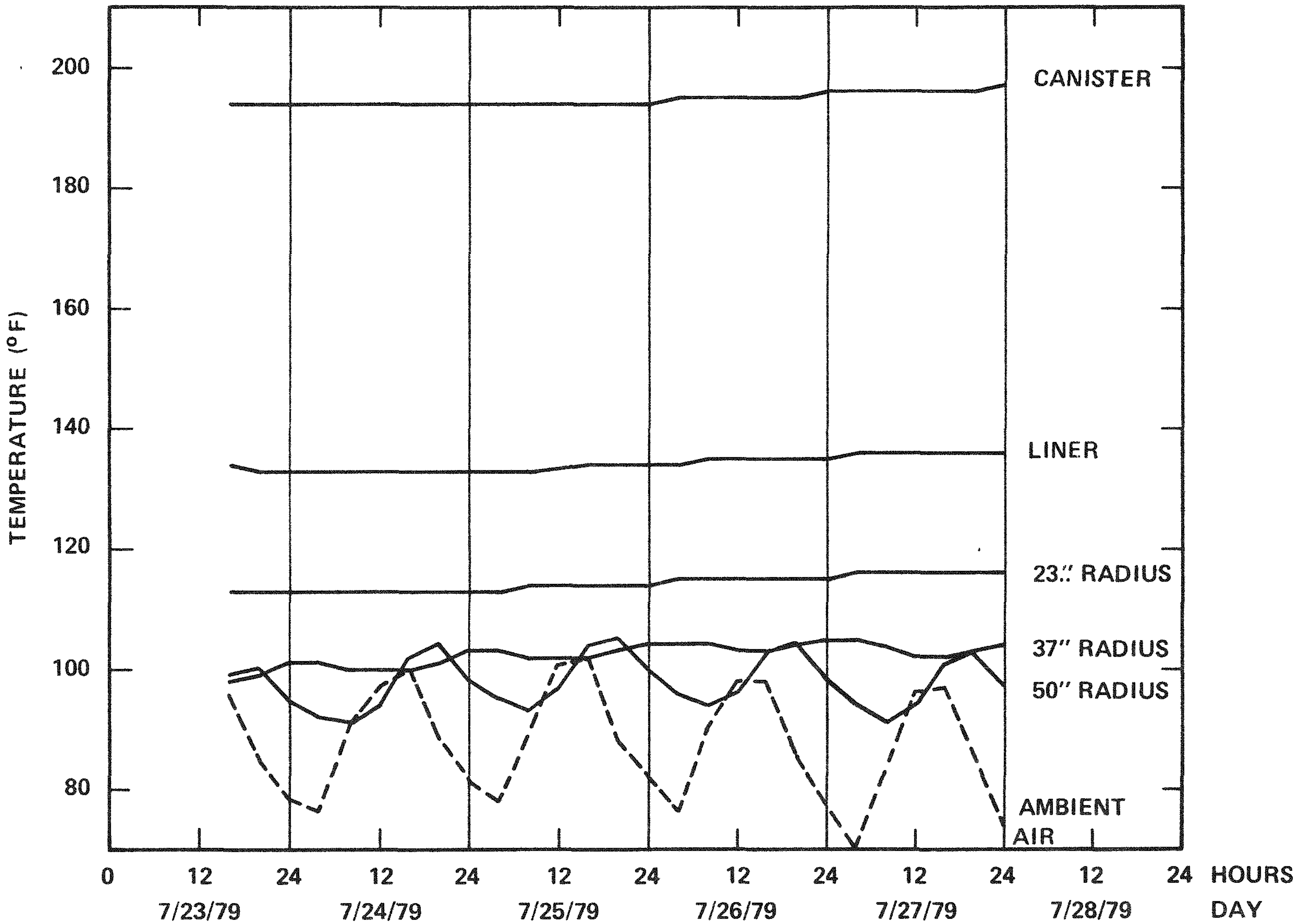

Figure 21. Temperature Distribution at 4 Hour Intervals, July 24, 1979 to July 27, 1979, Elevation 128", 45° NE Quadrant

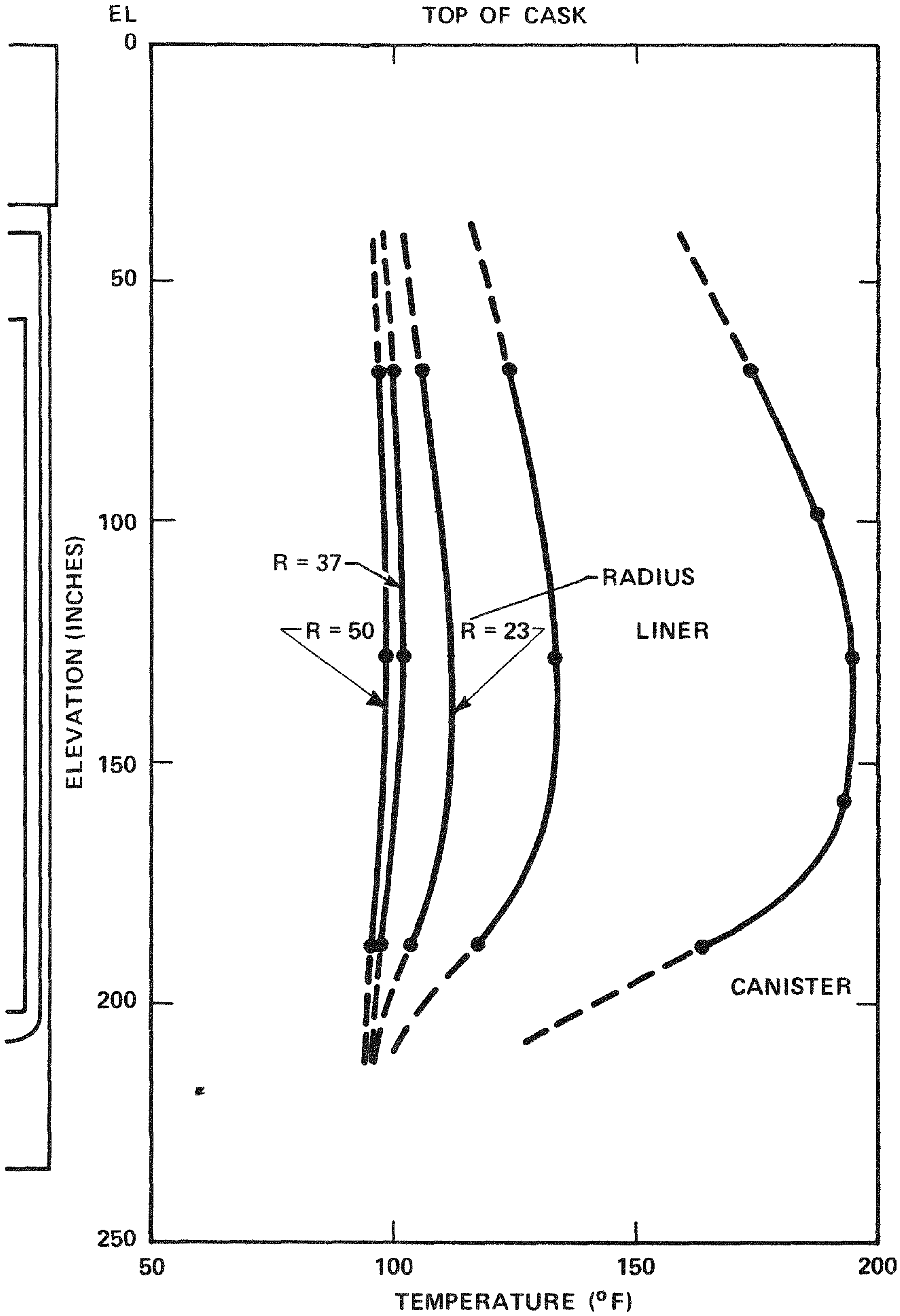

Figure 22. Axial Temperature Distribution, on July 24, 1979 (5427 Hours) Temperatures Averaged for 24 Hours

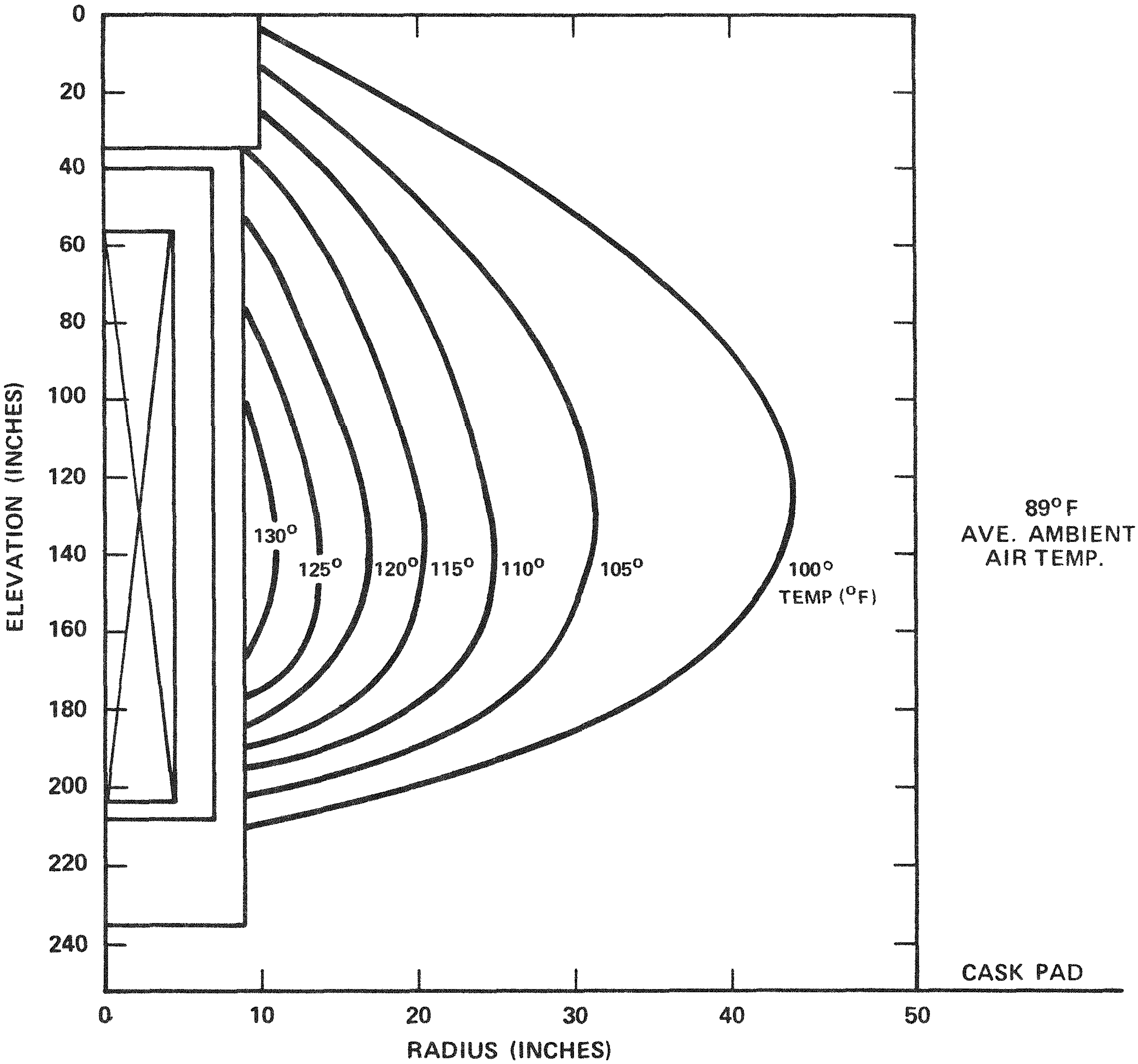

Figure 23. Isotherms on July 24, 1979 (5527 Hours)

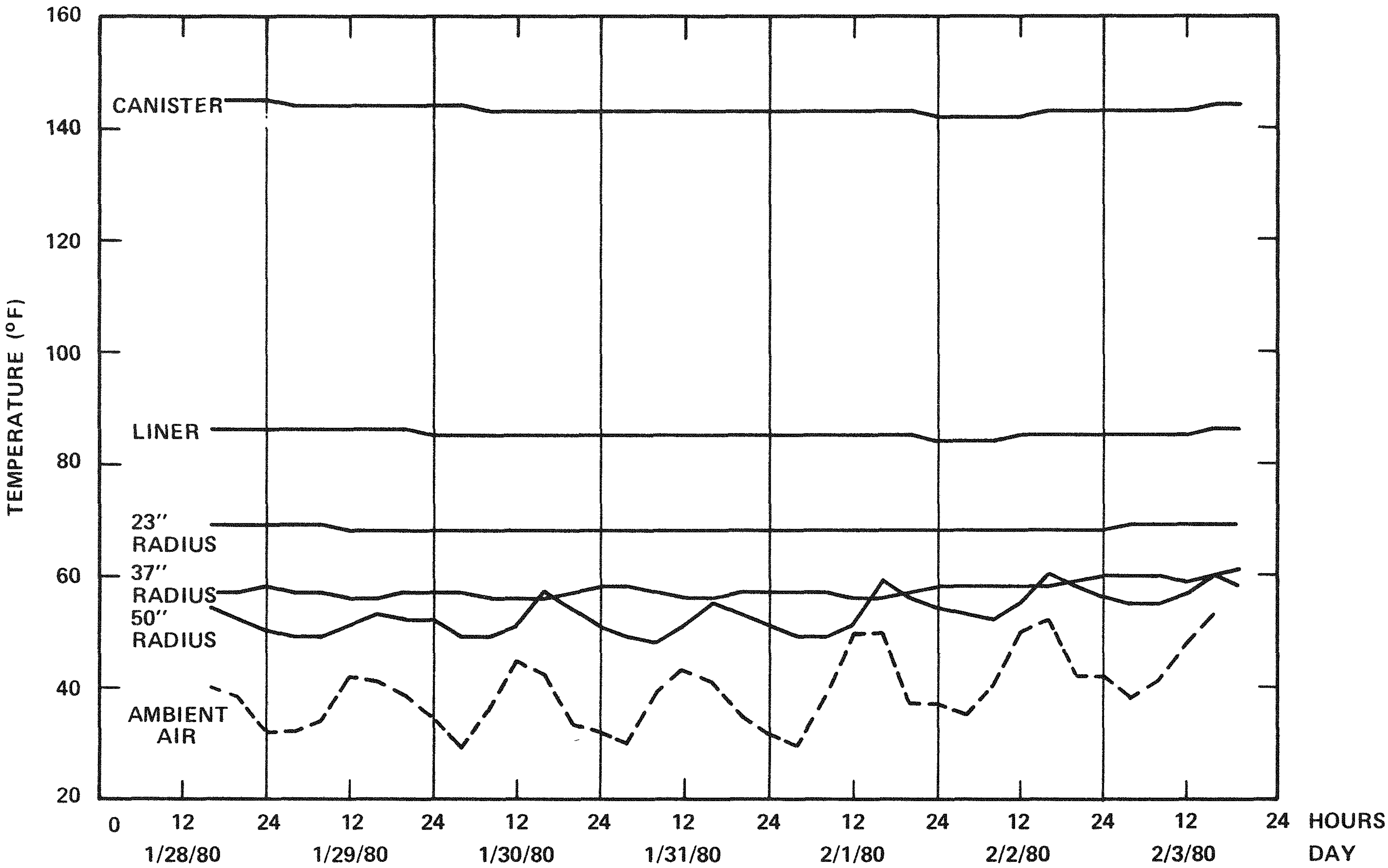

Figure 24. Temperature Distribution, 4 Hour Intervals, January 29, 1980 to February 3, 1980, Elevation 128", 45° NE Quadrant

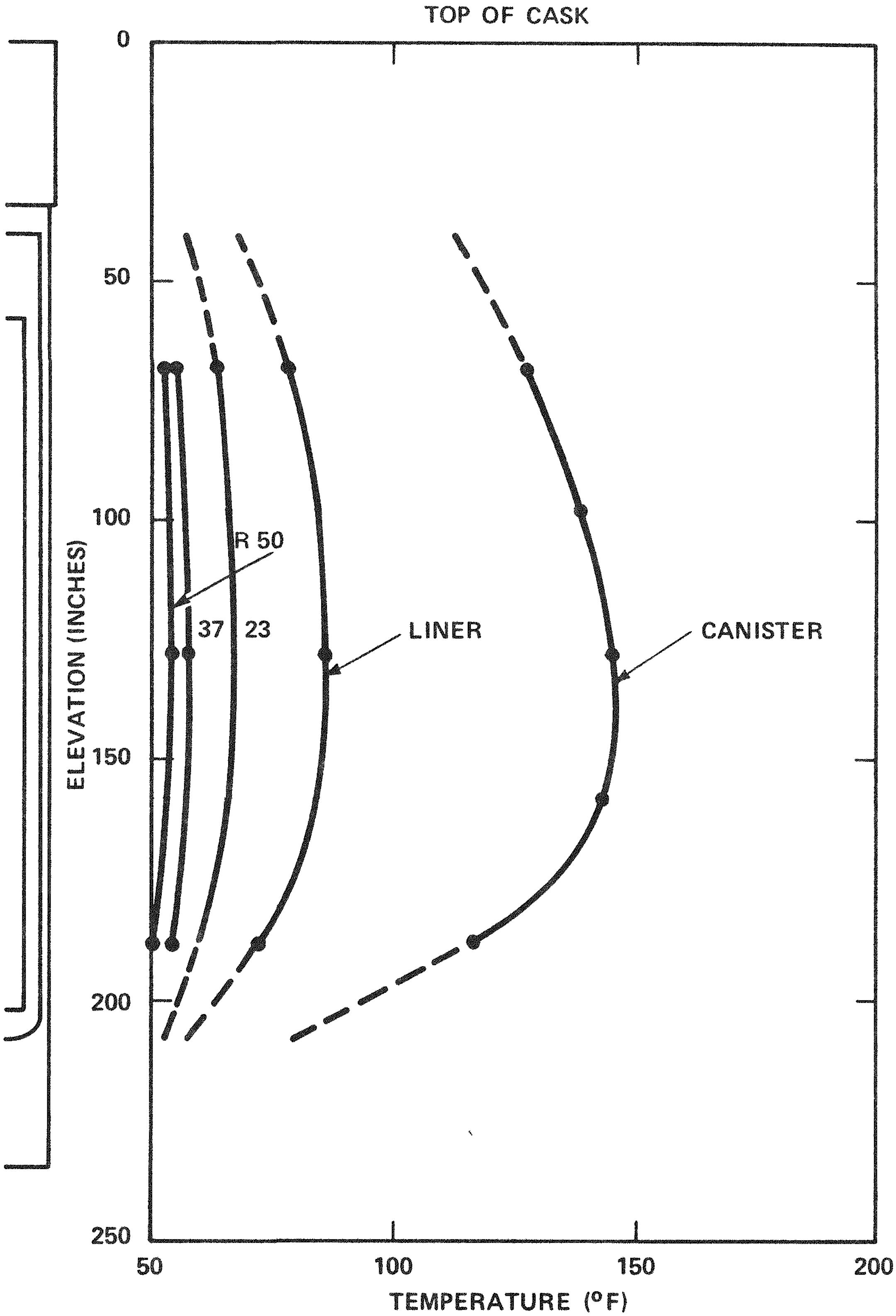

Figure 25. Axial Temperature Distribution on January 30, 1980, (9979 Hours), Temperatures Averaged for 24 Hours

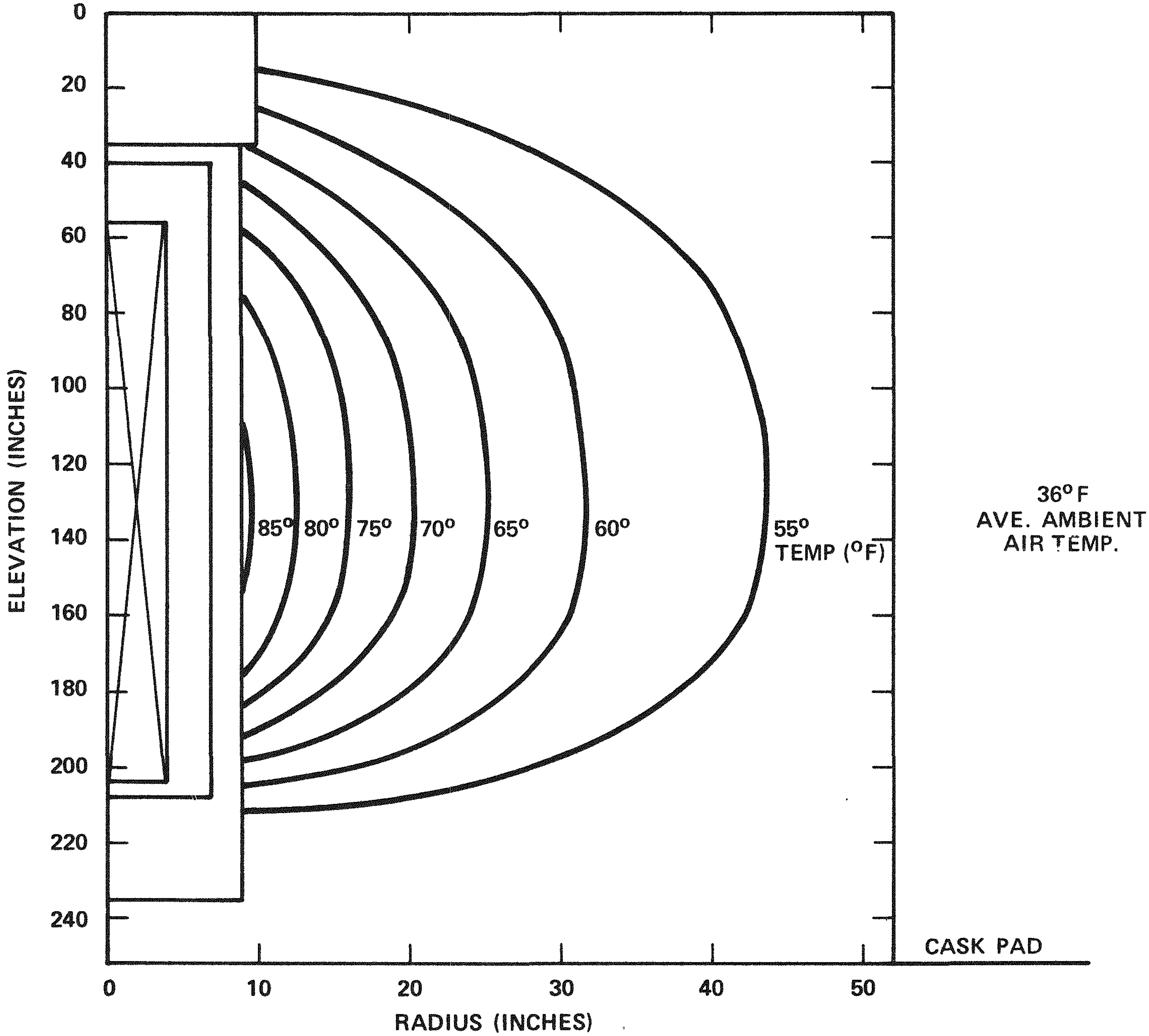

Figure 26. Isotherms on January 30, 1980 (9979 Hours)

January 28, 1980 to February 2, 1980 and illustrate the effects of summer and winter operations and the effects of day-night variations. The day-night ambient variations are closely followed near the surface of the cask (50 inch radius); are nearly damped out at the 37 inch radius; and are not detectable at the
23 inch radius. Figures 22 and 25 show the canister, liner and concrete axial profiles on July 24, 1979 and on January 30, 1980. The temperature data was averaged over a 24 hour period to eliminate the effects of day-night variations in the concrete. Figures 23 and 26 present the temperature distribution on the same dates using isotherms interpolated from the thermocouple data.

5.3 AMBIENT TEMPERATURE MEASUREMENTS

A continuous record of atmospheric conditions at E-MAD has been kept during the SSC test. The average monthly air temperature at E-MAD from January, 1979 to February, 1980 is listed in Table 2.

TABLE 2

MONTHLY AVERAGE AIR TEMPERATURE
AT E-MAD DURING TEST PERIOD

Month	Average Temperature (°F)
January - 1979	37
February	47
March	53
April	62
May	74
June	83
July	81
August	78
September	78
October	62
November	46
December	42
January - 1980	39
February	48
March	53

6.0 THERMAL ANALYSIS METHODS

6.1 ANALYSIS PURPOSE AND METHOD

The purpose of the Sealed Storage Cask (SSC) Test thermal analysis is to establish a reference thermal model for the SSC configuration and to demonstrate that the model can produce satisfactory predictions of cask and canister temperatures. Once that goal is achieved, the model could be used with increased confidence in SSC analyses involving higher decay heat levels and cask design alterations.

Sealed Storage Cask Test predictions and data analyses have been performed using the TAP-A digital computer program, Reference 4. TAP-A was developed at AESD and has been used extensively during the past ten years at that division and at the Westinghouse Advanced Reactors Division. TAP-A is a finite difference program which calculates steady-state and transient temperature distributions in a configuration of solid materials utilizing the radiation, convection and conduction modes of heat transfer. To apply the program, a two-or three-dimensional configuration is divided into elements called nodes. The nodes, which are connected to each other by heat transfer links having lengths and cross-sectional areas, can have time and temperature dependent thermal properties (density, heat capacity and conductivity) as well as time dependent heat generation rates. Outer surfaces are assigned time dependent temperatures or convective heat transfer coefficients that may also vary with time or with a surface-to-ambient temperature differential.

In the analysis reported herein, temperature data from the SSC Test have been compared with TAP-A temperature predictions and reasonable model refinements have been made to improve the agreement. The rationale supporting those refinements and the sensitivity of temperature to variations in certain parameters are discussed in the following sections.

6.2 MODEL DESCRIPTION

6.2.1 MODEL SIZE AND BOUNDARY CONDITIONS

The TAP-A nodal model of the SSC Test is depicted in Figure 27 and the 204 nodes representing each component are identified in Table 3. The model is two dimensional in the r and z directions (radius and depth respectively) with no variations circumferentially.

6.2.2 HEAT TRANSFER MECHANISMS

Heat transfer between the fuel assembly (nodes 1 to 30) and the canister is modeled by conduction. Heat transfer from the fuel to canister actually occurs by convection and radiation (primarily by radiation at high temperatures). Since TAP-A has no mass flow capability and therefore cannot model convection effects, a simplifying assumption was made in the model to calculate canister temperatures utilizing an arbitrarily chosen conductivity value to represent the combination of radiation, convection, and conduction heat transfer. A temperature dependent conductivity (Figure 28), calculated over the anticipated range of canister temperatures is used in the model. The fuel assembly heat capacity is modeled accurately to produce fairly accurate transient predictions for the entire SSC system.

Heat transfer from the canister to the liner and shield plug occurs by radiation, conduction and free convection and the thermal model considers all three modes. Convection and conduction are treated using the "effective thermal conductivity" approach while the radiation calculation for canister to liner heat transfer uses the following shape factor expression for concentric cylinders:

$$F_{12} = \frac{1}{\frac{1}{\epsilon_1} + \frac{A_1}{A_2}\left(\frac{1}{\epsilon_2} - 1\right)}$$

where

ϵ = emmisivity

A = surface area

1 = canister outer surface

2 = liner inner surface

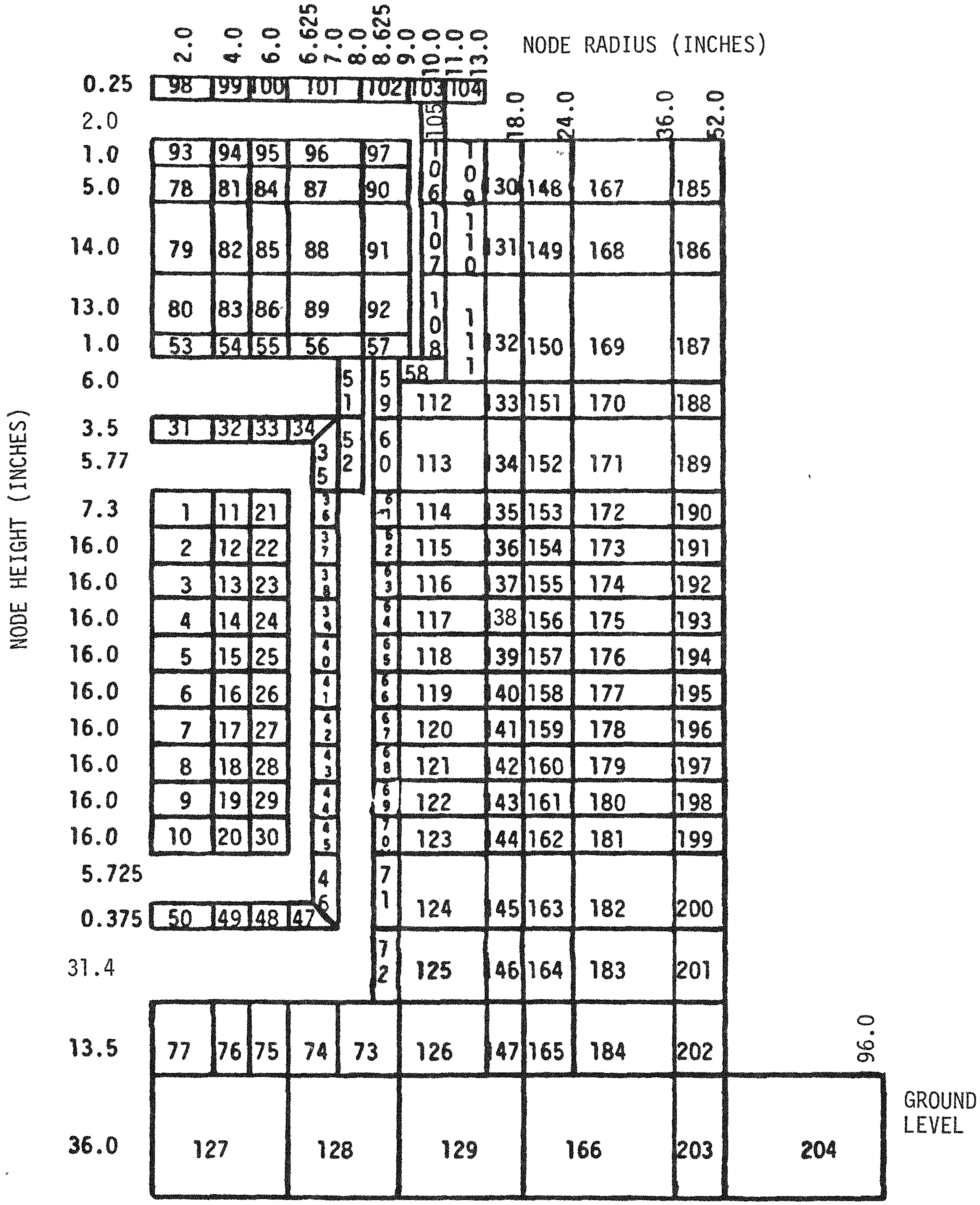

Figure 27. Sealed Storage Cask Thermal Model

TABLE 3

SSC TAP-A MODEL NODE DESCRIPTION

Nodes	Description
1-30	Fuel Assembly
31-50	Canister
51-52	Shield Plug Extension
53-57	Shield Plug Bottom Plate
58	Liner Transition Ring
59-72	Liner Center Section
73-77	Liner Lower Section
78-92	Shield Plug Concrete
93-97	Shield Plug Top Plate
98-104	SSC Cover
105-108	Liner Upper Section
109-126	SSC Concrete
127-129	Concrete Pad
130-165	SSC Concrete
166	Concrete Pad
167-202	SSC Concrete
203-204	Concrete Pad

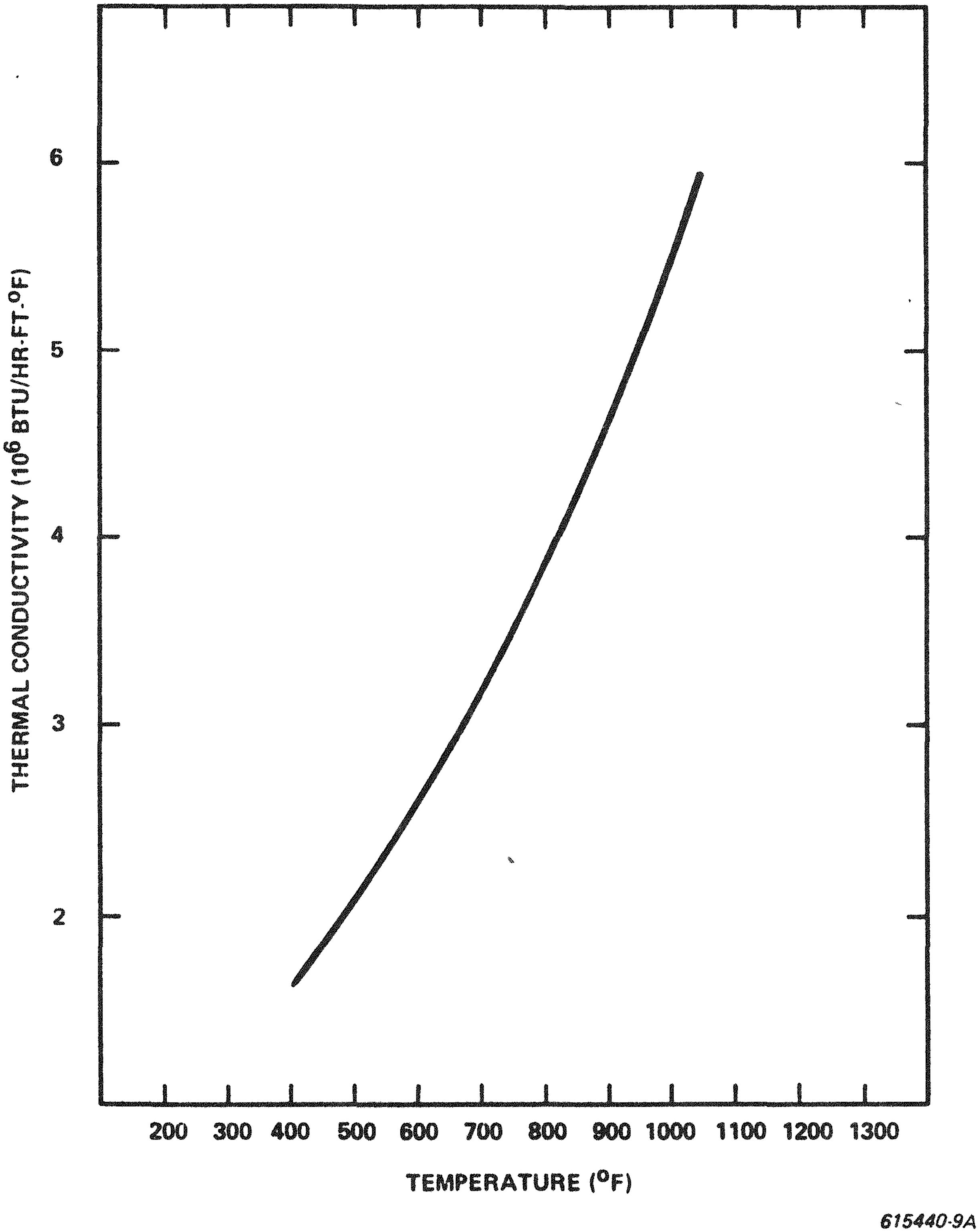

Figure 28. Thermal Conductivity Within Modeled Fuel Assembly

Emissivity values for the canister (0.45) and liner (0.60) were obtained from References 5 (p. 475) and 6 (p. 15-21), respectively, and they apply to Type 304 stainless steel for the canister and to hot rolled steel for the liner. The resulting shape factor value (0.36) is also applied to calculations between the canister and shield plug and between the canister and the liner section at the bottom of the SSC. The axial radiation heat transfer model is judged to be acceptable since data show heat transfer rates vertically through the shield plug and from the canister's lower end to be typically less than 2 percent of the total heat generation rate in the fuel assembly.

The free convection heat transfer between the canister and liner is modeled per Reference 7 by heat transfer in enclosed spaces. The function

$$N_u = \frac{\overline{h}b}{k} = 0.065\ Gr^{1/3} \left(\frac{L}{b}\right)^{-1/9}$$

where:

- Nu = Average Nusselt number
- $\overline{h}$ = Average heat transfer coefficient
- k = Thermal conductivity
- b = Width of enclosed space
- Gr = Grashof number
- L = Heated length

is used to determine the heat transfer coefficient due to natural convection between the canister and liner. For the parameters of the SSC, the heat transfer coefficient of 0.35 Btu/hr-ft^2-°F is used.

Heat transfer from the shield plug sides to the upper liner occurs primarily by radiation and free convection and by convection from the upper surface of the shield plug to the SSC cover plate. For modeling purposes, conduction through an air-filled space is assumed in each direction. This approach is used since

TAP-A has no mass flow capabilities. This simplifying assumption is judged to be acceptable since, due to the relatively small shield plug heat transfer rates, even large modeling inaccuracies in these regions would have little effect on canister temperature predictions. The values used for these heat transfer areas are shown in Table 4.

The interface between two solid materials in contact will produce a certain resistance to the flow of heat across the boundary. In this analysis, however, intimate contact is assumed between the liner and concrete and the contact resistance was assigned zero value.

6.2.3 FUEL ASSEMBLY

The fuel assembly is modeled as a uniform axial and radial heat generating medium with a power decay described in Figure 12 for this type of PWR fuel. The heat source is modeled as a right circular cylinder 144 inch long and 12 inch diameter with a thermal conductivity as shown in Figure 28. No attempt was made to model the individual fuel pins. An attempt was made to maintain the approximate heat capacity of the fuel region to more closely predict the canister and fuel temperature during transient heatup and ambient temperature changes. The fuel assembly was placed in the SSC in December, 1978 when the power level of the fuel assembly was approximately 1.1 kW (see Figure 12). The fuel power level then decays gradually to 0.7 kW at the end of March, 1980.

6.2.4 OUTSIDE SURFACE OF SSC

On the outside surface of the SSC several heat transfer processes occur: solar insolation, solar reflection, radiation back to sky and convection to and from the ambient air. Of these processes, solar effects are not considered. Test data has shown that the day-night solar effects are (on the south side of the SSC) damped out in the first 15 inches of concrete. Heat transfer by convection at the concrete/air interface is modeled by supplying a convective heat transfer coefficient at the interface and monthly air temperature averages calculated from E-MAD site weather data (see Table 2). The heat transfer coefficient is assigned a constant value of 2.0 Btu/hr-Ft^2-°F (obtained from

TABLE 4

THERMAL CONDUCTIVITY COEFFICIENTS REPRESENTING CONVECTION AND CONDUCTION AT VARIOUS SSC INTERFACES

Temperature (°F)	Between Top of Canister and Bottom of Shield Plug (Btu/hr-ft-°F)	Between Shield Plug and Liner (Btu/hr-ft-°F)	Between Canister and Liner (Btu/hr-ft-°F)	Between Canister and Bottom of Liner (Btu/hr-ft-°F)
100	0.00256	0.0212	0.058	0.00064
300	0.00321	0.0266	0.058	0.00080
500	0.00384	0.0318	0.058	0.00096

Reference 7) and applies to a wind speed of 5 to 10 miles/hour for a direction perpendicular to the SSC surface.

Radiative heat transfer to the sky from the concrete cylinder and the SSC cover plate is calculated using the following emissivity values from Reference 8, (p. 699):

Component	Emissivity
SSC cover plate-gray paint	0.95
Concrete	0.9

6.2.5 MATERIAL PROPERTIES

The various materials used in the SSC test and thermal properties which were input to the thermal model are identified in Table 5. The physical and thermal properties of concrete were measured as a function of temperature in laboratory tests performed by Holmes and Narver, Inc. The results of that work are shown in Table 6. An effective thermal conductivity of the concrete must take into account the reinforcing bar used in the construction of the SSC. A thermal conductivity value of 1.7 Btu/hr-ft-°F is used in the thermal model which best describes the radial temperature profile through the concrete. Appendix C provides several calculational methods which were used in determining the concrete thermal conductivity from the test data.

TABLE 5

MATERIAL THERMAL PROPERTIES USED IN ANALYSIS

Material	Density (lb/in^3)	Heat Capacity (Btu/lb-°F)	Thermal Conductivity (Btu/hr-ft-°F)	Emissivity
Fuel Assembly	0.170	0.10	See Figure 28	--
Stainless Steel	0.289	0.12	9.9	.45
Carbon Steel	0.283	0.12	23.0	.60
Concrete	0.083	0.21	1.7	.90

TABLE 6

SSC #2 CONCRETE PROPERTIES

TEMPERATURE (°F)	THERMAL CONDUCTIVITY (Btu/hr-ft-°F)		
	Bottom	Middle	Top
Room	1.29	1.23	1.37
100	-*	1.02	1.04
200	0.95	0.92	0.97
300	0.90	0.90	0.91
400	0.80	0.78	0.80
500	0.70	0.74	0.72
600	0.65	0.66	0.69
700	0.54	0.51	0.62

* No Data

TEMPERATURE (°F)	SPECIFIC HEAT (Btu/lb-°F)		
	Bottom	Middle	Top
100	0.213	0.215	0.213
200	0.222	0.224	0.222
300	0.232	0.234	0.232
400	0.241	0.244	0.241
500	0.251	0.253	0.251
600	0.260	0.263	0.260
700	0.270	0.272	0.270

COEFFICIENT OF THERMAL EXPANSION AND DENSITY

Test	Bottom	Middle	Top
Density (lb/ft^3)	142	145	144
Coefficient of Thermal Expansion (10^{-6}/°F)	6.0	6.0	6.2

7.0 THERMAL ANALYSIS RESULTS

7.1 MODEL EVALUATION CRITERIA

With proper input, a SSC thermal analysis model should produce accurate temperature predictions for the canister, liner, and concrete. Accurate canister temperatures are important as input to independent fuel assembly studies while accurate concrete temperatures are important to SSC stress analyses. Of greater importance is the need to correctly predict temperature trends and relationships for a range of power levels with seasonal temperature variations. Satisfying this objective will demonstrate that the analysis can correctly model the appropriate heat transfer mechanisms and maintain the proper relationships between them as system forcing functions and boundary conditions change. As long as the model satisfies this requirement, small systematic differences between predicted and measured temperatures should not be of concern. In most cases, their existence will be recognized and explained based upon model input uncertainty.

With these criteria in mind, the sections to follow will present a comparison of TAP-A temperature predictions with data from the SSC Test.

7.2 MODEL/DATA COMPARISON

The SSC was thermally analyzed over a 1.5 year time period from installation of the fuel canister in December, 1978 to July, 1980. A computer printout of the temperatures in the SSC at monthly intervals (the printouts are shown in Appendix B) were then compared to the actual temperature data. Figure 29 shows the monthly canister and liner maximum temperature comparisons at the 128 inch elevation position for the thermal model and actual data. From Figure 29 it can be seen that good agreement with the liner temperatures are obtained over the complete life of the test. This shows that using the monthly averaged air temperature approach for boundary condition is a reasonably good way to analyze the SSC. The data shows that the solar heating effect on the south side of the

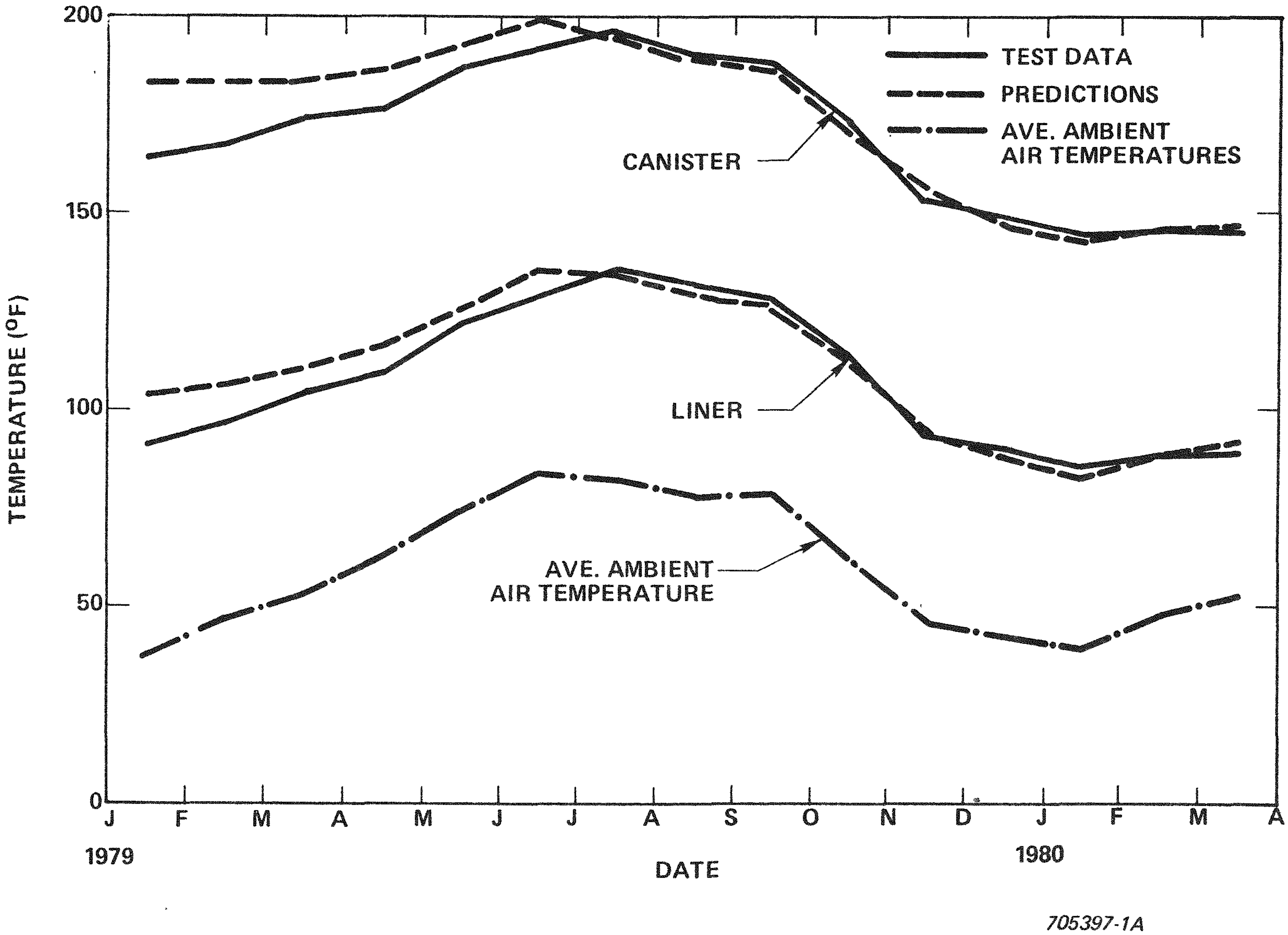

Figure 29. Test Data and Predictions Comparison of Monthly Average Midplane (Elevation 128") Temperatures

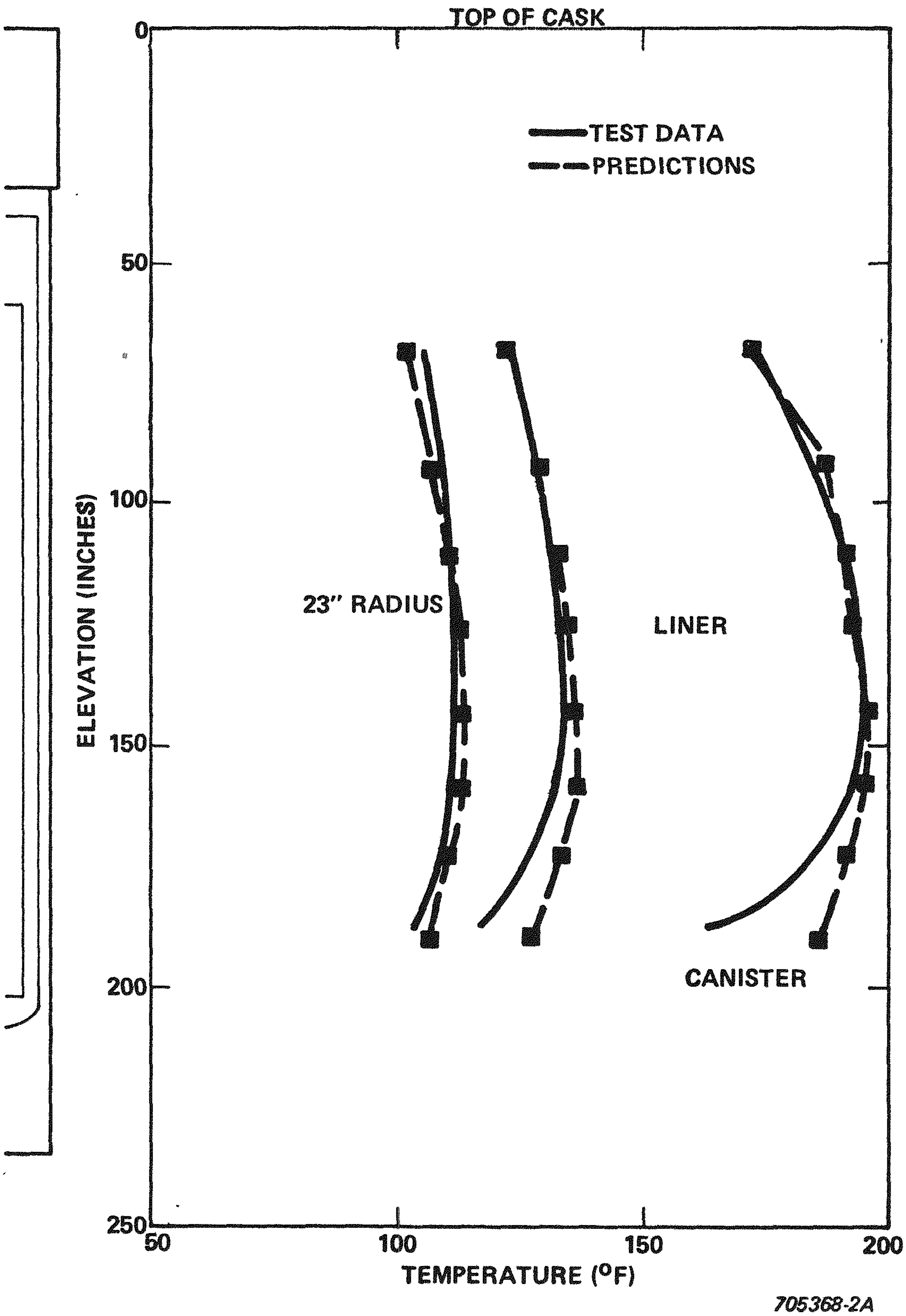

Figure 30. Test Data and Prediction Comparison of Axial Temperature Distribution on July 24, 1979 (5427 Hours)

SSC doesn't influence the liner temperature to any large degree. Hence, solar effects can be ignored when determining liner and canister temperatures.

The maximum canister temperature predictions are reasonably good when compared with the data. The thermal model tends to overpredict the canister temperature early in the test (January through July, 1979) by about 10 to 20°F. Later on, the results show excellent agreement between the canister temperature predictions and data.

Figure 30 shows a comparison of the axial temperature profiles for the canister, liner and one radial position in the concrete on July 24, 1979. The predictions are higher than the data in the lower section of the SSC near the canister bottom, but show excellent agreement elsewhere. The maximum values are in good agreement everywhere. The lower section between the canister and the liner bottom was conservatively modeled by conduction and radiation only. A better method would be to account for natural convection also, which would then have lowered the the temperature of the canister in this region. Likewise, for conservatism, radiation heat transfer was not used in the internals of the canister from the fuel to the canister, hence less heat was allowed to go axially downward to the bottom of the canister, which would have reduced the temperatures along the side of the canister in this lower region.

A comparison of the radial temperature profile in July, 1979 is shown in Figure 31. This figure shows the temperature comparison at the maximum temperature axial position. Good agreement between the thermal model and data is shown by this comparison. This shows that the effective thermal conductivity of SSC concrete of 1.7 which includes the reinforcing bar and the decay heat power used in the thermal analysis were reasonable values in predicting the actual radial temperature profiles.

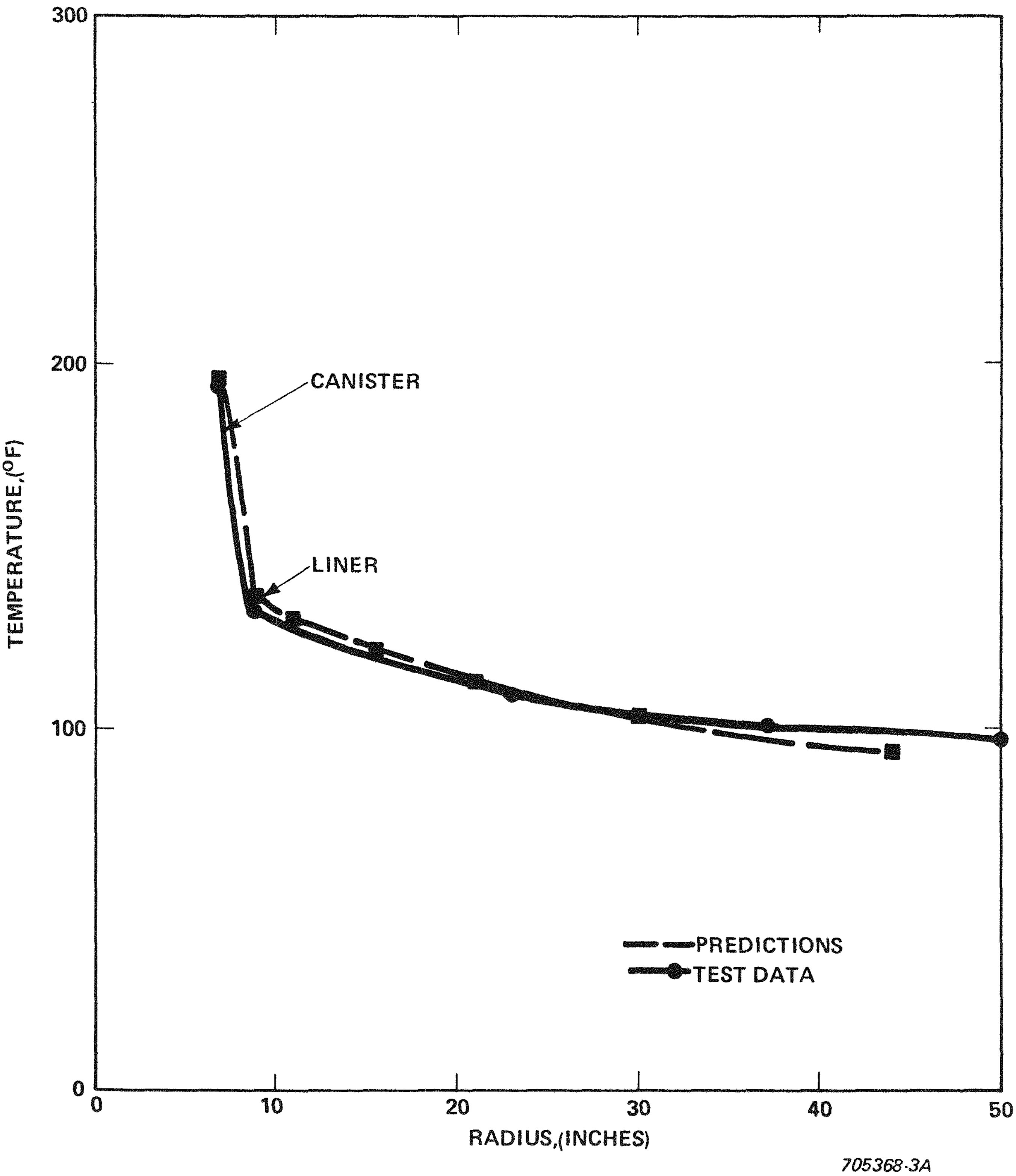

Figure 31. Test Data and Predictions Comparison of Radial Temperature Distribution at Elevation 128" on July 24, 1979 (5427 Hours)

8.0 REFERENCES

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APPENDIX A

SEALED STORAGE CASK TEST DATA

Test data are provided in this Appendix for the SSC thermocouples. Table 1 of the text provides the detail information on the location of the SSC #2 thermocouples. Table A-1 through A-16 provides data logger printouts of the thermocouple readings.

Table	Date	Operating Hours
A-1	1/15/79	937
A-2	2/15/79	1681
A-3	3/15/79	2353
A-4	4/15/79	3097
A-5	5/14/79	3793
A-6	6/18/79	4633
A-7	7/15/79	5281
A-8	8/15/79	6025
A-9	9/15/79	6769
A-10	10/14/79	7465
A-11	11/16/79	8287
A-12	12/15/79	8953
A-13	1/15/80	9713
A-14	2/16/80	10465
A-15	3/15/80	11137
A-16	4/15/80	11881

TABLE A-1

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 1/15/79 TIME: 16:00

OPERATING HOURS: 937

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	52.9	683	130.9
653	61.1	682	136.6
652	77.6	681	171.4
651	47.7	680	166.1
650	57.5	679	169.0
649	69.2	678	170.0
648	96.1	677	163.8
647	46.4	676	162.5
646	54.6	675	151.3
645	65.1	674	148.2
644	86.6	673	78.9
643	54.2	672	78.8
642	45.7	671	96.0
641	63.3	670	96.3
640	77.7	669	87.3
639	47.4	668	82.4
638	58.4	667	45.7
637	72.7	666	50.3
636	96.5	665	59.0
635	46.2	664	77.5
634	54.8	663	47.0
663	67.1	662	55.3
632	88.9	661	67.2
631	46.2	660	95.2
630	51.8	659	45.1
629	61.4	658	53.2
628	77.4	657	63.3
627	47.7	656	83.3
626	56.1	655	45.5
625	72.1		
624	95.2		
623	46.5		
622	54.4		
621	65.1		
620	86.0		

TABLE A-2

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 2/15/79 TIME: 16:00

OPERATING HOURS: 1681

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	59.9	683	132.8
653	66.8	682	138.5
652	82.0	681	172.6
651	83.8	680	167.2
650	65.5	679	170.9
649	75.1	678	172.2
648	100.6	677	165.8
647	84.7	676	164.8
646	63.0	675	153.6
645	71.7	674	150.4
644	91.7	673	83.0
643	60.2	672	82.8
642	60.1	671	100.3
641	68.3	670	100.5
640	81.9	669	92.3
639	66.0	668	87.6
638	65.4	667	55.1
637	78.2	666	55.5
636	100.8	665	64.2
635	65.8	664	81.6
634	62.6	663	57.6
633	73.3	662	60.7
632	93.8	661	72.7
631	54.8	660	99.7
630	57.2	659	57.7
629	66.5	658	59.0
628	81.7	657	69.2
627	58.4	656	88.3
626	61.7	655	66.1
625	77.3		
624	99.7		
623	57.9		
622	60.5		
621	71.1		
620	91.2		

TABLE A-3

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 3/15/79 TIME: 16:00

OPERATING HOURS: 2353

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	70.7	683	143.3
653	78.5	682	148.7
652	93.8	681	181.6
651	70.9	680	177.0
650	76.1	679	179.5
649	86.8	678	181.4
648	111.9	677	174.0
647	69.7	676	173.3
646	73.2	675	161.7
645	82.7	674	158.6
644	102.7	673	94.5
643	71.1	672	94.5
642	64.6	671	111.3
641	80.2	670	111.7
640	93.8	669	102.9
639	66.8	668	98.3
638	75.7	667	64.0
637	89.6	666	66.4
636	112.3	665	75.5
635	65.9	664	93.4
634	72.3	663	66.4
633	84.1	662	71.7
632	104.7	661	84.0
631	63.2	660	110.8
630	67.2	659	65.0
629	77.5	658	69.5
628	93.3	657	78.8
627	65.4	656	99.0
626	71.8	655	65.5
625	88.2		
624	110.7		
623	64.5		
622	70.3		
621	81.4		
620	101.8		

TABLE A-4

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 4/15/79 TIME: 16:00

OPERATING HOURS: 3097

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	75.9	683	141.8
653	80.6	682	146.6
652	93.4	681	178.9
651	96.7	680	174.5
650	80.8	679	177.0
649	88.4	678	178.5
648	111.0	677	171.7
647	97.3	676	170.8
646	78.5	675	159.7
645	84.6	674	157.2
644	102.2	673	94.2
643	75.6	672	94.1
642	79.5	671	110.2
641	81.3	670	110.5
640	93.2	669	102.5
639	84.3	668	98.2
638	80.3	667	76.7
637	90.4	666	71.7
636	110.9	665	77.5
635	83.9	654	92.8
634	77.7	663	79.8
633	85.4	662	76.2
632	104.0	661	85.4
631	75.2	660	109.5
630	71.9	659	81.1
629	78.8	658	74.0
628	92.6	657	81.5
627	80.5	656	98.5
626	76.3	655	82.8
625	88.6		
624	109.5		
623	80.2		
622	74.6		
621	82.5		
620	100.8		

TABLE A-5

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 5/14/79 TIME: 20:00

OPERATING HOURS: 3793

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	84.2	683	146.7
653	87.1	682	151.6
652	99.9	681	182.9
651	90.0	680	178.7
650	89.5	679	181.0
649	94.7	678	182.9
648	116.8	677	175.8
647	94.6	678	174.7
646	87.4	675	163.7
645	91.2	674	161.5
644	108.5	673	100.4
643	83.5	672	100.5
642	86.9	671	116.1
641	88.0	670	116.7
640	99.7	669	108.7
639	89.8	668	104.8
638	88.3	667	57.5
637	96.6	666	81.5
636	116.9	665	84.9
635	89.2	664	99.0
634	86.1	663	91.0
633	92.1	662	85.8
632	110.3	661	92.7
631	85.0	660	116.1
630	81.1	659	88.3
629	85.8	658	83.1
628	99.2	657	88.7
627	85.4	656	105.1
626	85.4	655	88.7
625	95.4		
624	115.8		
623	88.2		
622	83.5		
621	89.8		
620	107.4		

TABLE A-6

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 6/18/79 TIME: 16:00

OPERATING HOURS: 4633

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	85.2	683	159.3
653	96.7	682	163.4
652	113.4	681	194.3
651	91.6	680	190.3
650	89.2	679	192.5
649	103.6	678	193.0
648	129.8	677	186.6
647	90.9	676	185.7
646	88.0	675	174.3
645	99.5	674	171.4
644	120.3	673	114.8
643	86.0	672	114.6
642	78.1	671	130.1
641	98.5	670	130.2
640	113.2	669	121.1
639	83.8	668	116.5
638	89.2	667	77.6
637	106.7	666	82.5
636	130.1	665	95.7
635	83.3	664	113.7
634	85.6	663	80.2
633	101.0	662	87.0
632	122.1	661	103.0
631	75.9	660	129.4
630	83.2	659	81.0
629	97.6	658	84.9
628	113.5	657	98.7
627	80.8	656	117.6
626	86.9	655	81.0
625	107.5		
624	129.6		
623	80.2		
622	85.0		
621	100.1		
620	119.8		

TABLE A-7

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 7/15/79 TIME: 16:00

OPERATING HOURS: 5281

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	100.5	683	164.8
653	107.1	682	169.1
652	120.8	681	198.9
651	112.8	680	195.1
650	105.2	679	197.5
649	114.5	678	198.6
648	137.1	677	132.0
647	113.0	676	191.2
646	102.8	675	179.8
645	111.1	674	177.7
644	128.6	673	121.8
643	101.1	672	121.7
642	101.3	671	137.0
641	108.3	670	137.4
640	120.7	669	129.4
639	105.7	668	125.3
638	105.1	667	99.7
637	116.7	666	98.6
636	137.3	665	105.8
635	105.2	664	120.7
634	102.6	663	102.4
633	112.1	662	103.3
632	130.4	661	113.4
631	98.7	660	136.6
630	98.8	659	104.1
629	106.9	658	101.3
628	120.5	657	109.6
627	103.7	656	125.7
626	102.9	655	102.6
625	116.4		
624	136.5		
623	103.1		
622	101.7		
621	110.7		
620	128.0		

TABLE A-8

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 8/15/79 TIME: 16:00

OPERATING HOURS: 6025

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	90.6	683	157.0
653	98.3	682	161.5
652	113.1	681	190.6
651	102.3	680	186.6
650	94.8	679	188.6
649	105.1	678	189.9
648	128.7	677	182.6
647	102.2	676	181.8
646	91.8	675	170.5
645	100.7	674	168.1
644	119.1	673	114.1
643	91.1	672	114.0
642	89.7	671	128.6
641	99.9	670	128.9
640	113.1	669	119.9
639	93.8	668	115.4
638	94.8	667	88.7
637	107.8	666	89.0
636	128.9	665	97.4
635	93.1	664	113.4
634	91.4	663	91.2
633	102.1	662	93.4
632	120.9	661	104.5
631	87.7	660	128.4
630	89.5	659	91.6
629	99.0	658	90.5
628	113.2	657	99.9
627	92.2	656	116.4
626	93/3	655	91.2
625	104.2		
624	128.4		
623	91.5		
622	91.5		
621	101.1		
620	118.8		

TABLE A-9

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 9/15/79 TIME: 16:00

OPERATING HOURS: 6769

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	97.6	683	161.0
653	105.7	682	165.1
652	118.9	681	193.8
651	113.4	680	189.8
650	102.1	679	192.3
549	112.5	678	193.5
646	134.3	677	187.0
647	113.8	676	186.2
646	99.6	675	175.1
645	109.0	674	173.1
644	125.9	673	119.6
643	98.1	672	119.5
642	97.8	671	134.0
641	106.7	670	134.3
640	116.7	669	126.5
639	103.3	668	122.3
638	101.5	667	91.9
637	114.8	666	93.4
636	134.5	665	102.6
635	102.7	664	118.3
634	98.8	663	93.8
633	110.0	662	97.6
632	127.7	661	109.8
631	91.3	660	133.3
630	94.6	659	94.6
679	104.4	658	95.9
628	118.3	657	106.0
627	95.8	656	122.6
626	98.1	655	101.1
625	113.4		
624	133.3		
623	95.2		
622	97.1		
621	107.4		
620	125.0		

TABLE A-10

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 10/14/79 TIME: 16:00

OPERATING HOURS: 7465

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	82.5	683	146.4
653	90.7	682	150.5
652	104.0	681	178.8
651	98.5	680	175.0
650	86.4	679	177.1
649	96.9	678	178.4
648	118.7	677	171.6
647	100.1	676	170.7
646	83.7	675	160.4
645	93.1	674	157.7
644	110.1	673	104.9
643	83.8	672	104.6
642	81.1	671	118.6
641	92.3	670	118.6
640	103.8	669	110.6
639	86.6	668	106.3
636	86.9	667	76.7
637	99.8	666	78.6
636	119.0	665	88.2
635	85.4	664	103.6
634	83.8	663	78.6
633	94.6	662	82.7
632	111.9	661	94.6
631	76.0	660	117.7
630	80.0	659	78.5
629	90.3	658	80.7
628	103.7	657	90.8
627	80.6	656	107.0
626	83.4	655	84.6
625	98.8		
624	117.8		
623	79.7		
622	82.1		
621	92.3		
620	109.3		

TABLE A-11

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 11/16/79 TIME: 16:00

OPERATING HOURS: 8287

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	67.5	683	125.8
653	72.5	682	130.2
652	83.6	681	158.1
651	75.7	680	154.9
650	71.7	679	156.9
649	78.6	678	158.4
648	97.7	677	152.3
647	74.7	676	151.1
646	69.6	675	141.7
645	75.6	674	139.5
644	90.5	673	84.4
643	67.4	672	84.3
642	67.4	671	97.6
641	73.4	670	97.8
640	83.4	669	90.8
639	70.7	668	87.1
638	70.9	667	63.4
637	80.8	666	62.2
636	97.9	665	68.6
635	69.9	664	82.8
634	68.6	663	65.1
633	76.5	662	65.8
632	92.1	661	74.9
631	63.7	660	96.4
630	63.5	659	64.4
629	70.5	658	64.2
628	82.7	657	71.8
627	66.2	656	87.2
626	66.9	655	70.7
625	78.6		
624	96.4		
623	65.4		
622	65.4		
621	73.2		
620	89.1		

TABLE A-12

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 12/15/79 TIME: 16:00

OPERATING HOURS: 8953

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	58.8	683	117.4
653	64.2	682	121.8
652	75.6	681	149.4
651	83.4	680	145.9
650	62.9	679	147.6
649	70.2	678	149.5
648	89.4	677	143.0
647	83.9	676	142.1
646	60.4	675	132.6
645	66.6	674	129.9
644	81.6	673	76.1
643	59.0	672	76.2
642	62.1	671	89.0
641	65.4	670	89.2
640	75.4	669	82.0
639	67.8	668	78.2
638	62.5	667	55.2
637	72.7	666	53.4
636	89.7	665	60.4
635	66.7	664	74.8
634	59.7	663	57.6
633	67.8	662	57.1
632	83.4	661	66.6
631	55.9	660	88.3
630	54.9	659	57.7
629	62.5	658	55.0
628	74.7	657	62.9
627	59.9	656	78.3
626	58.2	655	68.1
625	70.5		
624	88.2		
623	59.1		
622	56.5		
621	64.6		
620	80.7		

TABLE A-13

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 1/15/80 TIME: 16:00

OPERATING HOURS: 9713

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	56.9	683	115.0
653	62.1	682	119.4
652	73.7	681	146.8
651	79.4	680	143.1
650	60.6	679	145.7
649	67.7	678	147.2
648	87.2	677	141.1
647	80.3	676	139.8
646	58.5	675	130.8
645	64.9	674	127.4
644	80.2	673	74.5
643	57.6	672	74.6
642	59.0	671	87.5
641	63.4	670	87.5
640	73.5	669	81.2
639	64.2	668	77.4
638	61.0	667	55.5
637	70.4	666	55.4
636	87.6	665	61.2
635	63.4	664	73.6
634	58.8	663	57.4
633	66.3	662	58.9
632	82.0	661	67.0
631	55.6	660	87.1
630	56.4	659	57.1
629	62.7	658	57.4
628	73.7	657	64.3
627	59.3	656	78.1
626	59.5	655	64.2
625	70.5		
624	87.2		
623	59.0		
622	58.3		
621	65.7		
620	80.3		

TABLE A-14

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 2/16/80 TIME: 16:00

OPERATING HOURS: 10465

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
654	55.4	683	112.4
653	60.3	682	116.8
652	71.7	681	143.6
651	54.4	680	140.1
650	59.1	679	142.7
649	66.0	678	144.1
648	85.2	677	138.1
647	52.8	676	136.9
646	56.8	675	127.8
645	62.9	674	124.5
644	78.1	673	72.6
643	56.0	672	72.6
642	52.1	671	85.4
641	61.5	670	85.6
640	71.7	669	78.8
639	54.0	668	75.1
638	59.5	667	51.8
637	68.6	666	54.1
636	85.7	665	59.2
635	52.8	664	71.8
634	57.0	663	53.1
633	64.4	662	57.7
632	79.8	661	65.2
631	52.1	660	85.0
630	55.0	659	51.3
629	60.8	658	55.9
628	71.7	657	62.1
627	54.0	656	75.9
626	58.2	655	51.9
625	68.6	655	51.9
624	85.0		
623	53.2		
622	56.8		
621	63.4		
620	78.1		

TABLE A-15

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 3/15/80 TIME: 16:00

OPERATING HOURS: 11137

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
653	67.2	683	115.9
652	76.7	682	120.0
651	82.8	681	146.5
650	67.4	680	143.5
649	73.0	679	145.7
648	89.9	678	147.3
647	82.8	677	141.4
646	65.4	676	140.1
645	70.2	675	131.3
644	83.4	674	128.9
643	62.9	673	77.2
642	64.1	672	77.2
641	67.6	671	89.5
640	76.4	670	89.9
639	68.5	669	83.7
638	66.3	668	80.4
637	74.6	667	61.5
636	89.9	666	58.7
635	68.2	665	63.5
634	64.4	664	75.7
633	70.9	663	64.1
632	84.9	662	62.3
631	60.6	661	69.6
630	59.4	660	88.6
629	64.7	659	65.6
628	75.6	658	60.8
627	65.6	657	66.7
626	62.8	656	80.3
625	72.5	655	68.2
624	88.6	654	63.6
623	65.6		
622	61.6		
621	67.9		
620	82.4		

TABLE A-16

SSC #2 TEST - TEMPERATURE DISTRIBUTION

DATE: 4/15/80 TIME: 16:00

OPERATING HOURS: 11881

THERMOCOUPLE READINGS

T/C No.	Temp (°F)	T/C No.	Temp (°F)
653	77.6	683	125.9
652	87.2	682	129.5
651	97.0	681	155.7
650	77.7	680	152.3
649	83.6	679	154.9
648	100.8	678	156.1
647	96.5	677	150.5
646	75.8	676	149.2
645	80.8	675	140.4
644	93.9	674	138.0
643	73.3	673	88.2
642	79.4	672	88.0
641	78.0	671	100.5
640	86.8	670	100.7
639	85.5	669	94.6
638	77.0	668	91.2
637	85.2	667	75.2
636	100.6	666	69.3
635	85.6	665	74.5
634	75.2	664	86.4
633	81.4	663	78.9
632	95.4	662	72.9
631	73.5	661	80.8
630	69.5	660	99.3
629	75.6	659	80.5
628	86.2	658	71.5
627	79.5	657	77.8
626	73.2	656	91.0
625	83.3	655	83.7
624	99.4	654	73.7
623	79.6		
622	72.1		
621	78.7		
620	92.8		

APPENDIX B

TAP-A INPUT AND OUTPUT

This Appendix contains a copy of typical computer printout of the TAP-A input data and printouts of the output data for the times listed. The nodes are identified and their locations are shown in Figure 27. For an explanation of the input data and its format, see Reference 4.

Temperature Calculations

Seconds*	Equivalent Operating Hours	Date
.130E07	946	1/15/79
.389E07	1668	2/14/79
.648E07	2388	3/15/79
.907E07	3104	4/14/79
.117E08	3835	5/14/79
.143E08	4557	6/13/79
.168E08	5252	7/13/79
.194E08	5974	8/12/79
.220E08	6696	9/11/79
.246E08	7418	10/11/79
.272E08	8140	11/10/79
.298E08	8862	12/10/79
.324E08	9585	1/10/80
.350E08	10307	2/9/80
.376E08	11029	3/9/80
.402E08	11752	4/8/80

* January 1, 1979 is zero time for printouts of output data.

TAP--TRANSIENT ANALYSIS PROGRAM

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

SPECIFICATIONS

INITIAL TIME	FINAL TIME	TIME INCREMENT	CONVERGE CRITERIA	PROBLEM TYPE	STEPS BEFORE ACCELERATE	MAXIMUM NO. ITERATION
0.0000	50000000.0000	21600.0000	.0050	3.0000	50	3000

BOUNDARY TEMPERATURE TABLES

TABLE	TIME	TEMP	TIME	TEMP	TIME	TEMP	TIME	TEMP	TIME	TEMP
1										
	0.00	41.00	1296000.00	41.00	3888000.00	46.00	6480000.00	51.00	9072000.00	60.00
	11664000.00	72.00	**********	83.00	**********	80.00	**********	78.00	**********	78.00
	24624000.00	62.00	**********	46.00	**********	42.00	**********	39.00	**********	48.00
	37584000.00	53.00	**********	62.00	**********	74.00	**********	82.00		

MATERIALS

NO.	DENSITY	HEAT CAP.	CONDUCTIVITY	TEMP.	HEAT CAP.	CONDUCTIVITY	TEMP.	HEAT CAP.	CONDUCTIVITY	TEMP.
201	.0540	.1000	.1620E-05	100.00	.1000	.1620E-05	345.00	.1000	.2360E-05	500.00
		.1000	.3009E-05	600.00	.1000	.3704E-05	700.00	.1000	.4398E-05	800.00
		.1000	.5092E-05	900.00	.1000	.6020E-05	1000.00	.1000	.6020E-05	1300.00
226	.2894	.1200	.2315E-03							
227	.2836	.1500	.5324E-03							
228	.0830	.2000	.3930E-04							

INTERNAL HEAT GENERATION MULTIPLIER TABLES

TABLE ONE	TABLE TWO	TIME
1.0000	0.0000	0.0000
.9040	0.0000	7776000.0000
.8160	0.0000	15552000.0000
.7360	0.0000	23328000.0000
.6800	0.0000	31104000.0000
.6160	0.0000	38880000.0000
.5760	0.0000	46656000.0000
.5360	0.0000	54432000.0000
.5040	0.0000	62208000.0000

INTERNAL NODES

NODE	MATERIAL	VOLUME	BASE GEN.1	BASE GEN.2	TEMPERATURE
1	201	.9173E+02	0.	0.	200.00
2	201	.2011E+03	.1288E-01	0.	200.00
3	201	.2011E+03	.1288E-01	0.	200.00
4	201	.2011E+03	.1288E-01	0.	200.00
5	201	.2011E+03	.1288E-01	0.	200.00
6	201	.2011E+03	.1288E-01	0.	200.00
7	201	.2011E+03	.1288E-01	0.	200.00
8	201	.2011E+03	.1288E-01	0.	200.00
9	201	.2011E+03	.1288E-01	0.	200.00
10	201	.2011E+03	.1288E-01	0.	200.00
11	201	.2752E+03	0.	0.	200.00
12	201	.6032E+03	.3514E-01	0.	200.00
13	201	.6032E+03	.3514E-01	0.	200.00
14	201	.6032E+03	.3514E-01	0.	200.00
15	201	.6032E+03	.3514E-01	0.	200.00
16	201	.6032E+03	.3514E-01	0.	200.00
17	201	.6032E+03	.3514E-01	0.	200.00
18	201	.6032E+03	.3514E-01	0.	200.00
19	201	.6032E+03	.3514E-01	0.	200.00
20	201	.6032E+03	.3514E-01	0.	200.00
21	201	.4587E+03	0.	0.	200.00
22	201	.1005E+04	.6441E-01	0.	200.00
23	201	.1005E+04	.6441E-01	0.	200.00
24	201	.1005E+04	.6441E-01	0.	200.00
25	201	.1005E+04	.6441E-01	0.	200.00
26	201	.1005E+04	.6441E-01	0.	200.00
27	201	.1005E+04	.6441E-01	0.	200.00
28	201	.1005E+04	.6441E-01	0.	200.00
29	201	.1005E+04	.6441E-01	0.	200.00
30	201	.1005E+04	.6441E-01	0.	200.00
31	226	.2199E+02	0.	0.	165.00
32	226	.1319E+03	0.	0.	165.00
33	226	.2199E+03	0.	0.	165.00
34	226	.1145E+03	0.	0.	165.00
35	226	.1207E+03	0.	0.	165.00
36	226	.1172E+03	0.	0.	165.00
37	226	.2568E+03	0.	0.	165.00
38	226	.2568E+03	0.	0.	165.00
39	226	.2568E+03	0.	0.	165.00
40	226	.2568E+03	0.	0.	165.00
41	226	.2568E+03	0.	0.	165.00
42	226	.2568E+03	0.	0.	165.00
43	226	.2568E+03	0.	0.	165.00
44	226	.2568E+03	0.	0.	165.00
45	226	.2568E+03	0.	0.	165.00

46	226	.9490E+02	0.	0.	165.00
47	226	.1226E+02	0.	0.	165.00
48	226	.2356E+02	0.	0.	165.00
49	226	.1414E+02	0.	0.	165.00
50	226	.2356E+01	0.	0.	165.00
51	227	.2827E+03	0.	0.	165.00
52	227	.4354E+03	0.	0.	165.00
53	227	.6283E+01	0.	0.	165.00
54	227	.3770E+02	0.	0.	165.00
55	227	.6283E+02	0.	0.	165.00
56	227	.8796E+02	0.	0.	165.00
57	227	.1131E+03	0.	0.	165.00
58	227	.6283E+02	0.	0.	100.00
59	227	.1246E+03	0.	0.	100.00
60	227	.1925E+03	0.	0.	100.00
61	227	.1516E+03	0.	0.	100.00
62	227	.3322E+03	0.	0.	100.00
63	227	.3322E+03	0.	0.	100.00
64	227	.3322E+03	0.	0.	100.00
65	227	.3322E+03	0.	0.	100.00
66	227	.3322E+03	0.	0.	100.00
67	227	.3322E+03	0.	0.	100.00
68	227	.3322E+03	0.	0.	100.00
69	227	.3322E+03	0.	0.	100.00
70	227	.3322E+03	0.	0.	100.00
71	227	.1207E+03	0.	0.	100.00
72	227	.6520E+03	0.	0.	100.00
73	228	.1357E+04	0.	0.	100.00
74	228	.5513E+03	0.	0.	100.00
75	228	.8482E+03	0.	0.	100.00
76	228	.5089E+03	0.	0.	100.00
77	228	.8482E+02	0.	0.	100.00
78	228	.3142E+02	0.	0.	100.00
79	228	.8796E+02	0.	0.	100.00
80	228	.8168E+02	0.	0.	165.00
81	228	.1885E+03	0.	0.	165.00
82	228	.5278E+03	0.	0.	165.00
83	228	.4901E+03	0.	0.	165.00
84	228	.3142E+03	0.	0.	165.00
85	228	.8796E+03	0.	0.	165.00
86	228	.8168E+03	0.	0.	165.00
87	228	.4398E+03	0.	0.	165.00
88	228	.1232E+04	0.	0.	165.00
89	228	.1144E+04	0.	0.	165.00
90	228	.5655E+03	0.	0.	165.00
91	228	.1583E+04	0.	0.	165.00
92	228	.1470E+04	0.	0.	165.00
93	227	.6283E+01	0.	0.	165.00
94	227	.3770E+02	0.	0.	165.00
95	227	.6283E+02	0.	0.	165.00
96	227	.8796E+02	0.	0.	165.00
97	227	.1131E+03	0.	0.	165.00
98	227	.1571E+01	0.	0.	45.00
99	227	.9425E+01	0.	0.	45.00
100	227	.1571E+02	0.	0.	45.00
101	227	.2199E+02	0.	0.	45.00
102	227	.2827E+02	0.	0.	45.00
103	227	.1649E+02	0.	0.	45.00
104	227	.3770E+02	0.	0.	45.00
105	227	.1001E+03	0.	0.	45.00
106	227	.3004E+03	0.	0.	45.00
107	227	.7010E+03	0.	0.	45.00
108	227	.7010E+03	0.	0.	45.00
109	228	.9048E+03	0.	0.	45.00
110	228	.2111E+04	0.	0.	45.00
111	228	.2187E+04	0.	0.	45.00
112	228	.1521E+04	0.	0.	45.00
113	228	.2563E+04	0.	0.	45.00
114	228	.2018E+04	0.	0.	45.00
115	228	.4423E+04	0.	0.	45.00
116	228	.4423E+04	0.	0.	45.00
117	228	.4423E+04	0.	0.	45.00
118	228	.4423E+04	0.	0.	45.00
119	228	.4423E+04	0.	0.	45.00
120	228	.4423E+04	0.	0.	45.00
121	228	.4423E+04	0.	0.	45.00
122	228	.4423E+04	0.	0.	45.00
123	228	.4423E+04	0.	0.	45.00
124	228	.1686E+04	0.	0.	45.00
125	228	.6681E+04	0.	0.	45.00

126	228	.3732E+04	0.	0.	45.00
127	228	.8168E+04	0.	0.	45.00
128	228	.1838E+05	0.	0.	45.00
129	228	.9924E+05	0.	0.	45.00
130	228	.2922E+04	0.	0.	45.00
131	228	.6817E+04	0.	0.	45.00
132	228	.7061E+04	0.	0.	45.00
133	228	.2678E+04	0.	0.	45.00
134	228	.4514E+04	0.	0.	45.00
135	228	.3555E+04	0.	0.	45.00
136	228	.7791E+04	0.	0.	45.00
137	228	.7791E+04	0.	0.	45.00
138	228	.7791E+04	0.	0.	45.00
139	228	.7791E+04	0.	0.	45.00
140	228	.7791E+04	0.	0.	45.00
141	228	.7791E+04	0.	0.	45.00
142	228	.7791E+04	0.	0.	45.00
143	228	.7791E+04	0.	0.	45.00
144	228	.7791E+04	0.	0.	45.00
145	228	.2970E+04	0.	0.	45.00
146	228	.1529E+05	0.	0.	45.00
147	228	.6574E+04	0.	0.	45.00
148	228	.4750E+04	0.	0.	45.00
149	228	.1108E+05	0.	0.	45.00
150	228	.1148E+05	0.	0.	45.00
151	228	.4354E+04	0.	0.	45.00
152	228	.7339E+04	0.	0.	45.00
153	228	.5779E+04	0.	0.	45.00
154	228	.1267E+05	0.	0.	45.00
155	228	.1267E+05	0.	0.	45.00
156	228	.1267E+05	0.	0.	45.00
157	228	.1267E+05	0.	0.	45.00
158	228	.1267E+05	0.	0.	45.00
159	228	.1267E+05	0.	0.	45.00
160	228	.1267E+05	0.	0.	45.00
161	228	.1267E+05	0.	0.	45.00
162	228	.1267E+05	0.	0.	45.00
163	228	.4829E+04	0.	0.	45.00
164	228	.2486E+05	0.	0.	45.00
165	228	.1069E+05	0.	0.	45.00
166	228	.3970E+06	0.	0.	45.00
167	228	.1357E+05	0.	0.	45.00
168	228	.3167E+05	0.	0.	45.00
169	228	.3280E+05	0.	0.	45.00
170	228	.1244E+05	0.	0.	45.00
171	228	.2047E+05	0.	0.	45.00
172	228	.1651E+05	0.	0.	45.00
173	228	.3619E+05	0.	0.	45.00
174	228	.3619E+05	0.	0.	45.00
175	228	.3619E+05	0.	0.	45.00
176	228	.3619E+05	0.	0.	45.00
177	228	.3619E+05	0.	0.	45.00
178	228	.3619E+05	0.	0.	45.00
179	228	.3619E+05	0.	0.	45.00
180	228	.3619E+05	0.	0.	45.00
181	228	.3619E+05	0.	0.	45.00
182	228	.1380E+05	0.	0.	45.00
183	228	.7103E+05	0.	0.	45.00
184	228	.3054E+05	0.	0.	45.00
185	228	.2654E+05	0.	0.	45.00
186	228	.6193E+05	0.	0.	45.00
187	228	.6414E+05	0.	0.	45.00
188	228	.2433E+05	0.	0.	45.00
189	228	.4100E+05	0.	0.	45.00
190	228	.3229E+05	0.	0.	45.00
191	228	.7077E+05	0.	0.	45.00
192	228	.7077E+05	0.	0.	45.00
193	228	.7077E+05	0.	0.	45.00
194	228	.7077E+05	0.	0.	45.00
195	228	.7077E+05	0.	0.	45.00
196	228	.7077E+05	0.	0.	45.00
197	228	.7077E+05	0.	0.	45.00
198	228	.7077E+05	0.	0.	45.00
199	228	.7077E+05	0.	0.	45.00
200	228	.2698E+05	0.	0.	45.00
201	228	.1389E+06	0.	0.	45.00
202	228	.5972E+05	0.	0.	45.00
203	228	.5750E+06	0.	0.	45.00
204	228	.1777E+07	0.	0.	45.00

INTERNAL ADMITTANCES

INTERNAL NODE	SELF ADMIT	BORDER NODE	ADMIT	BORDER NODE	ADMIT	BORDER NODE	ADMIT	BORDER NODE	ADMIT	BORDER NODE	ADMIT
1	-.749E-04	2	.175E-05	31	.556E-05	11	.676E-04				
2	-.151E-03	1	.175E-05	3	.127E-05	12	.148E-03				
3	-.151E-03	2	.127E-05	4	.127E-05	13	.148E-03				
4	-.151E-03	3	.127E-05	5	.127E-05	14	.148E-03				
5	-.151E-03	4	.127E-05	6	.127E-05	15	.148E-03				
6	-.151E-03	5	.127E-05	7	.127E-05	16	.148E-03				
7	-.151E-03	6	.127E-05	8	.127E-05	17	.148E-03				
8	-.151E-03	7	.127E-05	9	.127E-05	18	.148E-03				
9	-.151E-03	8	.127E-05	10	.127E-05	19	.148E-03				
10	-.152E-03	9	.127E-05	50	.254E-05	20	.148E-03				
11	-.235E-03	32	.167E-04	12	.524E-05	1	.676E-04	21	.146E-03		
12	-.476E-03	11	.524E-05	13	.382E-05	2	.148E-03	22	.319E-03		
13	-.475E-03	12	.382E-05	14	.382E-05	3	.148E-03	23	.319E-03		
14	-.475E-03	13	.382E-05	15	.382E-05	4	.148E-03	24	.319E-03		
15	-.475E-03	14	.382E-05	16	.382E-05	5	.148E-03	25	.319E-03		
16	-.475E-03	15	.382E-05	17	.382E-05	6	.148E-03	26	.319E-03		
17	-.475E-03	16	.382E-05	18	.382E-05	7	.148E-03	27	.319E-03		
18	-.475E-03	17	.382E-05	19	.382E-05	8	.148E-03	28	.319E-03		
19	-.475E-03	18	.382E-05	20	.382E-05	9	.148E-03	29	.319E-03		
20	-.479E-03	19	.382E-05	49	.763E-05	10	.148E-03	30	.319E-03		
21	-.589E-03	33	.278E-04	22	.874E-05	11	.146E-03	36	.407E-03		
22	-.123E-02	21	.874E-05	23	.636E-05	12	.319E-03	37	.893E-03		
23	-.122E-02	22	.636E-05	24	.636E-05	13	.319E-03	38	.893E-03		
24	-.122E-02	23	.636E-05	25	.636E-05	14	.319E-03	39	.893E-03		
25	-.122E-02	24	.636E-05	26	.636E-05	15	.319E-03	40	.893E-03		
26	-.122E-02	25	.636E-05	27	.636E-05	16	.319E-03	41	.893E-03		
27	-.122E-02	26	.636E-05	28	.636E-05	17	.319E-03	42	.893E-03		
28	-.122E-02	27	.636E-05	29	.636E-05	18	.319E-03	43	.893E-03		
29	-.122E-02	28	.636E-05	30	.636E-05	19	.319E-03	44	.893E-03		
30	-.123E-02	29	.636E-05	48	.127E-04	20	.319E-03	45	.893E-03		
31	-.630E-02	1	.556E-05	3001	.166E-02	32	.463E-02				
32	-.196E-01	11	.167E-04	3002	.499E-02	31	.463E-02	33	.997E-02		
33	-.377E-01	21	.278E-04	3003	.831E-02	32	.997E-02	34	.194E-01		
34	-.280E-01	3004	.540E-02	33	.194E-01	35	.318E-02				
35	-.252E+00	36	.448E-03	34	.318E-02	52	.249E+00				
36	-.392E+00	35	.448E-03	37	.319E-03	3007	.391E+00	21	.407E-03		
37	-.859E+00	36	.319E-03	38	.232E-03	3008	.857E+00	22	.893E-03		
38	-.859E+00	37	.232E-03	39	.232E-03	3009	.857E+00	23	.893E-03		
39	-.859E+00	38	.232E-03	40	.232E-03	3010	.857E+00	24	.893E-03		
40	-.859E+00	39	.232E-03	41	.232E-03	3011	.857E+00	25	.893E-03		
41	-.859E+00	40	.232E-03	42	.232E-03	3012	.857E+00	26	.893E-03		
42	-.859E+00	41	.232E-03	43	.232E-03	3013	.857E+00	27	.893E-03		
43	-.859E+00	42	.232E-03	44	.232E-03	3014	.857E+00	28	.893E-03		
44	-.859E+00	43	.232E-03	45	.232E-03	3015	.857E+00	29	.893E-03		
45	-.859E+00	44	.232E-03	46	.336E-03	3016	.857E+00	30	.893E-03		
46	-.329E+00	45	.336E-03	3017	.327E+00	47	.165E-02				
47	-.542E-01	3018	.504E-01	46	.165E-02	48	.208E-02				
48	-.807E-01	30	.127E-04	3019	.776E-01	47	.208E-02	49	.107E-02		
49	-.791E-01	20	.763E-05	3020	.776E-01	48	.107E-02	50	.497E-03		
50	-.781E-01	10	.254E-05	3021	.776E-01	49	.497E-03				
51	-.435E+00	52	.329E-02	3005	.311E+00	59	.121E+00				
52	-.919E+00	51	.329E-02	3006	.481E+00	35	.249E+00	60	.186E+00		
53	-.165E-01	3022	.134E-01	60	.755E-04	54	.305E-02				
54	-.500E-01	3023	.401E-01	83	.227E-03	53	.305E-02	55	.655E-02		
55	-.838E-01	3024	.669E-01	86	.378E-03	54	.655E-02	56	.994E-02		
56	-.117E+00	3025	.937E-01	89	.529E-03	55	.994E-02	57	.133E-01		
57	-.830E-01	58	.424E-01	92	.680E-03	59	.316E-02	56	.133E-01	108	.235E-01
58	-.624E-01	57	.424E-01	108	.368E-02	112	.178E-02	111	.131E-02	59	.132E-01
59	-.112E+01	60	.184E-02	57	.316E-02	3026	.976E+00	51	.121E+00	58	.132E-01
		112	.672E-02								
60	-.171E+01	59	.184E-02	61	.133E-02	3027	.151E+01	52	.186E+00	113	.113E-01
61	-.120E+01	60	.133E-02	62	.949E-03	3028	.119E+01	114	.891E-02		
62	-.262E+01	61	.949E-03	63	.691E-03	3029	.260E+01	115	.195E-01		
63	-.262E+01	62	.691E-03	64	.691E-03	3030	.260E+01	116	.195E-01		
64	-.262E+01	63	.691E-03	65	.691E-03	3031	.260E+01	117	.195E-01		
65	-.262E+01	64	.691E-03	66	.691E-03	3032	.260E+01	118	.195E-01		
66	-.262E+01	65	.691E-03	67	.691E-03	3033	.260E+01	119	.195E-01		

67	-.262E+01	66	.691E-03	68	.691E-03	3034	.260E+01	120	.195E-01		
68	-.262E+01	67	.691E-03	69	.691E-03	3035	.260E+01	121	.195E-01		
69	-.262E+01	68	.691E-03	70	.691E-03	3036	.260E+01	122	.195E-01		
70	-.263E+01	69	.691E-03	71	.100E-02	3037	.260E+01	123	.195E-01		
71	-.100E+01	70	.100F-02	72	.122E-02	3038	.993E+00	124	.745E-02		
72	-.397E-01	71	.122E-02	73	.113E-03	125	.383E-01				
73	-.268E-01	72	.113E-03	128	.160E-03	126	.105E-01	74	.161E-01		
74	-.291E-01	3039	.238E-03	128	.649E-04	73	.161E-01	75	.127E-01		
75	-.197E-01	3040	.366E-03	127	.998E-04	74	.127E-01	76	.653E-02		
76	-.984E-02	3041	.219E-03	127	.599E-04	75	.653E-02	77	.303E-02		
77	-.313E-02	3042	.732E-04	127	.200E-04	76	.303E-02				
78	-.137E-02	93	.195E-03	79	.520E-04	81	.112E-02				
79	-.324E-02	78	.520E-04	80	.366E-04	82	.315E-02				
80	-.303E-02	53	.755E-04	79	.366E-04	83	.292E-02				
81	-.428E-02	94	.584E-03	82	.156E-03	78	.112E-02	84	.242E-02		
82	-.102E-01	81	.156E-03	83	.110E-03	79	.315E-02	85	.677E-02		
83	-.955E-02	54	.227E-03	82	.110E-03	80	.292E-02	86	.629E-02		
84	-.732E-02	95	.973E-03	85	.260E-03	81	.242E-02	87	.367E-02		
85	-.175E-01	84	.260E-03	86	.183E-03	82	.677E-02	88	.103E-01		
86	-.164E-01	55	.378E-03	85	.183E-03	83	.629E-02	89	.955E-02		
87	-.103E-01	96	.136E-02	88	.364E-03	84	.367E-02	90	.491E-02		
88	-.247E-01	87	.364E-03	89	.256E-03	85	.103E-01	91	.138E-01		
89	-.231E-01	56	.529E-03	88	.256E-03	86	.955E-02	92	.128E-01		
90	-.186E-01	97	.175F-02	91	.468E-03	87	.491E-02	106	.114E-01		
91	-.466E-01	90	.468E-03	92	.329E-03	88	.138E-01	107	.320E-01		
92	-.435E-01	57	.680E-03	91	.329E-03	89	.128E-01	108	.297E-01		
93	-.166E-01	78	.195E-03	98	.244E-06	3077	.134E-01	94	.305E-02		
94	-.503E-01	81	.584E-03	99	.731E-06	3078	.401E-01	93	.305E-02	95	.655E-02
95	-.844E-01	84	.973E-03	100	.122E-05	3079	.669E-01	94	.655E-02	96	.995E-02
96	-.118E+00	87	.136E-02	101	.170E-05	3080	.937E-01	95	.995E-02	97	.133E-01
97	-.159E+00	90	.175F-02	102	.219E-05	3081	.120E+00	96	.133E-01	106	.235E-01
98	-.108E+00	93	.244E-06	3082	.535E-01	3043	.535F-01	99	.761E-03		
99	-.324E+00	94	.731E-06	3083	.161E+00	3044	.161E+00	98	.761E-03	100	.164E-02
100	-.539E+00	95	.122F-05	3084	.268E+00	3045	.268E+00	99	.164E-02	101	.249F-02
101	-.755E+00	96	.170E-05	3085	.375F+00	3046	.375E+00	100	.249E-02	102	.333E-02
102	-.973E+00	97	.219E-05	3086	.482E+00	3047	.482E+00	101	.333E-02	103	.588E-02
103	-.297E+00	105	.385E-02	3048	.281E+00	102	.588E-02	104	.627E-02		
104	-.659E+00	3049	.642F+00	103	.627E-02	3050	.105F-01				
105	-.199E+00	103	.385F-02	106	.222E-02	3051	.193F+00				
106	-.564E-01	105	.222E-02	107	.267E-02	90	.114E-01	97	.235E-01	109	.165E-01
107	-.752E-01	106	.267F-02	108	.190E-02	91	.320E-01	110	.386E-01		
108	-.968E-01	58	.368E-02	107	.190E-02	57	.235E-01	92	.297E-01	111	.400E-01
109	-.249E-01	3052	.198E-02	110	.593E-03	106	.165E-01	130	.579E-02		
110	-.531E-01	109	.593E-03	111	.416E-03	107	.386E-01	131	.135E-01		
111	-.563E-01	110	.416E-03	112	.593E-03	58	.131E-02	108	.400E-01	132	.140E-01
112	-.145E-01	58	.178E-02	111	.593E-03	113	.147E-02	133	.396E-02	59	.672E-02
113	-.208E-01	112	.147E-02	114	.131E-02	60	.113E-01	134	.668E-02		
114	-.164E-01	113	.131E-02	115	.933E-03	61	.891E-02	135	.526E-02		
115	-.327E-01	114	.933E-03	116	.679E-03	62	.195E-01	136	.115E-01		
116	-.324E-01	115	.679E-03	117	.679E-03	63	.195E-01	137	.115E-01		
117	-.324E-01	116	.679E-03	118	.679E-03	64	.195E-01	138	.115E-01		
118	-.324E-01	117	.679E-03	119	.679E-03	65	.195E-01	139	.115E-01		
119	-.324E-01	118	.679E-03	120	.679E-03	66	.195E-01	140	.115E-01		
120	-.324E-01	119	.679E-03	121	.679E-03	67	.195E-01	141	.115E-01		
121	-.324E-01	120	.679E-03	122	.679E-03	68	.195E-01	142	.115E-01		
122	-.324E-01	121	.679E-03	123	.679E-03	69	.195E-01	143	.115E-01		
123	-.327E-01	122	.679E-03	124	.983E-03	70	.195E-01	144	.115E-01		
124	-.140E-01	123	.983E-03	125	.120E-02	71	.745E-02	145	.439E-02		
125	-.630E-01	124	.120E-02	126	.850E-03	72	.383E-01	146	.226E-01		
126	-.215E-01	125	.850E-03	129	.439E-03	73	.105E-01	147	.972E-02		
127	-.352E-01	75	.998E-04	76	.599E-04	77	.200E-04	128	.350E-01		
128	-.899E-01	73	.160F-03	74	.649E-04	127	.350E-01	129	.546E-01		
129	-.102E+00	126	.439E-03	147	.773E-03	128	.546E-01	166	.463E-01		
130	-.190E-01	3053	.638E-02	131	.191E-02	109	.579E-02	148	.488E-02		
131	-.282E-01	130	.191E-02	132	.134E-02	110	.135E-01	149	.114E-01		
132	-.290E-01	131	.134E-02	133	.191E-02	111	.140E-01	150	.118E-01		
133	-.129E-01	132	.191E-02	134	.259E-02	112	.396E-02	151	.447E-02		
134	-.191E-01	133	.259E-02	135	.231E-02	113	.668E-02	152	.754E-02		
135	-.151E-01	134	.231E-02	136	.164E-02	114	.526E-02	153	.594E-02		
136	-.274E-01	135	.164E-02	137	.120E-02	115	.115E-01	154	.130E-01		
137	-.269E-01	136	.120E-02	138	.120E-02	116	.115E-01	155	.130E-01		
138	-.269E-01	137	.120E-02	139	.120E-02	117	.115E-01	156	.130E-01		
139	-.269E-01	138	.120F-02	140	.120E-02	118	.115E-01	157	.130E-01		
140	-.269E-01	139	.120E-02	141	.120E-02	119	.115E-01	158	.130E-01		

141	-.269E-01	140	.120E-02	142	.120E-02	120	.115E-01	159	.130E-01
142	-.269E-01	141	.120E-02	143	.120E-02	121	.115E-01	160	.130E-01
143	-.269E-01	142	.120E-02	144	.120E-02	122	.115E-01	161	.130E-01
144	-.275E-01	143	.120E-02	145	.173E-02	123	.115E-01	162	.130E-01
145	-.132E-01	144	.173E-02	146	.211E-02	124	.439E-02	163	.496E-02
146	-.518E-01	145	.211E-02	147	.150E-02	125	.226E-01	164	.255E-01
147	-.230E-01	146	.150E-02	129	.773E-03	126	.972E-02	165	.110E-01
148	-.225E-01	3054	.104E-01	149	.311E-02	130	.488E-02	167	.415E-02
149	-.263E-01	148	.311E-02	150	.215E-02	131	.114E-01	168	.969E-02
150	-.270E-01	149	.215E-02	151	.304E-02	132	.118E-01	169	.100E-01
151	-.155E-01	150	.304E-02	152	.421E-02	133	.447E-02	170	.381E-02
152	-.219E-01	151	.421E-02	153	.376E-02	134	.754E-02	171	.642E-02
153	-.174E-01	152	.376E-02	154	.267E-02	135	.594E-02	172	.505E-02
154	-.287E-01	153	.267E-02	155	.194E-02	136	.130E-01	173	.111E-01
155	-.280E-01	154	.194E-02	156	.194E-02	137	.130E-01	174	.111E-01
156	-.280E-01	155	.194E-02	157	.194E-02	138	.130E-01	175	.111E-01
157	-.280E-01	156	.194E-02	158	.194E-02	139	.130E-01	176	.111E-01
158	-.280E-01	157	.194E-02	159	.194E-02	140	.130E-01	177	.111E-01
159	-.280E-01	158	.194E-02	160	.194E-02	141	.130E-01	178	.111E-01
160	-.280E-01	159	.194E-02	161	.194E-02	142	.130E-01	179	.111E-01
161	-.280E-01	160	.194E-02	162	.194E-02	143	.130E-01	180	.111E-01
162	-.289E-01	161	.194E-02	163	.282E-02	144	.130E-01	181	.111E-01
163	-.154E-01	162	.282E-02	164	.343E-02	145	.496E-02	182	.422E-02
164	-.531E-01	163	.343E-02	165	.243E-02	146	.255E-01	183	.217E-01
165	-.240E-01	164	.243E-02	166	.126E-02	147	.110E-01	184	.935E-02
166	-.117E+00	165	.126E-02	184	.359E-02	129	.463E-01	203	.657E-01
167	-.465E-01	3055	.296E-01	168	.889E-02	148	.415E-02	185	.387E-02
168	-.337E-01	167	.889E-02	169	.613E-02	149	.969E-02	186	.903E-02
169	-.342E-01	168	.613E-02	170	.867E-02	150	.100E-01	187	.935E-02
170	-.281E-01	169	.867E-02	171	.120E-01	151	.381E-02	188	.355E-02
171	-.352E-01	170	.120E-01	172	.107E-01	152	.642E-02	189	.598E-02
172	-.281E-01	171	.107E-01	173	.763E-02	153	.505E-02	190	.471E-02
173	-.346E-01	172	.763E-02	174	.556E-02	154	.111E-01	191	.103E-01
174	-.325E-01	173	.556E-02	175	.556E-02	155	.111E-01	192	.103E-01
175	-.325E-01	174	.556E-02	176	.556E-02	156	.111E-01	193	.103E-01
176	-.325E-01	175	.556E-02	177	.556E-02	157	.111E-01	194	.103E-01
177	-.325E-01	176	.556E-02	178	.556E-02	158	.111E-01	195	.103E-01
178	-.325E-01	177	.556E-02	179	.556E-02	159	.111E-01	196	.103E-01
179	-.325E-01	178	.556E-02	180	.556E-02	160	.111E-01	197	.103E-01
180	-.325E-01	179	.556E-02	181	.556E-02	161	.111E-01	198	.103E-01
181	-.350E-01	180	.556E-02	182	.804E-02	162	.111E-01	199	.103E-01
182	-.260E-01	181	.804E-02	183	.979E-02	163	.422E-02	200	.393E-02
183	-.587E-01	182	.979E-02	184	.696E-02	164	.217E-01	201	.202E-01
184	-.286E-01	183	.696E-02	166	.359E-02	165	.935E-02	202	.870E-02
185	-.881E-01	3056	.579E-01	186	.174E-01	167	.387E-02	3057	.887E-02
186	-.591E-01	185	.174E-01	187	.120E-01	168	.903E-02	3058	.207E-01
187	-.597E-01	186	.120E-01	188	.170E-01	169	.935E-02	3059	.214E-01
188	-.522E-01	187	.170E-01	189	.235E-01	170	.355E-02	3060	.813E-02
189	-.642E-01	188	.235E-01	190	.210E-01	171	.598E-02	3061	.137E-01
190	-.514E-01	189	.210E-01	191	.149E-01	172	.471E-02	3062	.108E-01
191	-.598E-01	190	.149E-01	192	.109E-01	173	.103E-01	3063	.237E-01
192	-.557E-01	191	.109E-01	193	.109E-01	174	.103E-01	3064	.237E-01
193	-.557E-01	192	.109E-01	194	.109E-01	175	.103E-01	3065	.237E-01
194	-.557E-01	193	.109E-01	195	.109E-01	176	.103E-01	3066	.237E-01
195	-.557E-01	194	.109E-01	196	.109E-01	177	.103E-01	3067	.237E-01
196	-.557E-01	195	.109E-01	197	.109E-01	178	.103E-01	3068	.237E-01
197	-.557E-01	196	.109E-01	198	.109E-01	179	.103E-01	3069	.237E-01
198	-.557E-01	197	.109E-01	199	.109E-01	180	.103E-01	3070	.237E-01
199	-.606E-01	198	.109E-01	200	.157E-01	181	.103E-01	3071	.237E-01
200	-.478E-01	199	.157E-01	201	.191E-01	182	.393E-02	3072	.902E-02
201	-.994E-01	200	.191E-01	202	.136E-01	183	.202E-01	3073	.464E-01
202	-.493E-01	201	.136E-01	203	.702E-02	184	.870E-02	3074	.200E-01
203	-.147E+00	202	.702E-02	166	.657E-01	204	.737E-01		
204	-.256E+00	3075	.299E-01	203	.737E-01	3076	.152E+00		

INTERNAL CONTACT CONDUCTANCES

NODE	TO NODE-TABLE	NODE-TABLE	NODE-TABLE	NODE-TABLE	NODE-TABLE	NODE-TABLE	NODE-TABLE
93	98 1.						
94	99 1.						
95	100 1.						
96	101 1.						
97	102 1.						
98	93 1.						
99	94 1.						
100	95 1.						
101	96 1.						
102	97 1.						

FORCED CONVECTION,GAS CONDUCTIVITY OR CONTACT CONDUCTANCE TABLES

TABLE	TIME (TEMP)	COEFF.	TIME (TEMP)	COEFF.	TIME (TEMP)	COEFF.	TIME (TEMP)	COEFF.	TIME (TEMP)	COEFF.
1	100.000	.195E-07	300.000	.241E-07	500.000	.289E-07	700.000	.335E-07	900.000	.379E-07
2	100.000	.594E-07	300.000	.744E-07	500.000	.891E-07	700.000	.103E-06	900.000	.117E-06
3	100.000	.492E-06	300.000	.616E-06	500.000	.738E-06	700.000	.856E-06	900.000	.987E-06
4	100.000	.136E-05	300.000	.136E-05	500.000	.630E+00	700.000	.136E-05	900.000	.136E-05
5	100.000	.148E-07	300.000	.186E-07	500.000	.222E-07	700.000	.258E-07	900.000	.292E-07

SURFACE TO BOUNDARY CONNECTORS

NODE	TEMP	NODE	TEMP	MECHANISM	AREA	FILM COEF	ADMIT	GAP
3001	165.00	5022	45.00	RADIATION CONNECT	12.5664	.2607E-05	.3276E-04	
3001	165.00	5022	45.00	CONDUCT. THRU GAP	12.5664	.5978E-07	.7512E-06	6.000000
3002	165.00	5023	45.00	RADIATION CONNECT	37.6991	.2607E-05	.9828E-04	
3002	165.00	5023	45.00	CONDUCT. THRU GAP	37.6991	.5978E-07	.2253E-05	6.000000
3003	165.00	5024	45.00	RADIATION CONNECT	62.8318	.2607E-05	.1638E-03	
3003	165.00	5024	45.00	CONDUCT. THRU GAP	62.8318	.5978E-07	.3756E-05	6.000000
3004	165.00	5025	45.00	RADIATION CONNECT	40.8407	.2607E-05	.1065E-03	
3004	165.00	5025	45.00	CONDUCT. THRU GAP	40.8407	.5978E-07	.2441E-05	6.000000
3005	165.00	5026	45.00	RADIATION CONNECT	301.5900	.2607E-05	.7863E-03	
3005	165.00	5026	45.00	CONDUCT. THRU GAP	301.5900	.4947E-06	.1492E-03	.500000
3006	165.00	5027	45.00	RADIATION CONNECT	465.9566	.2607E-05	.1215E-02	
3006	165.00	5027	45.00	CONDUCT. THRU GAP	465.9566	.4947E-06	.2305E-03	.500000
3007	165.00	5028	45.00	RADIATION CONNECT	321.0686	.1180E-05	.3788E-03	
3007	165.00	5028	45.00	CONDUCT. THRU GAP	321.0686	.1360E-05	.4367E-03	1.500000
3008	165.00	5029	45.00	RADIATION CONNECT	703.7120	.1180E-05	.8302E-03	
3008	165.00	5029	45.00	CONDUCT. THRU GAP	703.7120	.1360E-05	.9570E-03	1.500000
3009	165.00	5030	45.00	RADIATION CONNECT	703.7120	.1180E-05	.8302E-03	
3009	165.00	5030	45.00	CONDUCT. THRU GAP	703.7120	.1360E-05	.9570E-03	1.500000
3010	165.00	5031	45.00	RADIATION CONNECT	703.7120	.1180E-05	.8302E-03	
3010	165.00	5031	45.00	CONDUCT. THRU GAP	703.7120	.1360E-05	.9570E-03	1.500000
3011	165.00	5032	45.00	RADIATION CONNECT	703.7120	.1180E-05	.8302E-03	
3011	165.00	5032	45.00	CONDUCT. THRU GAP	703.7120	.1360E-05	.9570E-03	1.500000
3012	165.00	5033	45.00	RADIATION CONNECT	703.7120	.1180E-05	.8302E-03	
3012	165.00	5033	45.00	CONDUCT. THRU GAP	703.7120	.1360E-05	.9570E-03	1.500000
3013	165.00	5034	45.00	RADIATION CONNECT	703.7120	.1180E-05	.8302E-03	
3013	165.00	5034	45.00	CONDUCT. THRU GAP	703.7120	.1360E-05	.9570E-03	1.500000
3014	165.00	5035	45.00	RADIATION CONNECT	703.7120	.1180E-05	.8302E-03	
3014	165.00	5035	45.00	CONDUCT. THRU GAP	703.7120	.1360E-05	.9570E-03	1.500000
3015	165.00	5036	45.00	RADIATION CONNECT	703.7120	.1180E-05	.8302E-03	
3015	165.00	5036	45.00	CONDUCT. THRU GAP	703.7120	.1360E-05	.9570E-03	1.500000
3016	165.00	5037	45.00	RADIATION CONNECT	703.7120	.1180E-05	.8302E-03	
3016	165.00	5037	45.00	CONDUCT. THRU GAP	703.7120	.1360E-05	.9570E-03	1.500000
3017	165.00	5038	45.00	RADIATION CONNECT	268.2902	.2281E-05	.6120E-03	
3017	165.00	5038	45.00	CONDUCT. THRU GAP	268.2902	.1360E-05	.3649E-03	1.500000
3018	165.00	5039	45.00	RADIATION CONNECT	40.8407	.2607E-05	.1065E-03	
3018	165.00	5039	45.00	CONDUCT. THRU GAP	40.8407	.1490E-07	.6083E-06	5.725000
3019	165.00	5040	45.00	RADIATION CONNECT	62.8318	.2607E-05	.1638E-03	
3019	165.00	5040	45.00	CONDUCT. THRU GAP	62.8318	.1490E-07	.9359E-06	5.725000
3020	165.00	5041	45.00	RADIATION CONNECT	62.8318	.2607E-05	.1638E-03	
3020	165.00	5041	45.00	CONDUCT. THRU GAP	62.8318	.1490E-07	.9359E-06	5.725000
3021	165.00	5042	45.00	RADIATION CONNECT	62.8318	.2607E-05	.1638E-03	
3021	165.00	5042	45.00	CONDUCT. THRU GAP	62.8318	.1490E-07	.9359E-06	5.725000
3022	45.00	5001	165.00	RADIATION CONNECT	12.5664	.1948E-05	.2448E-04	
3022	45.00	5001	165.00	CONDUCT. THRU GAP	12.5664	.5978E-07	.7512E-06	6.000000
3023	45.00	5002	165.00	RADIATION CONNECT	37.6991	.1948E-05	.7343E-04	
3023	45.00	5002	165.00	CONDUCT. THRU GAP	37.6991	.5978E-07	.2253E-05	6.000000
3024	45.00	5003	165.00	RADIATION CONNECT	62.8318	.1948E-05	.1224E-03	
3024	45.00	5003	165.00	CONDUCT. THRU GAP	62.8318	.5978E-07	.3756E-05	6.000000
3025	45.00	5004	165.00	RADIATION CONNECT	87.9645	.1948E-05	.1713E-03	
3025	45.00	5004	165.00	CONDUCT. THRU GAP	87.9645	.5978E-07	.5258E-05	6.000000

3026	45.00	5005	165.00	RADIATION CONNECT	339.2880	.1781E-05	.6042E-03	
3026	45.00	5005	165.00	CONDUCT. THRU GAP	339.2880	.4947E-06	.1679E-03	.500000
3027	45.00	5006	165.00	RADIATION CONNECT	524.2000	.1781E-05	.9334F-03	
3027	45.00	5006	165.00	CONDUCT. THRU GAP	524.2000	.4947E-06	.2595F-03	.500000
3028	45.00	5007	165.00	RADIATION CONNECT	412.8004	.8813E-06	.3638E-03	
3028	45.00	5007	165.00	CONDUCT. THRU GAP	412.8004	.1360E-05	.5614E-03	1.500000
3029	45.00	5008	165.00	RADIATION CONNECT	904.7680	.8813E-06	.7974E-03	
3029	45.00	5008	165.00	CONDUCT. THRU GAP	904.7680	.1360E-05	.1230F-02	1.500000
3030	45.00	5009	165.00	RADIATION CONNECT	904.7680	.8813E-06	.7974E-03	
3030	45.00	5009	165.00	CONDUCT. THRU GAP	904.7680	.1360E-05	.1230E-02	1.500000
3031	45.00	5010	165.00	RADIATION CONNECT	904.7680	.8813E-06	.7974E-03	
3031	45.00	5010	165.00	CONDUCT. THRU GAP	904.7680	.1360E-05	.1230E-02	1.500000
3032	45.00	5011	165.00	RADIATION CONNECT	904.7680	.8813E-06	.7974E-03	
3032	45.00	5011	165.00	CONDUCT. THRU GAP	904.7680	.1360E-05	.1230E-02	1.500000
3033	45.00	5012	165.00	RADIATION CONNECT	904.7680	.8813E-06	.7974E-03	
3033	45.00	5012	165.00	CONDUCT. THRU GAP	904.7680	.1360E-05	.1230E-02	1.500000
3034	45.00	5013	165.00	RADIATION CONNECT	904.7680	.8813E-06	.7974E-03	
3034	45.00	5013	165.00	CONDUCT. THRU GAP	904.7680	.1360E-05	.1230E-02	1.500000
3035	45.00	5014	165.00	RADIATION CONNECT	904.7680	.8813E-06	.7974E-03	
3035	45.00	5014	165.00	CONDUCT. THRU GAP	904.7680	.1360E-05	.1230E-02	1.500000
3036	45.00	5015	165.00	RADIATION CONNECT	904.7680	.8813E-06	.7974E-03	
3036	45.00	5015	165.00	CONDUCT. THRU GAP	904.7680	.1360E-05	.1230E-02	1.500000
3037	45.00	5016	165.00	RADIATION CONNECT	904.7680	.8813E-06	.7974E-03	
3037	45.00	5016	165.00	CONDUCT. THRU GAP	904.7680	.1360E-05	.1230E-02	1.500000
3038	45.00	5017	165.00	RADIATION CONNECT	344.9428	.8813E-06	.3040E-03	
3038	45.00	5017	165.00	CONDUCT. THRU GAP	344.9428	.1360E-05	.4691E-03	1.500000
3039	45.00	5018	165.00	RADIATION CONNECT	40.8407	.1948E-05	.7955E-04	
3039	45.00	5018	165.00	CONDUCT. THRU GAP	40.8407	.1490E-07	.6083E-06	5.725000
3040	45.00	5019	165.00	RADIATION CONNECT	62.8318	.1948E-05	.1224E-03	
3040	45.00	5019	165.00	CONDUCT. THRU GAP	62.8318	.1490E-07	.9359E-06	5.725000
3041	45.00	5020	165.00	RADIATION CONNECT	37.6991	.1948E-05	.7343E-04	
3041	45.00	5020	165.00	CONDUCT. THRU GAP	37.6991	.1490E-07	.5615E-06	5.725000
3042	45.00	5021	165.00	RADIATION CONNECT	12.5664	.1948E-05	.2448E-04	
3042	45.00	5021	165.00	CONDUCT. THRU GAP	12.5664	.1490E-07	.1872E-06	5.725000
3043	165.00	5043	45.00	RADIATION CONNECT	12.5664	.1955E-05	.2457E-04	
3043	165.00	5044	41.00	CONSTANT FILM COEF	12.5664	.1929E-05	.2424E-04	
3044	165.00	5043	45.00	RADIATION CONNECT	37.6991	.1955E-05	.7371E-04	
3044	165.00	5044	41.00	CONSTANT FILM COEF	37.6991	.1929E-05	.7272E-04	
3045	165.00	5043	45.00	RADIATION CONNECT	62.8318	.1955E-05	.1229E-03	
3045	165.00	5044	41.00	CONSTANT FILM COEF	62.8318	.1929E-05	.1212E-03	
3046	165.00	5043	45.00	RADIATION CONNECT	87.9645	.1955E-05	.1720E-03	
3046	165.00	5044	41.00	CONSTANT FILM COEF	87.9645	.1929E-05	.1697E-03	
3047	165.00	5043	45.00	RADIATION CONNECT	113.0972	.1955E-05	.2211E-03	
3047	165.00	5044	41.00	CONSTANT FILM COEF	113.0972	.1929E-05	.2182E-03	
3048	165.00	5043	45.00	RADIATION CONNECT	65.9734	.1955E-05	.1290E-03	
3048	165.00	5044	41.00	CONSTANT FILM COEF	65.9734	.1929E-05	.1273E-03	
3049	165.00	5043	45.00	RADIATION CONNECT	150.7963	.1955E-05	.2948E-03	
3049	165.00	5044	41.00	CONSTANT FILM COEF	150.7963	.1929E-05	.2909E-03	
3050	165.00	5043	45.00	RADIATION CONNECT	20.4203	.1955E-05	.3993E-04	
3050	165.00	5044	41.00	CONSTANT FILM COEF	20.4203	.1929E-05	.3939E-04	
3051	45.00	5043	45.00	RADIATION CONNECT	138.2300	.1461E-05	.2019E-03	
3051	45.00	5044	41.00	CONSTANT FILM COEF	138.2300	.1929E-05	.2666E-03	
3052	45.00	5045	41.00	RADIATION CONNECT	150.7963	.1704E-05	.2570E-03	
3052	45.00	5046	41.00	CONSTANT FILM COEF	150.7963	.1929E-05	.2909E-03	
3053	45.00	5045	41.00	RADIATION CONNECT	486.9465	.1704E-05	.8299E-03	
3053	45.00	5046	41.00	CONSTANT FILM COEF	486.9465	.1929E-05	.9393E-03	
3054	45.00	5045	41.00	RADIATION CONNECT	791.6807	.1704E-05	.1349E-02	
3054	45.00	5046	41.00	CONSTANT FILM COEF	791.6807	.1929E-05	.1527E-02	
3055	45.00	5045	41.00	RADIATION CONNECT	2261.9448	.1704E-05	.3855E-02	
3055	45.00	5046	41.00	CONSTANT FILM COEF	2261.9448	.1929E-05	.4363E-02	
3056	45.00	5045	41.00	RADIATION CONNECT	4423.3587	.1704E-05	.7538E-02	
3056	45.00	5046	41.00	CONSTANT FILM COEF	4423.3587	.1929E-05	.8533E-02	
3057	45.00	5048	41.00	RADIATION CONNECT	1960.3200	.1704E-05	.3341F-02	
3058	45.00	5048	41.00	RADIATION CONNECT	4574.0800	.1704E-05	.7795E-02	
3059	45.00	5048	41.00	RADIATION CONNECT	4737.4400	.1704E-05	.8074E-02	
3060	45.00	5048	41.00	RADIATION CONNECT	1796.9600	.1704E-05	.3062E-02	
3061	45.00	5048	41.00	RADIATION CONNECT	3028.6944	.1704E-05	.5162E-02	
3062	45.00	5048	41.00	RADIATION CONNECT	2385.0560	.1704E-05	.4065F-02	
3063	45.00	5048	41.00	RADIATION CONNECT	5227.5200	.1704E-05	.8909E-02	
3064	45.00	5048	41.00	RADIATION CONNECT	5227.5200	.1704E-05	.8909E-02	
3065	45.00	5048	41.00	RADIATION CONNECT	5227.5200	.1704E-05	.8909E-02	
3066	45.00	5048	41.00	RADIATION CONNECT	5227.5200	.1704E-05	.8909F-02	
3067	45.00	5048	41.00	RADIATION CONNECT	5227.5200	.1704E-05	.8909F-02	
3068	45.00	5048	41.00	RADIATION CONNECT	5227.5200	.1704F-05	.8909F-02	
3069	45.00	5048	41.00	RADIATION CONNECT	5227.5200	.1704E-05	.8909F-02	
3070	45.00	5048	41.00	RADIATION CONNECT	5227.5200	.1704E-05	.8909F-02	

3071	45,00	5048	41,00	RADIATION CONNECT	5227,5200	,1704E-05	,8909E-02
3072	45,00	5048	41,00	RADIATION CONNECT	1992,9920	,1704E-05	,3397E-02
3073	45,00	5048	41,00	RADIATION CONNECT	10259,0080	,1704E-05	,1748E-01
3074	45,00	5048	41,00	RADIATION CONNECT	4410,7200	,1704E-05	,7517F-02
3075	45,00	5048	41,00	RADIATION CONNFCT	13672,1997	,1704E-05	,2330E-01
3076	45,00	5048	41,00	RADIATION CONNECT	68611,4000	,1704E-05	,1169F+00
3077	45,00	5054	45,00	RADIATION CONNECT	12,5664	,8429E-06	,1059E-04
3078	45,00	5055	45,00	RADIATION CONNECT	37,6991	,8429E-06	,3178F-04
3079	45,00	5056	45,00	RADIATION CONNECT	62,8318	,8429E-06	,5296E-04
3080	45,00	5057	45,00	RADIATION CONNECT	87,9645	,8429E-06	,7414E-04
3081	45,00	5058	45,00	RADIATION CONNECT	113,0972	,8429E-06	,9533E-04
3082	45,00	5049	45,00	RADIATION CONNECT	12,5664	,8429E-06	,1059F-04
3083	45,00	5050	45,00	RADIATION CONNECT	37,6991	,8429E-06	,3178E-04
3084	45,00	5051	45,00	RADIATION CONNECT	62,8318	,8429E-06	,5296E-04
3085	45,00	5052	45,00	RADIATION CONNECT	87,9645	,8429E-06	,7414E-04
3086	45,00	5053	45,00	RADIATION CONNECT	113,0972	,8429E-06	,9533E-04
3001	165,00	5001	165,00	TEMP CONNECTED	12,5664		
3002	165,00	5002	165,00	TEMP CONNECTED	37,6991		
3003	165,00	5003	165,00	TEMP CONNECTED	62,8318		
3004	165,00	5004	165,00	TEMP CONNECTED	40,8407		
3005	165,00	5005	165,00	TEMP CONNECTED	301,5900		
3006	165,00	5006	165,00	TEMP CONNECTED	465,9566		
3007	165,00	5007	165,00	TEMP CONNECTED	321,0686		
3008	165,00	5008	165,00	TEMP CONNECTED	703,7120		
3009	165,00	5009	165,00	TEMP CONNECTED	703,7120		
3010	165,00	5010	165,00	TEMP CONNECTED	703,7120		
3011	165,00	5011	165,00	TEMP CONNECTED	703,7120		
3012	165,00	5012	165,00	TEMP CONNECTED	703,7120		
3013	165,00	5013	165,00	TEMP CONNECTED	703,7120		
3014	165,00	5014	165,00	TEMP CONNECTED	703,7120		
3015	165,00	5015	165,00	TEMP CONNECTED	703,7120		
3016	165,00	5016	165,00	TEMP CONNECTED	703,7120		
3017	165,00	5017	165,00	TEMP CONNECTED	268,2902		
3018	165,00	5018	165,00	TEMP CONNECTED	40,8407		
3019	165,00	5019	165,00	TEMP CONNECTED	62,8318		
3020	165,00	5020	165,00	TEMP CONNECTED	62,8318		
3021	165,00	5021	165,00	TEMP CONNECTED	62,8318		
3022	45,00	5022	45,00	TEMP CONNECTED	12,5664		
3023	45,00	5023	45,00	TEMP CONNECTED	37,6991		
3024	45,00	5024	45,00	TEMP CONNECTED	62,8318		
3025	45,00	5025	45,00	TEMP CONNECTED	87,9645		
3026	45,00	5026	45,00	TEMP CONNECTED	339,2880		
3027	45,00	5027	45,00	TEMP CONNECTED	524,2000		
3028	45,00	5028	45,00	TEMP CONNECTED	412,8004		
3029	45,00	5029	45,00	TEMP CONNECTED	904,7680		
3030	45,00	5030	45,00	TEMP CONNECTED	904,7680		
3031	45,00	5031	45,00	TEMP CONNECTED	904,7680		
3032	45,00	5032	45,00	TEMP CONNECTED	904,7680		
3033	45,00	5033	45,00	TEMP CONNECTED	904,7680		
3034	45,00	5034	45,00	TEMP CONNECTED	904,7680		
3035	45,00	5035	45,00	TEMP CONNECTED	904,7680		
3036	45,00	5036	45,00	TEMP CONNECTED	904,7680		
3037	45,00	5037	45,00	TEMP CONNECTED	904,7680		
3038	45,00	5038	45,00	TEMP CONNECTED	344,9428		
3039	45,00	5039	45,00	TEMP CONNECTED	40,8407		
3040	45,00	5040	45,00	TEMP CONNECTED	62,8318		
3041	45,00	5041	45,00	TEMP CONNECTED	37,6991		
3042	45,00	5042	45,00	TEMP CONNECTED	12,5664		
3077	45,00	5049	45,00	TEMP CONNECTED	12,5664		
3078	45,00	5050	45,00	TEMP CONNECTED	37,6991		
3079	45,00	5051	45,00	TEMP CONNECTED	62,8318		
3080	45,00	5052	45,00	TEMP CONNECTED	87,9645		
3081	45,00	5053	45,00	TEMP CONNECTED	113,0972		
3082	45,00	5054	45,00	TEMP CONNECTED	12,5664		
3083	45,00	5055	45,00	TEMP CONNECTED	37,6991		
3084	45,00	5056	45,00	TEMP CONNECTED	62,8318		
3085	45,00	5057	45,00	TEMP CONNECTED	87,9645		
3086	45,00	5058	45,00	TEMP CONNECTED	113,0972		

PRINTOUT TIMES
1296000,003888000,006480000,009072000,00***
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VOLUME WEIGHTED INTERNAL OR AREA WEIGHTED SURFACE AVERAGES
FROM TO FROM TO FROM TO FROM TO FROM TO FROM TO FROM TO
CALCULATED SPREAD BETWEEN INTERNAL NODES = 55

NO, OF ITERATIONS 82, CRIC= ,024754

NO, OF ITERATIONS 68, CRIC= ,024187

NO, OF ITERATIONS 91, CRIC= ,009167

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NO. OF ITERATIUNS      5, CRIC= 1.000000
NO. OF ITERATIUNS      5, CRIC= 1.000000
NO. OF ITERATIUNS     96, CRIC=  .008540
NO. OF ITERATIUNS     60, CRIC=  .008855
NO. OF ITERATIUNS     46, CRIC=  .008644
NO. OF ITERATIUNS     35, CRIC=  .009456
NO. OF ITERATIUNS     26, CRIC=  .013150
NO. OF ITERATIUNS     13, CRIC=  .026018
NO. OF ITERATIUNS     13, CRIC=  .027619
NO. OF ITERATIUNS     12, CRIC=  .029259
NO. OF ITERATIUNS     12, CRIC=  .030942
NO. OF ITERATIUNS     11, CRIC=  .032691
NO. OF ITERATIUNS     11, CRIC=  .034491
NO. OF ITERATIUNS     10, CRIC=  .036372
NO. OF ITERATIUNS     10, CRIC=  .038302
NO. OF ITERATIUNS     10, CRIC=  .040330
NO. OF ITERATIUNS     10, CRIC=  .036357
NO. OF ITERATIUNS     10, CRIC=  .036825
NO. OF ITERATIUNS     10, CRIC=  .030036
NO. OF ITERATIUNS     10, CRIC=  .031319
NO. OF ITERATIUNS     10, CRIC=  .025208
NO. OF ITERATIUNS     10, CRIC=  .027997
NO. OF ITERATIUNS     11, CRIC=  .019894
NO. OF ITERATIUNS     11, CRIC=  .017193
NO. OF ITERATIUNS     11, CRIC=  .018583
NO. OF ITERATIUNS     11, CRIC=  .016066
NO. OF ITERATIUNS     11, CRIC=  .017590
NO. OF ITERATIUNS     11, CRIC=  .013935
NO. OF ITERATIUNS     11, CRIC=  .015407
NO. OF ITERATIUNS     10, CRIC=  .015142
NO. OF ITERATIUNS     10, CRIC=  .016676
NO. OF ITERATIUNS     10, CRIC=  .014653
NO. OF ITERATIUNS     10, CRIC=  .013469
NO. OF ITERATIUNS     10, CRIC=  .015048
NO. OF ITERATIUNS     10, CRIC=  .013003
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TAP-A INPUT (Cont'd)

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NO. OF ITERATIONS    10, CRIC=  .014928
NO. OF ITERATIONS     9, CRIC=  .013453
NO. OF ITERATIONS     9, CRIC=  .015289
NO. OF ITERATIONS     9, CRIC=  .015121
NO. OF ITERATIONS     9, CRIC=  .013805
NO. OF ITERATIONS     9, CRIC=  .013861
NO. OF ITERATIONS     8, CRIC=  .013616
NO. OF ITERATIONS     8, CRIC=  .015347
NO. OF ITERATIONS     8, CRIC=  .014635
NO. OF ITERATIONS     8, CRIC=  .012924
NO. OF ITERATIONS     8, CRIC=  .012417
NO. OF ITERATIONS     7, CRIC=  .014638
NO. OF ITERATIONS     7,.CRIC=  .013874
NO. OF ITERATIONS     7, CRIC=  .014301
NO. OF ITERATIONS     7, CRIC=  .014868
NO. OF ITERATIONS     7, CRIC=  .018435
NO. OF ITERATIONS     6, CRIC=  .025073
NO. OF ITERATIONS     6, CRIC=  .029256
NO. OF ITERATIONS     6, CRIC=  .034571
NO. OF ITERATIONS     6, CRIC=  .041141
NO. OF ITERATIONS     6, CRIC=  .049192
NO. OF ITERATIONS     5, CRIC=  .064794
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TAP-A OUTPUT

TEMPERATURE CALCULATION FOR 946 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .150E+07 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	108.65	2	466.29	3	493.28	4	498.57	5	500.33
6	500.75	7	500.22	8	498.29	9	492.50	10	457.67
11	101.62	12	403.29	13	430.64	14	436.53	15	438.53
16	439.01	17	438.40	18	436.22	19	429.82	20	396.14
21	91.39	22	273.99	23	299.55	24	306.05	25	308.31
26	308.86	27	308.16	28	305.69	29	298.71	30	269.77
31	56.80	32	56.76	33	56.70	34	56.65	35	56.45
36	86.18	37	154.24	38	175.85	39	182.13	40	184.36
41	184.90	42	184.21	43	181.78	44	175.08	45	152.42
46	91.07	47	88.46	48	87.37	49	85.92	50	83.15
51	52.09	52	56.39	53	50.51	54	50.50	55	50.48
56	50.45	57	50.40	58	50.71	59	51.98	60	56.39
61	66.35	62	84.78	63	97.24	64	102.70	65	105.00
66	105.59	67	104.83	68	102.31	69	96.46	70	83.29
71	65.29	72	52.30	73	48.33	74	48.70	75	49.03
76	49.30	77	49.43	78	44.16	79	45.67	80	49.39
81	44.14	82	45.65	83	49.41	84	44.09	85	45.61
86	49.44	87	44.01	88	45.56	89	49.49	90	43.88
91	45.48	92	49.57	93	43.90	94	43.88	95	43.86
96	43.83	97	43.80	98	41.59	99	41.61	100	41.66
101	41.74	102	41.87	103	42.00	104	41.88	105	42.48
106	43.77	107	45.43	108	49.63	109	43.58	110	45.29
111	49.32	112	51.88	113	55.94	114	64.36	115	79.30
116	90.46	117	95.60	118	97.81	119	98.58	120	97.65
121	95.22	122	89.70	123	77.87	124	63.02	125	51.91
126	47.80	127	42.79	128	42.73	129	42.66	130	43.09
131	44.85	132	48.32	133	51.12	134	54.41	135	60.46
136	70.56	137	79.33	138	83.75	139	85.74	140	86.26
141	85.59	142	83.40	143	78.63	144	69.25	145	58.88
146	50.80	147	47.10	148	42.64	149	44.21	150	47.07
151	49.75	152	52.34	153	56.56	154	63.30	155	69.88
156	73.50	157	75.20	158	75.66	159	75.07	160	73.18
161	69.26	162	62.14	163	55.03	164	49.38	165	46.28
166	42.41	167	42.16	168	43.33	169	45.41	170	47.42
171	49.13	172	51.56	173	55.25	174	59.31	175	61.81
176	63.06	177	63.41	178	62.96	179	61.56	180	58.83
181	54.37	182	50.37	183	47.16	184	45.03	185	41.56
186	42.13	187	43.13	188	44.05	189	44.79	190	45.75
191	47.17	192	48.84	193	49.95	194	50.55	195	50.71
196	50.49	197	49.82	198	48.59	199	46.74	200	45.20
201	43.97	202	43.04	203	41.96	204	41.38		

TAP-A OUTPUT

TEMPERATURE CALCULATIONS FOR 1665 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .389E+07 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	109.92	2	456.45	3	484.77	4	490.01	5	491.79
6	492.23	7	491.69	8	469.75	9	484.05	10	450.23
11	103.18	12	396.50	13	423.16	14	428.99	15	431.00
16	431.49	17	430.88	18	428.70	19	422.40	20	389.71
21	93.42	22	270.33	23	295.27	24	301.70	25	303.97
26	304.53	27	303.84	28	301.37	29	294.49	30	266.34
31	59.75	32	59.71	33	59.67	34	59.63	35	59.51
36	88.46	37	154.52	38	175.65	39	181.86	40	184.10
41	184.65	42	183.96	43	181.53	44	174.92	45	152.82
46	93.25	47	90.62	48	89.50	49	88.02	50	85.28
51	55.44	52	59.46	53	53.94	54	53.94	55	53.93
56	53.92	57	53.89	58	54.18	59	55.34	60	59.47
61	69.52	62	87.64	63	99.88	64	105.28	65	107.58
66	108.18	67	107.43	68	104.92	69	99.15	70	86.27
71	68.71	72	56.06	73	51.79	74	52.13	75	52.44
76	52.69	77	52.81	78	48.30	79	49.60	80	52.92
81	48.28	82	49.59	83	52.94	84	48.26	85	49.57
86	52.98	87	48.20	88	49.54	89	53.05	90	48.12
91	49.49	92	53.14	93	48.08	94	48.07	95	48.07
96	48.06	97	48.05	98	46.39	99	46.41	100	46.45
101	46.51	102	46.60	103	46.70	104	46.62	105	47.07
106	48.05	107	49.46	108	53.21	109	47.91	110	49.36
111	52.96	112	55.34	113	59.21	114	67.64	115	82.35
116	93.33	117	98.42	118	100.62	119	101.20	120	100.48
121	98.06	122	92.62	123	81.03	124	66.53	125	55.68
126	51.34	127	45.91	128	45.89	129	45.86	130	47.58
131	49.03	132	52.13	133	54.80	134	57.98	135	63.97
136	73.94	137	82.57	138	86.96	139	88.94	140	89.47
141	88.80	142	86.62	143	81.92	144	72.71	145	62.55
146	54.63	147	50.73	148	47.25	149	48.53	150	51.10
151	53.65	152	56.16	153	60.32	154	66.97	155	73.45
156	77.04	157	78.74	158	79.20	159	78.61	160	76.74
161	72.87	162	65.86	163	58.87	164	53.30	165	50.02
166	45.76	167	46.87	168	47.82	169	49.69	170	51.61
171	53.26	172	55.64	173	59.28	174	63.28	175	65.75
176	67.00	177	67.35	178	66.90	179	65.52	180	62.82
181	58.41	182	54.45	183	51.26	184	48.93	185	46.40
186	46.85	187	47.74	188	48.61	189	49.33	190	50.26
191	51.65	192	53.29	193	54.39	194	54.98	195	55.15
196	54.93	197	54.27	198	53.04	199	51.21	200	49.67
201	48.42	202	47.34	203	45.62	204	45.59		

TEMPERATURE CALCULATIONS FOR 2388 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .646E+07 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	112.49	2	451.27	3	476.77	4	481.85	5	483.57
6	483.99	7	483.47	8	481.59	9	476.06	10	443.34
11	106.00	12	390.44	13	416.22	14	421.86	15	423.81
16	424.29	17	423.70	18	421.58	19	415.47	20	383.89
21	96.63	22	267.46	23	291.54	24	297.78	25	299.98
26	300.53	27	299.85	28	297.45	29	290.77	30	263.58
31	64.24	32	64.21	33	64.17	34	64.13	35	64.03
36	91.85	37	155.52	38	175.94	39	181.96	40	184.13
41	184.67	42	184.00	43	181.64	44	175.23	45	153.83
46	96.24	47	93.66	48	92.55	49	91.08	50	88.40
51	60.10	52	63.98	53	58.66	54	58.66	55	58.65
56	58.63	57	58.61	58	58.88	59	60.00	60	63.99
61	73.71	62	91.22	63	103.04	64	108.25	65	110.47
66	111.04	67	110.32	68	107.90	69	102.32	70	89.88
71	72.89	72	60.68	73	56.56	74	56.88	75	57.18
76	57.42	77	57.54	78	53.21	79	54.46	80	57.67
81	53.19	82	54.45	83	57.69	84	53.17	85	54.43
86	57.73	87	53.12	88	54.40	89	57.79	90	53.04
91	54.36	92	57.88	93	52.99	94	52.99	95	52.98
96	52.97	97	52.97	98	51.37	99	51.39	100	51.43
101	51.49	102	51.58	103	51.67	104	51.59	105	52.03
106	52.97	107	54.33	108	57.95	109	52.84	110	54.23
111	57.70	112	60.01	113	63.74	114	71.89	115	86.11
116	96.71	117	101.62	118	103.75	119	104.31	120	103.60
121	101.27	122	96.01	123	84.81	124	70.79	125	60.31
126	56.11	127	50.86	128	50.84	129	50.81	130	52.51
131	53.91	132	56.91	133	59.49	134	62.55	135	68.35
136	77.97	137	86.31	138	90.54	139	92.45	140	92.96
141	92.32	142	90.22	143	85.67	144	76.77	145	66.95
146	59.30	147	55.53	148	52.20	149	53.43	150	55.91
151	58.38	152	60.79	153	64.81	154	71.24	155	77.50
156	80.96	157	82.60	158	83.04	159	82.47	160	80.67
161	76.92	162	70.16	163	63.40	164	58.01	165	54.84
166	50.72	167	51.84	168	52.75	169	54.55	170	56.40
171	58.00	172	60.29	173	63.80	174	67.67	175	70.05
176	71.26	177	71.59	178	71.16	179	69.82	180	67.21
181	62.95	182	59.13	183	56.05	184	53.80	185	51.38
186	51.81	187	52.66	188	53.51	189	54.19	190	55.10
191	56.43	192	58.01	193	59.07	194	59.64	195	59.81
196	59.59	197	58.95	198	57.77	199	56.00	200	54.52
201	53.32	202	52.27	203	50.59	204	50.57		

TAP-A OUTPUT (Continued)

TEMPERATURE CALCULATIONS FOR 3104 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .907E+07 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	118.52	2	446.69	3	471.35	4	476.25	5	477.92
6	478.33	7	477.81	8	475.98	9	470.61	10	438.89
11	112.27	12	387.32	13	412.17	14	417.62	15	419.51
16	419.97	17	419.58	18	417.32	19	411.39	20	380.85
21	103.26	22	267.91	23	291.05	24	297.05	25	299.18
26	299.71	27	299.04	28	296.70	29	290.23	30	263.99
31	72.27	32	72.24	33	72.20	34	72.17	35	72.10
36	98.65	37	159.71	38	179.31	39	185.12	40	187.21
41	187.73	42	187.07	43	184.77	44	178.55	45	157.90
46	102.32	47	99.76	48	98.66	49	97.19	50	94.57
51	68.36	52	72.05	53	67.00	54	67.00	55	66.99
56	66.97	57	66.94	58	67.20	59	68.27	60	72.07
61	81.45	62	98.39	63	109.77	64	114.79	65	116.91
66	117.46	67	116.76	68	114.41	69	109.01	70	96.96
71	80.47	72	68.67	73	64.55	74	64.87	75	65.15
76	65.38	77	65.49	78	61.91	79	63.05	80	66.04
81	61.90	82	63.04	83	66.06	84	61.87	85	63.02
86	66.10	87	61.83	88	62.99	89	66.16	90	61.76
91	62.95	92	66.25	93	61.72	94	61.72	95	61.71
96	61.71	97	61.70	98	60.33	99	60.35	100	60.38
101	60.43	102	60.50	103	60.59	104	60.51	105	60.89
106	61.70	107	62.93	108	66.31	109	61.58	110	62.83
111	66.08	112	68.26	113	71.83	114	79.70	115	93.44
116	103.65	117	108.37	118	110.41	119	110.95	120	110.26
121	108.01	122	102.91	123	92.06	124	78.45	125	68.31
126	64.13	127	58.75	128	58.73	129	58.71	130	61.28
131	62.52	132	65.31	133	67.76	134	70.69	135	76.28
136	85.57	137	93.60	138	97.67	139	99.51	140	100.00
141	99.37	142	97.33	143	92.93	144	84.30	145	74.77
146	67.35	147	63.57	148	60.99	149	62.07	150	64.36
151	66.71	152	69.02	153	72.89	154	79.08	155	85.11
156	88.43	157	90.01	158	90.43	159	89.88	160	88.13
161	84.50	162	77.94	163	71.38	164	66.14	165	62.95
166	58.68	167	60.66	168	61.44	169	63.09	170	64.85
171	66.37	172	68.57	173	71.94	174	75.66	175	77.95
176	79.11	177	79.42	178	79.00	179	77.71	180	75.18
181	71.04	182	67.33	183	64.31	184	62.02	185	60.27
186	60.62	187	61.38	188	62.18	189	62.83	190	63.69
191	64.96	192	66.48	193	67.49	194	68.04	195	68.19
196	67.98	197	67.36	198	66.22	199	64.51	200	63.06
201	61.88	202	60.76	203	58.74	204	59.05		

TAP-A OUTPUT (Continued)
TEMPERATURE CALCULATIONS FOR 3835 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .117E+08 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	127.69	2	444.60	3	468.42	4	473.16	5	474.78
6	475.18	7	474.67	8	472.88	9	467.65	10	436.87
11	121.66	12	386.99	13	410.91	14	416.16	15	417.98
16	418.43	17	417.85	18	415.84	19	410.09	20	380.54
21	112.95	22	271.45	23	293.59	24	299.36	25	301.41
26	301.92	27	301.27	28	298.99	29	292.74	30	267.48
31	83.39	32	83.37	33	83.33	34	83.31	35	83.26
36	108.48	37	166.81	38	185.55	39	191.12	40	193.14
41	195.64	42	193.00	43	190.76	44	184.75	45	164.88
46	111.57	47	108.84	48	107.74	49	106.28	50	103.72
51	79.70	52	83.22	53	78.42	54	78.42	55	78.41
56	78.39	57	78.35	58	78.60	59	79.61	60	83.24
61	92.33	62	108.74	63	119.71	64	124.53	65	126.57
66	127.10	67	126.41	68	124.14	69	118.92	70	107.24
71	91.21	72	79.83	73	75.74	74	76.04	75	76.32
76	76.54	77	76.65	78	73.64	79	74.68	80	77.50
81	73.63	82	74.68	83	77.52	84	73.61	85	74.66
86	77.55	87	73.58	88	74.64	89	77.61	90	73.52
91	74.60	92	77.69	93	73.47	94	73.47	95	73.47
96	73.47	97	73.46	98	72.28	99	72.29	100	72.32
101	72.36	102	72.43	103	72.50	104	72.43	105	72.76
106	73.47	107	74.58	108	77.76	109	73.36	110	74.49
111	77.53	112	79.61	113	83.02	114	90.64	115	103.94
116	113.78	117	118.33	118	120.29	119	120.80	120	120.13
121	117.95	122	113.02	123	102.50	124	89.29	125	79.48
126	75.34	127	69.89	128	69.88	129	69.87	130	73.09
131	74.20	132	76.80	133	79.14	134	81.95	135	87.35
136	96.33	137	104.08	138	107.99	139	109.75	140	110.22
141	109.61	142	107.63	143	103.57	144	95.01	145	85.76
146	78.56	147	74.82	148	72.83	149	73.77	150	75.91
151	78.14	152	80.35	153	84.08	154	90.06	155	95.87
156	99.07	157	100.58	158	100.99	159	100.45	160	98.75
161	95.24	162	88.88	163	82.51	164	77.42	165	74.24
166	69.89	167	72.53	168	73.19	169	74.72	170	76.38
171	77.84	172	79.95	173	83.20	174	86.78	175	88.98
176	90.09	177	90.39	178	89.98	179	88.72	180	86.28
181	82.27	182	78.65	183	75.72	184	73.40	185	72.18
186	72.46	187	73.16	188	73.91	189	74.52	190	75.34
191	76.56	192	78.01	193	78.98	194	79.50	195	79.65
196	79.44	197	78.85	198	77.75	199	76.09	200	74.68
201	73.53	202	72.37	203	70.09	204	70.65		

TAP-A OUTPUT (Continued)

TEMPERATURE CALCULATIONS FOR 4557 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .143E+08 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	156.58	2	442.23	3	465.23	4	469.83	5	471.40
6	471.79	7	471.29	8	469.55	9	464.48	10	434.66
11	130.57	12	386.35	13	409.37	14	414.44	15	416.20
16	416.64	17	416.08	18	414.12	19	408.56	20	380.03
21	122.15	22	274.62	23	295.82	24	301.37	25	303.36
26	303.84	27	303.21	28	301.02	29	294.99	30	270.72
31	93.94	32	93.92	33	93.89	34	93.86	35	93.85
36	117.82	37	173.54	38	191.46	39	196.82	40	198.78
41	199.26	42	198.64	43	196.47	44	190.68	45	171.61
46	120.20	47	117.73	48	116.64	49	115.22	50	112.73
51	90.43	52	93.81	53	89.21	54	89.21	55	89.20
56	89.17	57	89.14	58	89.38	59	90.35	60	93.82
61	102.65	62	118.55	63	129.13	64	133.77	65	135.74
66	136.24	67	135.58	68	133.40	69	128.36	70	117.09
71	101.57	72	90.62	73	86.72	74	87.02	75	87.28
76	87.50	77	87.60	78	84.58	79	85.60	80	88.32
81	84.58	82	85.59	83	88.33	84	84.56	85	85.57
86	88.37	87	84.52	88	85.55	89	88.42	90	84.47
91	85.52	92	88.50	93	84.42	94	84.42	95	84.42
96	84.41	97	84.41	98	83.27	99	83.29	100	83.31
101	83.35	102	83.41	103	83.48	104	83.42	105	83.73
106	84.42	107	85.50	108	88.56	109	84.31	110	85.41
111	88.55	112	90.35	113	93.63	114	101.02	115	113.90
116	123.40	117	127.78	118	129.67	119	130.16	120	129.52
121	127.41	122	122.66	123	112.52	124	99.73	125	90.29
126	86.33	127	81.12	128	81.11	129	81.10	130	84.05
131	85.13	132	87.65	133	89.90	134	92.61	135	97.84
136	106.54	137	114.02	138	117.79	139	119.49	140	119.94
141	119.35	142	117.45	143	113.34	144	105.28	145	96.34
146	89.41	147	85.82	148	83.80	149	84.72	150	86.79
151	88.94	152	91.08	153	94.69	154	100.48	155	106.09
156	109.17	157	110.63	158	111.02	159	110.50	160	108.87
161	105.48	162	99.35	163	93.20	164	88.30	165	85.26
166	81.11	167	83.51	168	84.17	169	85.64	170	87.25
171	88.65	172	90.70	173	93.84	174	97.29	175	99.41
176	100.48	177	100.77	178	100.38	179	99.17	180	96.81
181	92.95	182	89.47	183	86.65	184	84.44	185	83.18
186	83.46	187	84.13	188	84.85	189	85.44	190	86.23
191	87.40	192	88.80	193	89.73	194	90.23	195	90.37
196	90.17	197	89.60	198	88.55	199	86.96	200	85.61
201	84.51	202	83.41	203	81.28	204	81.78		

TAP-A OUTPUT (Continued)

TEMPERATURE CALCULATIONS FOR 5252 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .166E+08 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	134.45	2	432.60	3	454.81	4	459.21	5	460.72
6	461.09	7	460.62	8	458.95	9	454.08	10	425.35
11	128.81	12	377.32	13	399.51	14	404.39	15	406.08
16	406.49	17	405.96	18	404.08	19	398.74	20	371.27
21	120.66	22	267.88	23	288.32	24	293.66	25	295.57
26	296.04	27	295.44	28	293.32	29	287.51	30	264.10
31	93.76	32	93.73	33	93.69	34	93.65	35	93.53
36	116.42	37	170.14	38	187.42	39	192.58	40	194.46
41	194.93	42	194.33	43	192.25	44	186.66	45	168.23
46	118.52	47	116.19	48	115.18	49	113.82	50	111.45
51	89.90	52	93.48	53	88.63	54	88.61	55	88.58
56	88.53	57	88.46	58	88.72	59	89.79	60	93.47
61	101.47	62	116.50	63	126.57	64	131.01	65	132.88
66	133.37	67	132.74	68	130.65	69	125.84	70	115.06
71	100.19	72	89.68	73	86.48	74	86.79	75	87.07
76	87.30	77	87.40	78	82.98	79	84.34	80	87.62
81	82.95	82	84.32	83	87.63	84	82.90	85	84.28
86	87.65	87	82.82	88	84.22	89	87.69	90	82.70
91	84.14	92	87.74	93	82.73	94	82.71	95	82.69
96	82.65	97	82.62	98	80.58	99	80.60	100	80.65
101	80.72	102	80.82	103	80.94	104	80.82	105	81.38
106	82.59	107	84.09	108	87.79	109	82.40	110	83.96
111	87.50	112	89.66	113	93.02	114	99.81	115	111.98
116	121.02	117	125.20	118	127.00	119	127.47	120	126.86
121	124.85	122	120.32	123	110.61	124	98.38	125	89.35
126	86.02	127	81.87	128	81.84	129	81.79	130	81.93
131	83.54	132	86.59	133	88.92	134	91.63	135	96.54
136	104.77	137	111.88	138	115.47	139	117.10	140	117.52
141	116.97	142	115.16	143	111.23	144	103.54	145	95.02
146	88.43	147	85.42	148	81.50	149	82.95	150	85.45
151	87.69	152	89.81	153	93.25	154	98.74	155	104.09
156	107.03	157	108.42	158	108.79	159	108.30	160	106.74
161	103.52	162	97.68	163	91.85	164	87.23	165	84.72
166	81.60	167	81.05	168	82.14	169	83.95	170	85.63
171	87.04	172	89.02	173	92.03	174	95.33	175	97.35
176	98.37	177	98.65	178	98.27	179	97.13	180	94.89
181	91.24	182	87.97	183	85.35	184	83.64	185	80.51
186	81.04	187	81.90	188	82.67	189	83.27	190	84.05
191	85.19	192	86.53	193	87.42	194	87.90	195	88.03
196	87.85	197	87.31	198	86.31	199	84.82	200	83.58
201	82.59	202	81.88	203	81.17	204	80.58		

TAP-A OUTPUT (Continued)

TEMPERATURE CALCULATIONS FOR 5974 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .194E+08 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	130.53	2	422.29	3	445.68	4	448.16	5	449.62
6	449.98	7	449.52	8	447.90	9	443.18	10	415.39
11	125.11	12	367.46	13	389.03	14	393.77	15	395.42
16	395.82	17	395.30	18	393.48	19	388.28	20	361.71
21	117.33	22	260.06	23	279.98	24	285.19	25	287.05
26	287.51	27	286.92	28	284.86	29	279.19	30	256.45
31	91.21	32	91.18	33	91.14	34	91.11	35	90.99
36	113.27	37	165.55	38	182.42	39	187.47	40	189.30
41	189.76	42	189.17	43	187.14	44	181.69	45	163.72
46	115.40	47	113.13	48	112.13	49	110.78	50	108.47
51	87.47	52	90.94	53	86.24	54	86.23	55	86.20
56	86.15	57	86.09	58	86.34	59	87.37	60	90.93
61	98.66	62	113.18	63	122.93	64	127.22	65	129.04
66	129.51	67	128.90	68	126.88	69	122.22	70	111.79
71	97.42	72	87.24	73	84.10	74	84.41	75	84.67
76	84.89	77	84.99	78	80.82	79	82.12	80	85.28
81	80.79	82	82.10	83	85.29	84	80.75	85	82.06
86	85.51	87	80.67	88	82.01	89	85.34	90	80.56
91	81.94	92	85.39	93	80.58	94	80.57	95	80.54
96	80.51	97	80.48	98	78.55	99	78.57	100	78.61
101	78.68	102	78.78	103	78.89	104	78.78	105	79.31
106	80.45	107	81.88	108	85.44	109	80.27	110	81.76
111	85.16	112	87.25	113	90.49	114	97.07	115	108.82
116	117.56	117	121.61	118	123.35	119	123.81	120	123.22
121	121.27	122	116.88	123	107.49	124	95.66	125	86.92
126	83.67	127	79.60	128	79.57	129	79.52	130	79.82
131	81.36	132	84.28	133	86.54	134	89.16	135	93.90
136	101.85	137	108.73	138	112.21	139	113.78	140	114.19
141	113.65	142	111.90	143	108.10	144	100.66	145	92.41
146	86.03	147	83.09	148	79.42	149	80.79	150	83.19
151	85.35	152	87.41	153	90.73	154	96.03	155	101.20
156	104.05	157	105.59	158	105.75	159	105.27	160	103.77
161	100.65	162	95.00	163	89.36	164	84.87	165	82.42
166	79.54	167	78.99	168	80.02	169	81.76	170	83.37
171	84.74	172	86.65	173	89.55	174	92.74	175	94.70
176	95.69	177	95.96	178	95.59	179	94.48	180	92.32
181	88.78	182	85.62	183	83.07	184	81.39	185	78.48
186	78.98	187	79.80	188	80.54	189	81.12	190	81.87
191	82.97	192	84.27	193	85.13	194	85.59	195	85.72
196	85.54	197	85.02	198	84.05	199	82.60	200	81.40
201	80.44	202	79.73	203	78.97	204	78.46		

TAP-A OUTPUT (Continued)

TEMPERATURE CALCULATIONS FOR 6696 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .220E+08 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	128,30	2	413,24	3	434,25	4	438,42	5	439,85
6	440,20	7	439,75	8	438,17	9	433,58	10	406,67
11	123,09	12	359,03	13	380,01	14	384,64	15	386,25
16	386,65	17	386,14	18	384,35	19	379,29	20	353,57
21	115,67	22	255,87	23	273,28	24	278,39	25	280,21
26	280,66	27	280,08	28	278,07	29	272,53	30	250,45
31	90,29	32	90,26	33	90,22	34	90,19	35	90,09
36	111,79	37	162,58	38	179,05	39	183,99	40	185,79
41	186,23	42	185,66	43	183,67	44	178,34	45	160,84
46	113,94	47	111,72	48	110,74	49	109,38	50	107,13
51	86,72	52	90,05	53	85,53	54	85,52	55	85,49
56	85,46	57	85,40	58	85,64	59	86,63	60	90,04
61	97,63	62	111,72	63	121,20	64	125,37	65	127,14
66	127,60	67	127,00	68	125,04	69	120,51	70	110,39
71	96,48	72	86,60	73	83,47	74	83,76	75	84,01
76	84,22	77	84,32	78	80,44	79	81,64	80	84,61
81	80,42	82	81,63	83	84,63	84	80,38	85	81,60
86	84,65	87	80,32	88	81,55	89	84,69	90	80,22
91	81,50	92	84,75	93	80,22	94	80,21	95	80,19
96	80,17	97	80,15	98	78,46	99	78,47	100	78,51
101	78,57	102	78,66	103	78,76	104	78,66	105	79,13
106	80,13	107	81,45	108	84,79	109	79,98	110	81,35
111	84,54	112	86,53	113	89,66	114	96,09	115	107,51
116	116,01	117	119,94	118	121,64	119	122,09	120	121,51
121	119,62	122	115,35	123	106,24	124	94,78	125	86,29
126	83,07	127	79,02	128	78,99	129	78,95	130	79,60
131	81,00	132	83,74	133	85,91	134	88,44	135	93,06
136	100,79	137	107,47	138	110,86	139	112,39	140	112,79
141	112,26	142	110,56	143	106,87	144	99,64	145	91,64
146	85,45	147	82,53	148	79,25	149	80,49	150	82,74
151	84,81	152	86,80	153	90,03	154	95,19	155	100,21
156	102,98	157	104,28	158	104,63	159	104,17	160	102,71
161	99,67	162	94,19	163	88,71	164	84,35	165	81,91
166	78,81	167	78,87	168	79,80	169	81,42	170	82,97
171	84,28	172	86,14	173	88,96	174	92,06	175	93,96
176	94,92	177	95,18	178	94,83	179	93,75	180	91,64
181	88,20	182	85,13	183	82,65	184	80,96	185	78,41
186	78,86	187	79,62	188	80,33	189	80,89	190	81,61
191	82,68	192	83,94	193	84,78	194	85,23	195	85,35
196	85,18	197	84,67	198	83,73	199	82,32	200	81,15
201	80,20	202	79,46	203	78,53	204	78,19		

TAP-A OUTPUT(Continued)

TEMPERATURE CALCULATIONS FOR 7418 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .246E+08 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	113.53	2	395.65	3	416.83	4	420.88	5	422.26
6	422.61	7	422.19	8	420.70	9	416.29	10	388.72
11	108.52	12	340.80	13	361.88	14	366.40	15	367.97
16	368.36	17	367.89	18	366.20	19	361.31	20	335.12
21	101.43	22	236.42	23	255.59	24	260.62	25	262.41
26	262.86	27	262.32	28	260.39	29	255.01	30	233.51
31	76.49	32	76.46	33	76.41	34	76.37	35	76.18
36	97.67	37	147.87	38	164.21	39	169.08	40	170.85
41	171.29	42	170.76	43	168.85	44	163.68	45	146.53
46	100.66	47	98.60	48	97.70	49	96.43	50	94.27
51	72.69	52	76.13	53	71.46	54	71.44	55	71.41
56	71.36	57	71.30	58	71.55	59	72.59	60	76.12
61	83.21	62	96.69	63	105.83	64	109.87	65	111.59
66	112.04	67	111.49	68	109.63	69	105.33	70	95.69
71	82.44	72	72.95	73	70.55	74	70.85	75	71.11
76	71.33	77	71.43	78	65.63	79	67.13	80	70.50
81	65.60	82	67.11	83	70.51	84	65.54	85	67.06
86	70.53	87	65.44	88	67.00	89	70.55	90	65.29
91	66.91	92	70.60	93	65.34	94	65.32	95	65.29
96	65.25	97	65.20	98	62.71	99	62.73	100	62.79
101	62.88	102	63.01	103	63.16	104	63.02	105	63.70
106	65.16	107	66.84	108	70.63	109	64.94	110	66.71
111	70.35	112	72.44	113	75.61	114	81.69	115	92.61
116	100.80	117	104.61	118	106.26	119	106.70	120	106.17
121	104.38	122	100.32	123	91.66	124	80.76	125	72.65
126	70.10	127	67.30	128	67.25	129	67.18	130	64.41
131	66.29	132	69.44	133	71.68	134	74.21	135	78.65
136	86.05	137	92.50	138	95.78	139	97.26	140	97.67
141	97.18	142	95.56	143	92.06	144	85.21	145	77.63
146	71.77	147	69.48	148	63.93	149	65.66	150	68.28
151	70.43	152	72.43	153	75.56	154	80.53	155	85.38
156	88.06	157	89.33	158	89.68	159	89.25	160	87.87
161	85.00	162	79.81	163	74.65	164	70.58	165	68.72
166	66.80	167	63.43	168	64.78	169	66.72	170	68.35
171	69.69	172	71.52	173	74.26	174	77.27	175	79.12
176	80.05	177	80.31	178	79.99	179	78.97	180	76.98
181	73.75	182	70.89	183	68.63	184	67.48	185	62.78
186	63.49	187	64.45	188	65.21	189	65.79	190	66.53
191	67.58	192	68.82	193	69.64	194	70.08	195	70.21
196	70.05	197	69.56	198	68.68	199	67.36	200	66.30
201	65.47	202	65.16	203	65.85	204	64.27		

TAP-A OUTPUT (Continued)
TEMPERATURE CALCULATIONS FOR 8140 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .272E+06 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	96.69	2	375.09	3	399.57	4	403.83	5	405.18
6	405.51	7	405.12	8	403.66	9	398.98	10	368.71
11	92.01	12	319.76	13	343.56	14	348.26	15	349.81
16	350.19	17	349.73	18	348.07	19	342.97	20	314.50
21	85.20	22	218.00	23	237.16	24	242.21	25	243.99
26	244.44	27	243.90	28	241.99	29	236.64	30	215.37
31	60.30	32	60.27	33	60.22	34	60.17	35	59.96
36	81.58	37	131.71	38	148.14	39	153.02	40	154.78
41	155.22	42	154.69	43	152.81	44	147.66	45	130.58
46	85.27	47	83.29	48	82.43	49	81.18	50	79.03
51	56.52	52	59.91	53	55.29	54	55.27	55	55.24
56	55.20	57	55.14	58	55.39	59	56.42	60	59.89
61	66.78	62	79.65	63	88.78	64	92.75	65	94.44
66	94.89	67	94.35	68	92.53	69	88.33	70	78.96
71	66.12	72	56.81	73	54.46	74	54.74	75	55.00
76	55.21	77	55.31	78	49.60	79	51.07	80	54.37
81	49.57	82	51.05	83	54.37	84	49.51	85	51.00
86	54.39	87	49.41	88	50.94	89	54.42	90	49.27
91	50.85	92	54.46	93	49.32	94	49.30	95	49.27
96	49.22	97	49.17	98	46.70	99	46.72	100	46.78
101	46.87	102	47.01	103	47.15	104	47.02	105	47.69
106	49.14	107	50.79	108	54.49	109	48.92	110	50.66
111	54.22	112	56.27	113	59.38	114	65.29	115	75.89
116	83.89	117	87.63	118	89.25	119	89.69	120	89.17
121	87.42	122	83.46	123	75.03	124	64.45	125	56.52
126	54.02	127	51.32	128	51.28	129	51.20	130	48.40
131	50.24	132	53.33	133	55.53	134	58.01	135	62.32
136	69.52	137	75.81	138	79.03	139	80.49	140	80.88
141	80.41	142	78.83	143	75.41	144	68.74	145	61.38
146	55.65	147	53.42	148	47.93	149	49.63	150	52.20
151	54.31	152	56.26	153	59.31	154	64.14	155	68.88
156	71.51	157	72.76	158	73.10	159	72.68	160	71.33
161	68.53	162	63.48	163	58.46	164	54.48	165	52.67
166	50.83	167	47.44	168	48.77	169	50.67	170	52.27
171	53.58	172	55.36	173	58.04	174	60.98	175	62.79
176	63.71	177	63.97	178	63.65	179	62.66	180	60.72
181	57.56	182	54.78	183	52.57	184	51.46	185	46.79
186	47.49	187	48.44	188	49.19	189	49.77	190	50.49
191	51.53	192	52.74	193	53.55	194	53.99	195	54.11
196	53.96	197	53.48	198	52.61	199	51.32	200	50.28
201	49.46	202	49.17	203	49.88	204	48.30		

TAP-A OUTPUT (Continued)

TEMPERATURE CALCULATIONS FOR 8862 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .298E+08 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	89.88	2	362.82	3	386.80	4	391.73	5	393.38
6	393.79	7	393.28	8	391.47	9	386.14	10	356.57
11	85.47	12	307.79	13	331.18	14	336.40	15	338.18
16	338.62	17	338.08	18	336.13	19	330.50	20	302.56
21	78.93	22	208.75	23	227.62	24	232.60	25	234.35
26	234.78	27	234.24	28	232.33	29	227.01	30	206.03
31	54.49	32	54.46	33	54.41	34	54.37	35	54.18
36	75.47	37	124.76	38	140.98	39	145.80	40	147.52
41	147.94	42	147.41	43	145.53	44	140.41	45	123.51
46	78.99	47	77.02	48	76.15	49	74.88	50	72.71
51	50.93	52	54.13	53	49.76	54	49.75	55	49.73
56	49.70	57	49.65	58	49.88	59	50.84	60	54.12
61	60.84	62	73.53	63	82.22	64	86.08	65	87.73
66	88.16	67	87.61	68	85.81	69	81.66	70	72.44
71	59.87	72	50.69	73	47.93	74	48.19	75	48.43
76	48.62	77	48.71	78	44.80	79	46.01	80	48.91
81	44.78	82	45.99	83	48.92	84	44.73	85	45.95
86	48.94	87	44.65	88	45.90	89	48.97	90	44.54
91	45.83	92	49.02	93	44.58	94	44.56	95	44.54
96	44.50	97	44.47	98	42.55	99	42.57	100	42.61
101	42.68	102	42.79	103	42.90	104	42.79	105	43.32
106	44.44	107	45.78	108	49.05	109	44.26	110	45.66
111	48.80	112	50.70	113	53.65	114	59.40	115	69.68
116	77.47	117	81.10	118	82.68	119	83.09	120	82.57
121	80.83	122	76.92	123	68.63	124	58.24	125	50.40
126	47.54	127	44.06	128	44.03	129	43.99	130	43.83
131	45.28	132	47.98	133	50.02	134	52.37	135	56.54
136	63.52	137	69.64	138	72.76	139	74.17	140	74.55
141	74.07	142	72.50	143	69.13	144	62.55	145	55.28
146	49.59	147	47.02	148	43.43	149	44.74	150	46.96
151	48.91	152	50.75	153	53.69	154	58.36	155	62.95
156	65.51	157	66.72	158	67.05	159	66.62	160	65.28
161	62.50	162	57.50	163	52.52	164	48.54	165	46.40
166	43.79	167	43.01	168	44.00	169	45.62	170	47.08
171	48.31	172	50.01	173	52.59	174	55.43	175	57.19
176	58.08	177	58.33	178	58.00	179	57.01	180	55.08
181	51.94	182	49.14	183	46.89	184	45.44	185	42.51
186	43.00	187	43.78	188	44.46	189	45.00	190	45.68
191	46.67	192	47.84	193	48.63	194	49.05	195	49.17
196	49.01	197	48.53	198	47.66	199	46.36	200	45.28
201	44.42	202	43.84	203	43.36	204	42.72		

TEMPERATURE CALCULATIONS FOR 9585 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .324E+08 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	85.36	2	352.01	3	375.41	4	380.23	5	381.85
6	382.25	7	381.75	8	379.98	9	374.77	10	346.07
11	81.18	12	297.51	13	320.39	14	325.52	15	327.26
16	327.69	17	327.16	18	325.25	19	319.73	20	292.50
21	74.89	22	201.32	23	219.83	24	224.72	25	226.43
26	226.85	27	226.33	28	224.46	29	219.24	30	198.73
31	50.98	32	50.95	33	50.90	34	50.86	35	50.68
36	71.55	37	119.77	38	135.70	39	140.43	40	142.12
41	142.54	42	142.01	43	140.17	44	135.15	45	118.58
46	75.15	47	73.23	48	72.38	49	71.14	50	68.99
51	47.53	52	50.63	53	46.40	54	46.39	55	46.37
56	46.34	57	46.30	58	46.52	59	47.44	60	50.62
61	57.18	62	69.50	63	77.95	64	81.71	65	83.31
66	83.73	67	83.20	68	81.44	69	77.40	70	68.44
71	56.25	72	47.30	73	44.57	74	44.82	75	45.05
76	45.23	77	45.32	78	41.64	79	42.79	80	45.58
81	41.62	82	42.77	83	45.59	84	41.57	85	42.74
86	45.61	87	41.50	88	42.69	89	45.64	90	41.39
91	42.62	92	45.68	93	41.43	94	41.41	95	41.39
96	41.36	97	41.33	98	39.51	99	39.53	100	39.57
101	39.64	102	39.74	103	39.85	104	39.75	105	40.24
106	41.30	107	42.57	108	45.72	109	41.13	110	42.46
111	45.48	112	47.32	113	50.18	114	55.77	115	65.76
116	73.33	117	76.87	118	78.41	119	78.81	120	78.30
121	76.61	122	72.80	123	64.74	124	54.66	125	47.02
126	44.19	127	40.75	128	40.72	129	40.68	130	40.72
131	42.10	132	44.69	133	46.67	134	48.95	135	53.01
136	59.79	137	65.73	138	68.77	139	70.15	140	70.52
141	70.05	142	68.53	143	65.24	144	58.84	145	51.78
146	46.24	147	43.69	148	40.35	149	41.59	150	43.72
151	45.61	152	47.39	153	50.25	154	54.79	155	59.25
156	61.74	157	62.92	158	63.24	159	62.82	160	61.52
161	58.81	162	53.95	163	49.09	164	45.22	165	43.11
166	40.50	167	39.95	168	40.89	169	42.44	170	43.85
171	45.04	172	46.70	173	49.20	174	51.97	175	53.68
176	54.54	177	54.78	178	54.47	179	53.50	180	51.62
181	48.56	182	45.83	183	43.63	184	42.19	185	39.47
186	39.94	187	40.69	188	41.34	189	41.86	190	42.52
191	43.49	192	44.63	193	45.39	194	45.81	195	45.92
196	45.77	197	45.30	198	44.45	199	43.18	200	42.13
201	41.29	202	40.69	203	40.12	204	39.57		

TAP-A OUTPUT (Continued)

TEMPERATURE CALCULATIONS FOR 10307 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .350E+08 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	90.09	2	348.69	3	371.40	4	376.11	5	377.70
6	378.08	7	377.60	8	375.86	9	370.76	10	342.69
11	86.12	12	295.60	13	317.80	14	322.80	15	324.51
16	324.93	17	324.40	18	322.53	19	317.15	20	290.74
21	80.11	22	202.54	23	220.50	24	225.27	25	226.95
26	227.36	27	226.84	28	225.01	29	219.91	30	200.01
31	56.81	32	56.79	33	56.75	34	56.73	35	56.65
36	76.96	37	123.63	38	139.10	39	143.72	40	145.38
41	145.78	42	145.27	43	143.46	44	138.55	45	122.46
46	80.36	47	78.42	48	77.54	49	76.28	50	74.15
51	53.91	52	56.62	53	52.90	54	52.90	55	52.89
56	52.88	57	52.87	58	53.06	59	53.84	60	56.63
61	63.44	62	75.64	63	83.93	64	87.62	65	89.18
66	89.59	67	89.07	68	87.34	69	83.38	70	74.62
71	62.69	72	53.98	73	50.84	74	51.07	75	51.27
76	51.43	77	51.51	78	49.28	79	50.07	80	52.21
81	49.27	82	50.07	83	52.23	84	49.26	85	50.05
86	52.26	87	49.23	88	50.04	89	52.30	90	49.18
91	50.01	92	52.36	93	49.15	94	49.15	95	49.15
96	49.14	97	49.14	98	48.22	99	48.23	100	48.25
101	48.28	102	48.34	103	48.39	104	48.34	105	48.59
106	49.14	107	49.99	108	52.41	109	49.06	110	49.92
111	52.24	112	53.83	113	56.44	114	62.14	115	72.05
116	79.48	117	82.95	118	84.45	119	84.84	120	84.34
121	82.68	122	78.95	123	71.06	124	61.18	125	53.72
126	50.55	127	46.44	128	46.43	129	46.42	130	48.85
131	49.70	132	51.68	133	53.46	134	55.59	135	59.64
136	66.35	137	72.19	138	75.17	139	76.52	140	76.87
141	76.41	142	74.92	143	71.69	144	65.41	145	58.47
146	53.01	147	50.16	148	48.65	149	49.37	150	51.00
151	52.69	152	54.37	153	57.17	154	61.64	155	66.03
156	68.46	157	69.61	158	69.92	159	69.52	160	68.23
161	65.57	162	60.79	163	55.99	164	52.14	165	49.73
166	46.43	167	48.42	168	48.93	169	50.09	170	51.35
171	52.45	172	54.05	173	56.49	174	59.19	175	60.86
176	61.71	177	61.94	178	61.63	179	60.68	180	58.83
181	55.80	182	53.07	183	50.85	184	49.09	185	48.15
186	48.37	187	48.90	188	49.47	189	49.94	190	50.57
191	51.49	192	52.60	193	53.35	194	53.74	195	53.86
196	53.70	197	53.25	198	52.41	199	51.14	200	50.07
201	49.19	202	48.30	203	46.58	204	46.98		

TAP-A OUTPUT (Continued)

TEMPERATURE CALCULATIONS FOR 11029 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .576E+08 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	95.92	2	344.27	3	366.27	4	370.83	5	372.38
6	372.76	7	372.29	8	370.61	9	365.68	10	338.15
11	90.10	12	292.56	13	313.98	14	318.82	15	320.48
16	320.89	17	320.39	18	318.58	19	313.38	20	287.89
21	84.29	22	202.53	23	219.86	24	224.49	25	226.12
26	226.52	27	226.02	28	224.25	29	219.33	30	200.13
31	61.83	32	61.81	33	61.78	34	61.76	35	61.69
36	81.23	37	126.20	38	141.13	39	145.60	40	147.21
41	147.61	42	147.12	43	145.37	44	140.63	45	125.12
46	84.50	47	82.62	48	81.77	49	80.56	50	78.50
51	59.02	52	61.66	53	58.04	54	58.04	55	58.03
56	58.02	57	58.01	58	58.20	59	58.95	60	61.67
61	68.30	62	80.15	63	88.18	64	91.75	65	93.27
66	93.67	67	93.17	68	91.51	69	87.70	70	79.25
71	67.73	72	59.35	73	56.46	74	56.68	75	56.88
76	57.04	77	57.12	78	54.40	79	55.23	80	57.37
81	54.39	82	55.22	83	57.38	84	54.37	85	55.21
86	57.41	87	54.34	88	55.19	89	57.46	90	54.29
91	55.16	92	57.52	93	54.26	94	54.26	95	54.26
96	54.25	97	54.25	98	53.23	99	53.25	100	53.27
101	53.31	102	53.37	103	53.43	104	53.37	105	53.65
106	54.25	107	55.14	108	57.56	109	54.17	110	55.08
111	57.40	112	58.96	113	61.50	114	67.05	115	76.68
116	85.88	117	87.24	118	88.70	119	89.08	120	88.60
121	87.00	122	83.41	123	75.80	124	66.28	125	59.10
126	56.17	127	52.47	128	52.45	129	52.44	130	53.96
131	54.86	132	56.86	133	58.61	134	60.69	135	64.63
136	71.15	137	76.82	138	79.70	139	81.01	140	81.36
141	80.92	142	79.48	143	76.38	144	70.33	145	63.65
146	58.41	147	55.78	148	53.75	149	54.54	150	56.19
151	57.86	152	59.50	153	62.23	154	66.58	155	70.84
156	73.19	157	74.31	158	74.62	159	74.23	160	72.99
161	70.44	162	65.84	163	61.23	164	57.54	165	55.32
166	52.40	167	53.51	168	54.09	169	55.29	170	56.54
171	57.61	172	59.17	173	61.55	174	64.17	175	65.80
176	66.62	177	66.85	178	66.55	179	65.64	180	63.86
181	60.95	182	58.34	183	56.23	184	54.64	185	53.22
186	53.49	187	54.05	188	54.62	189	55.08	190	55.69
191	56.59	192	57.66	193	58.39	194	58.77	195	58.88
196	58.74	197	58.30	198	57.50	199	56.29	200	55.27
201	54.45	202	53.69	203	52.38	204	52.50		

TAP-A OUTPUT (Continued)

TEMPERATURE CALCULATIONS FOR 11752 HOURS

****** SEALED STORAGE CASK FINAL DESIGN 1.0KW ******

INTERNAL TEMPERATURES AT .402E+08 SECONDS

NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP	NODE	TEMP
1	101.03	2	343.94	3	365.24	4	369.63	5	371.13
6	371.49	7	371.03	8	369.39	9	364.59	10	337.79
11	97.52	12	293.67	13	314.31	14	318.97	15	320.58
16	320.97	17	320.47	18	318.71	19	313.66	20	288.94
21	91.68	22	206.16	23	222.84	24	227.29	25	228.86
26	229.25	27	228.75	28	227.02	29	222.25	30	203.64
31	70.12	32	70.10	33	70.08	34	70.06	35	70.01
36	88.70	37	131.96	38	146.31	39	150.61	40	152.17
41	152.55	42	152.06	43	150.35	44	145.75	45	130.74
46	91.37	47	89.50	48	88.65	49	87.44	50	85.43
51	67.45	52	69.98	53	66.53	54	66.52	55	66.52
56	66.51	57	66.49	58	66.67	59	67.39	60	69.99
61	76.41	62	87.91	63	95.68	64	99.12	65	100.58
66	100.96	67	100.47	68	98.85	69	95.14	70	86.90
71	75.64	72	67.50	73	64.55	74	64.76	75	64.96
76	65.11	77	65.18	78	63.16	79	63.89	80	65.88
81	63.15	82	63.88	83	65.89	84	63.14	85	63.87
86	65.92	87	63.11	88	63.85	89	65.96	90	63.07
91	63.83	92	66.02	93	63.04	94	63.04	95	63.03
96	63.03	97	63.03	98	62.20	99	62.21	100	62.22
101	62.26	102	62.30	103	62.35	104	62.31	105	62.53
106	63.03	107	63.81	108	66.06	109	62.96	110	63.75
111	65.90	112	67.39	113	69.82	114	75.19	115	84.53
116	91.49	117	94.73	118	96.13	119	96.50	120	96.02
121	94.47	122	90.97	123	83.55	124	74.24	125	67.25
126	64.27	127	60.37	128	60.36	129	60.36	130	62.77
131	65.54	132	65.38	133	67.04	134	69.03	135	72.84
136	79.16	137	84.63	138	87.42	139	88.68	140	89.01
141	88.57	142	87.17	143	84.14	144	78.24	145	71.71
146	66.59	147	63.91	148	62.58	149	63.24	150	64.74
151	66.32	152	67.89	153	70.52	154	74.73	155	78.84
156	81.11	157	82.19	158	82.48	159	82.10	160	80.89
161	78.40	162	73.90	163	69.40	164	65.78	165	63.50
166	60.38	167	62.36	168	62.83	169	63.90	170	65.08
171	66.10	172	67.60	173	69.89	174	72.42	175	73.98
176	74.77	177	74.99	178	74.70	179	73.80	180	72.07
181	69.23	182	66.67	183	64.58	184	62.92	185	62.12
186	62.31	187	62.81	188	63.33	189	63.77	190	64.35
191	65.22	192	66.24	193	66.94	194	67.31	195	67.41
196	67.27	197	66.84	198	66.06	199	64.88	200	63.88
201	63.05	202	62.21	203	60.54	204	60.97		

APPENDIX C

THERMAL CONDUCTIVITY OF CONCRETE EVALUATIONS

Calculational methods were used to determine and confirm the thermal conductivity of the concrete as a result of test data to be used in the thermal model. The methods used are as follows:

Transient Line Source Method

During the initial heatup transient of the cask, hourly temperature data was recorded. The incremental temperature change with time may be used in the following equation: (Reference C1)

$$k = \frac{Q}{4\pi (T_2 - T_1)} \ln \frac{t_2}{t_1}$$

Where:

Q = Heat supplied per unit length and time, Btu/hr-ft

T = Temperature, °F

t = Time, hrs.

The use of this expression requires a knowledge of both the heat input and the time-temperature values to determine the thermal conductivity. The heat output from the canister is not constant along its length. Using the test data, incremental calculations for radiation, conduction and convection between the canister and liner indicated that at the canister midplane (El. 128"), $Q = 1.22\ Q_{ave}$. Figure 12 was used to estimate the total decay power (1.13 kW) at the time of the transient. The canister length (167 inches) was used to obtain the heat output per unit length at the midplane. The conductivity calculated for a time interval between 101 hours and 199 hours of operation using temperature data at a radius of 23 inches in Quadrant 1 at elevation 128 inches was k = 1.50 Btu/hr-ft-°F.

Periodical Change of Surface Temperature

Hourly temperature data was recorded during March 25 to March 28, 1980. The thermal lag time between two radii due to the daily solar cycle may be used in the following equation to evaluate the concrete thermal conductivity: (Reference C2)

$$k = .5\ n\ Cp\ \rho\left(\frac{r_2 - r_1}{t}\right)^2$$

Where:

- k = Thermal conductivity, Btu/hr-ft-°F
- n = Frequency of the thermal cycle, $\pi/12$ radians per hour
- Cp = Specific heat, .21 Btu/lb-°F
- ρ = Density of concrete, 144 lbs/ft^3
- r = Radial position $(r_2 - r_1)$ = 1.083 ft.
- t = Lag time between the two radii, 6.50 hrs.

The average phase lag (maximum to maximum and minimum to minimum) between radii 50 and 37 inches for 4 quadrants and 3 elevations was 6.50 hours. This phase lag is detectable in Figure 21. The resulting conductivity was calculated to be 1.60 Btu/hr-ft-°F.

Temperature Drop Between Radii 9 and 23 Inches (See Figures 22 and 25) on July 24, 1979 and January 30, 1980

The following equations were used to determine the concrete thermal conductivity for an axial incremental length at the cask midplane: (Reference C3)

$$q = \sigma A_1\ F_{12}\ (T_1^4 - T_2^4) + UA_m\ (T_1 - T_2),\ \text{Btu/hr} \quad (1)$$

$$\frac{Ub}{k} = 0.0317\ (Gr)^{0.37} \quad (2)$$

$$k = \frac{q}{2\pi\ l(T_2 - T_3)}\ \ln\frac{r_3}{r_2} \quad (3)$$

Where:

σ = Stefan-Boltzman's constant, 0.1714 x 10^{-8} Btu/hr-ft^2-°R^4

F_{12} = Shape factor for concentric cylinders

A = Surface area, Ft^2

T = Absolute temperature, °R

U = Overall heat transfer coefficient, Btu/hr-ft^2-°F

b = Radial clearance between canister and liner, ft.

k = Thermal conductivity, Btu/hr-ft-°F

Gr = Grashof number

l = Length, Ft.

r = Radius, Ft.

1 = Canister property

2 = Liner property

3 = Concrete property

m = Average property

q = Assembly power level, Btu/hr.

Equation (1) provides the radiation, conduction and convection heat transfer between the canister and liner. Equation (2) provides the overall heat transfer coefficient for an enclosed vertical air space. Equation (3) then provides the concrete thermal conductivity required for the heat transfer obtained in Equation (1).

The decay power obtained from Figure 12 and calculated thermal conductivity for the two dates are:

Date	kW	k
July 24, 1979	.85	1.63
January 30, 1980	.72	1.56

Integration Between Two Constant Isotherms on July 24, 1979 and January 30, 1980 (See Figures 23 and 26)

Numerical integration for volume and mean surface area between two constant temperature lines can be used in the following equation:

$$q = -\frac{A^2}{V} k (T_1 - T_2), \text{ Btu/hr}$$

Where:

q = Assembly power level

A = Average area of the isothermal volume

V = Volume between two constant temperature lines

T = Temperature

k = Thermal conductivity

This equation is developed from:

$$q = - \frac{A k (T_1 - T_2)}{x}$$

where the average thickness (x) or distance between two isothermal lines is obtained from V/A.

The decay power obtained from Figure 12, assumed axial end losses, isothermal temperatures and calculated thermal conductivity for the two dates are:

Date	kW	Axial Loss	Isothermal Temperatures	k
July 24, 1980	.85	3%	110°F to 105°F	1.63
January 30, 1980	.72	3%	70°F to 65°F	1.57

Comparison of Concrete Thermal Conductivities

The following table provides a summary of the thermal conductivities calculated using the various calculational methods.

Calculational Method	Thermal Conductivity
Holmes and Narver (Table 6)	1.23/1.37
Transient Line Source	1.5
Periodical Change	1.6
Conduction in Concrete	1.63/1.56
Integration Between two Constant Isotherms	1.63/1.57

References

C1. Y. S. Touloukian, et al, "Thermophysical Properties of Matter," Volume 1, Plenum Publishing Corporation, 1978.

C2. Jakob, M. and Hawkins, G. A., "Elements of Heat Transfer and Insulation," John Wiley & Sons, 1950.

C3. Kreith, F., "Principles of Heat Transfer," International Textbook Company, Second Edition, 1965.