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US Nuclear Regulatory Commission
Washington, DC 20555

Attention: Document Control Desk

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Defueling Completion Report, Third Submittal

Dear Sirs:

Attached is the third submittal of the Defueling Completion Report (DCR). Previous submittals were provided by GPU Nuclear letters 4410-89-L-0070 dated July 5, 1989, and 4410-89-L-0078 dated August 18, 1989.

The attachment provides residual fuel quantities for portions of the Reactor Coolant System (i.e., Section 5.3). Fuel measurements of the remaining portions of the RCS, which may impact or be impacted by ongoing defueling activities (reference Table 5-4), will be performed following the completion of Reactor Vessel defueling. An update of Section 5.3 ,including the results of these measurements, will be provided as part of the final DCR submittal. The attachment also includes Sections 4.4.3.3.8, 4.4.3.4, and 4.4.3.5, which describe fuel removal activities in the Lower Core Support Assembly (CSA), Lower Head, and Upper CSA, and Section 4.3.4, "RCS Fuel Removal Assessment."

Page changes incorporating minor corrections to previously submitted sections of the DCR are attached. Changes are annotated by change bars in the margin. Changed pages and the new material submitted herein are identified as Revision 2 to the initial submittal of the DCR.

Sincerely,

M B Roche

M. B. Roche
Director, TMI-2

RDW/emf

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Attachment

cc: W. T. Russell - Regional Administrator, Region I
J. F. Stolz - Director, Plant Directorate I-4
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TABLE 1-2

ACRONYMS

AB	Auxiliary Building
ACES	Automated Cutting Equipment System
AFHB	Auxiliary and Fuel Handling Buildings
ALARA	As Low As Is Reasonably Achievable
CBM	Core Bore Machine
CFT	Core Flood Tank
CRA	Contral Rod Assembly
CSA	Core Support Assembly
CWST	Concentrated Waste Storage Tank
DCR	Defueling Completion Report
DF	Decontamination Factor
DHR	Decay Heat Removal
DOE	Department of Energy
DWCS	Defueling Water Cleanup System
ECCS	Emergency Core Cooling System
FHB	Fuel Handling Building
FTC	Fuel Transfer Canal
GM	Geiger-Mueller Counter
HEPA	High-Efficiency Particulate Absolute
HPGe	High-Purity Germanium
HPI	High Pressure Injection
IIGT	Incore Instrument Guide Tube
INEL	Idaho National Engineering Laboratory
LS	Lead Screw
LCSA	Lower Core Support Assembly
MDL	Minimum Detectable Level
MeV	Million Electron Volts
MU	Makeup
MU&P	Makeup and Purification
MWHT	Miscellaneous Waste Holdup Tank

TABLE 1-2 (Cont'd)

ACRONYMS

NaI(Tl)	Thalluim Drifted Sodium Iodide
NRC	Nuclear Regulatory Commission
OTSG	Once-Through Steam Generator
PORV	Pilot Operated Relief Valve
RB	Reactor Building
RCBT	Reactor Coolant Bleed Tank
RCDT	Reactor Coolant Drain Tank
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RV	Reactor Vessel
SDS	Submerged Demineralizer System
SER	Safety Evaluation Report
SFML	Safe Fuel Mass Limit
SIVR	Seal Injection Valve Room
SNM	Special Nuclear Material
SRST	Spent Resin Storage Tank
SSTRs	Solid-State Track Recorders
Si(Li)	Lithium Drifted Silicon
TMI-2	Three Mile Island, Unit 2
TRVFS	Temporary Reactor Vessel Filtration System
UCSA	Upper Core Support Assembly
WDL	Waste Disposal Liquid

4.3.3.3 Once-Through Steam Generators and Hot Legs (References 4.22 and 4.23)

Pick-and-place and vacuuming techniques were used to defuel the "A" and "B" OTSG upper tube sheets. Long-handled gripping tools were used to lift large pieces of debris into canisters and a vacuum system removed the smaller debris. While this process essentially succeeded in defueling the "A" OTSG tubesheet, a crust of tightly adherent debris remained on the surface of the "B" OTSG tubesheet. Despite extensive efforts to remove this crust or to collect a sample for analysis by scraping, no further progress was achieved. It has been concluded that no further defueling of the "B" OTSG tubesheet is necessary or appropriate because the small amount of remaining fuel is tightly adherent and unlikely to be transported elsewhere in the system in the future due to a lack of a motive force and our demonstrated inability to remove it with dynamic defueling techniques.

The OTSG tubes were surveyed to detect blockages and adherent fuel-bearing films. GM counters and alpha detectors were used. The lower head of the OTSGs and the J-Legs were surveyed using GM counters and activation foils. No further defueling efforts are planned.

The hot legs were defueled using a combination scraper/vacuuming tool and the Westinghouse vacuum system. Residual fuel in the "B" hot leg was scraped, flushed, and vacuumed into defueling canisters as part of RV defueling (Section 4.4).

Further assessment of the dynamic defueling techniques applied in attempting to remove the tightly adherent residual fuel in the "B" OTSG upper tubesheets is provided in Section 6.0.

4.3.3.4 Decay Heat Drop Line (Reference 4.23)

The in-vessel vacuum system was used to defuel the Decay Heat Drop Line. A deployment tool was developed to guide the vacuum hose into the Decay Heat Drop Line from the RCS "B" hot leg. All loose debris in the vertical portion of the Decay Heat Drop Line was vacuumed. Below the vacuumable loose debris, a hard compacted region of debris was encountered. A drain cleaning machine was used to penetrate this hard debris and size it so vacuuming could continue. The material was airlifted into the "B" hot leg and was removed, as described in the above section, as part of the RV defueling.

4.3.4 RCS Fuel Removal Assessment

Extensive defueling operations were performed in the RCS with the goal of removing the majority of fuel transported to the RCS as a result of the accident. These activities were successful. For example, defueling operations removed approximately 97% of the fuel in the Pressurizer, approximately 70% of the fuel in the OTSG Upper Tube Sheets, and approximately 95% of the fuel in the decay heat drop line. The residual fuel quantity in the RCS components is discussed in Section 5.3.

re-installed and cutting of a large center section from the incore guide support plate was begun. By the end of December, 1988, the plate was sectioned into four, roughly pie-shaped pieces. All 25 cuts, including recuts required to section this plate, were cleaned and verified.

In early January 1989, the cut quadrants of the incore guide tube support plate were lifted from the LCSA, flushed, and transferred to Core Flood Tank "A" for storage.

4.4.3.3.7 Flow Distributor Plate Removal

Following completion of the incore guide support plate removal, loose debris and small pieces of fuel rods wer vacuumed from above and below the flow distributor plat . Long-handled tools were used to pick-and-place larger pieces of debris, much of which had originated in the core region and had accumulated on the flow distributor plate as the result of defueling operations.

In late February 1989, the cutting of the flow distributor began. The plasma arc torch made 104 cut: with numerous recuttings needed to ensure severance. The flow distributor was cut into 26 pieces. By the end of March, the cutting was complete. The sections of the flow distributor plate that did not contain incore guide tubes were removed from the RV and placed inside Core Flood Tank "A". The sections of the plate that contained incore guide tubes were bagged and stored inside the "A" D-Ring.

4.4.3.3.8 Lower Core Support Assembly Remnant Defueling

Following completion of LCSA plate removal, LCSA remnant defueling began. This consisted of removing the loose and resolidified debris that remained on the plate remnants. The primary defueling approach utilized high volume, low pressure water flush and low volume, high pressure cavitating water jet flush. Much of this work was done under conditions of poor to zero visibility due to the suspension of loose debris and was accomplished by indexing positioning tools to LCSA remnants to access specific target areas. High volume, low pressure water flush tools were used first to flush the loose debris off the remnants and into the lower head. The newly exposed resolidified debris was then dislodged with the cavitating water jet. This displaced material was then removed from the lower head as part of lower head defueling using airlifting and vacuuming as well as pick and place activities.

4.4.3.4 Lower Head Defueling

Lower head defueling commenced following the removal of the flow distributor plate which provided a large access hole to the lower head. Lower head defueling included the removal of the accident generated monolith and loose core debris on the lower head as well as post-accident generated debris that relocated to the lower head during the defueling of the other areas within the vessel.

This evolution involved sizing and conditioning of the resolidified material in the monolith with the impact hammer and the cavitating water jet; pick and place of the rods and large debris; and airlifting and vacuuming of loose core debris.

4.4.3.4.1 Loose Debris Defueling in the Lower Head

Prior to removal of the flow distributor plate, a large quantity of material was airlifted from the lower head to facilitate cutting and removal of that plate. When the final LCSA plate was removed, airlifting of the lower head was again performed to remove additional debris. The airlifting activity removed the bulk of the loose debris; pick and place activities removed the remaining loose debris. These activities uncovered a monolith of resolidified debris in the lower head. Following the conditioning and sizing of the monolith, airlifting was repeated in order to remove the remainder of the core debris.

4.4.3.4.2 Monolith Defueling in the Lower Head

The accident resulted in formation of a resolidified mass in the lower head which was irregular in shape varying in depth to less than two (2) feet in the center. This resolidified debris was sized and conditioned successfully using two (2) tools. The first, an impact hammer, was used to break up the central region where there was ready access from above. The monolith was broken up in much the same way as one would approach the demolition of a concrete slab, starting from the outside edges and working inward. The cavitating water jet was used to break up the remaining resolidified debris on the lower head which was located under the LCSA remnants and was inaccessible to the impact hammer. Pick and place and airlifting then removed the conditioned debris.

4.4.3.4.3 Vacuuming in the Lower Head

Following the completion of pick and place activities and airlifting in the lower head, the lower head was vacuumed to minimize the relocation of core debris to other surfaces in the vessel during use of the airlift and to improve visibility. The in-vessel vacuum system, a modified application of the in-vessel filtration system utilizing a knockout canister and filter canister in series, was used for this evolution.

4.4.3.5 Upper Core Support Assembly Defueling

UCSA defueling encompasses removing the fuel debris located between the baffle plates and the core barrel (i.e., the core former region). Resolidified debris formed in this region during the accident. Loose debris also was deposited during the accident and subsequent defueling operations elsewhere in the RV. The scope of this defueling effort includes gaining access to the core former region through the removal of the baffle plates and removal of the resolidified and loose debris.

4.4.3.5.1 Gaining Access to the Upper Core Support Assembly

o gain access to the UCSA required removal of the baffle plates. This was accomplished by cutting the baffle plates into eight (8) sections using the plasma arc torch. Then, the bolts and screws that fastened the baffle plates to the former plates were removed. Bolt removal required use of a hydraulic untorquing tool and a drill tool. The drill tool was used when the untorquing tool either failed to remove the bolt or the untorquing tool could not be used. A total of 864 bolts and screws were removed. A third operation involved clearing the kerf and recutting or drilling the baffle plate cuts previously made by the plasma torch.

4.4.3.5.2 Baffle Plate Handling

Baffle plate handling exposes the UCSA for defueling of the core former area. Two (2) of the eight (8) baffle plate sections were removed and hung from vent valve seats. The exposed area was defueled before removal of the next plate section. Handling of the plates essentially rotates each plate 90° from its original location to its final location.

4.4.3.5.3 Defueling of Upper Core Support Assembly

Defueling the UCSA includes brushing, vacuuming, conditioning resolidified debris, and a second vacuuming.

The inboard and outboard surfaces of the baffle plates, the top and bottom surfaces of the former plates, and the inboard surface of the core barrel, which contained visible fuel, are brushed. The task is accomplished using hydraulically-powered counter-rotating brushes mounted on a pivoting deployment end effector.

Loose debris was vacuumed from the core former plates after removal of the baffle plates and again after conditioning the resolidified debris and brushing the plate surfaces. The in-vessel vacuum system was used for this task. Conditioning the resolidified debris in the UCSA was accomplished using mechanical methods and the cavitating water jet system. The cavijet was directed to the flow holes in the periphery of the

grid rib section outboard of the baffle plates, which contained core debris, while the plates were being removed, permitting access to these flow holes.

4.4.4 Reactor Vessel Fuel Removal Assessment

Figure 2-2 indicates that there was approximately 133,000 kg of core debris in the RV following the accident. The extensive defueling efforts described in the above sections have been very successful in removing this core debris. Currently, it is estimated that defueling efforts will result in the removal of $\geq$99% of the fuel (UO_2) and nearly all of the post-accident core debris from the RV. A summary of the efforts in defueling the various components of the RV is provided below. The following sections will be updated as part of the final DCR submittal.

4.4.4.1 Core Region

Figure 2-2 indicates that there was a total amount of 104,000 kg of core debris in the upper debris bed, resolidified mass, and intact fuel assemblies. Of this total, 99.9% was removed as a result of defueling activities. The small percentage of core debris remaining in this region is essentially in the R-6 incore location. Following extensive defueling in this area, some of this resolidified mass remains.

4.4.4.2 Lower Core Support Assembly

Figure 2-2 indicates that there was approximately 6000 kg of core debris contained in LCSA components following the accident. Approximately 85% of this core debris was removed during the extensive LCSA removal phase and LCSA remnant defueling.

4.4.4.3 Lower Head

Figure 2-2 indicates that approximately 19,000 kg of core debris (i.e., 12,000 kg of loose debris and 7,000 kg of resolidified mass) existed in the RV lower head due to the accident. The defueling efforts in the lower head region, described in Section 4.4.3.4, has removed approximately 93% of this debris. Final vacuuming of the lower head after UCSA defueling is completed is expected to further reduce the amount of core debris in this region.

4.4.4.4 Upper Core Support Assembly

Video inspections of the UCSA indicated that there was approximately 5000 kg of core debris in this region, primarily behind the baffle plates. Following removal of the baffle plates, the core debris in this area was accessible for defueling activities (e.g., flushing, vacuuming, cavijet). Thus, the quantity of core debris in the region is being reduced by ongoing defueling activities.

This estimate is a total of the fuel measured in the seven (7) cubicles before decontamination and resin transfer. Following these measurements, the cleanup filters, cleanup demineralizers, and 85% of the combined total of the A and B MU demineralizers resin were removed. Therefore, a reasonable estimate of the residual fuel content is 710 grams. For bounding purposes, 800 grams is used in Table 5-2.

5.1.2.3 Cubicle AX021 - Reactor Coolant Bleed Tank 1A

The RCBT 1A cubicle contains one of the three (3) 80,000 gallon tanks that are used as a reservoir for reactor coolant. RCBT 1A was drained and decontaminated after the TMI-2 accident but has subsequently been returned to service as a drain tank for reactor coolant. The residual fuel in RCBT 1A is less than 1 kg (reference 5.3.1).

5.1.2.4 Cubicle AX102 - Reactor Building Sump Pump Filter Room

The RB sump pump filters (WDL-F-8A, 8B), filter housings, and associated piping are located in the AX102 cubicle. The RB sump filters were used during the TMI-2 accident to filter the water from the flooded RB basement as it was pumped to the Auxiliary Building. Post-accident sampling of the sludge in the RB basement found it contained a small quantity of fuel. Therefore, some fuel may have been transferred from the RB basement and deposited in AX102 during the accident as a result of the water transfer.

Since the TMI-2 accident, there has been no transfer of water from the RB to the Auxiliary Building sump via the RB sump filters. The RB sump filters that were installed during the accident were removed during 1980 and disposed as radioactive waste. Subsequent to the accident, the RB sump filters have been used routinely to filter water transferred from the Auxiliary Building sump to the MWHT. During the time from 1980 to the present, there have been over 30 filter changeouts of the RB sump filters.

The residual fuel content of AX102 has not been measured because the system is still in use. The residual fuel content will be measured after the defueling program is completed.

A bounding estimate of the residual fuel content of AX102 is 300 grams. This estimate is conservative since any fuel deposited in the RB sump filters and piping as a result of the accident is believed to have been flushed into the filters and removed as part of the multiple (over 30) filter changeouts or by being flushed to the MWHT. The major use of the RB sump filters during the post-accident period has been to filter

transport. Storage of the LCSA components outside but in proximity to the RV (e.g., in the "A" CFT) was deemed necessary to permit continuous progress in the RV defueling activities. Prior to removal from the RV, the LCSA segements were flushed and brushed to remove fuel. The segments were then video inspected to ensure that no visible fuel was present. Sample sections of each plate were measured by gamma spectroscopy and/or alpha measurements to determine the quantity of residual fuel. Extrapolation of fuel content in other sections was determined based on the fuel quantity of the measured sections. For example, two (2) of the four (4) quadrants of the lower grid distributor plate were measured for fuel content and determined to contain a total residual fuel quantity of 163 grams. These measurements were extrapolated for the other two (2) quadrants and an MDL value of less than or equal to 320 grams of residual fuel was assigned to the lower grid distributor plate (Reference 5.10). Likewise, one (1) of the 11 pieces of the flow distributor plate was measured for fuel content (Reference 5.13). Its residual fuel value (i.e., 10 grams) was deemed to be representative of the remaining segments and a total residual fuel quantity of 110 grams was assigned for the flow distributor plate.

Based on the above approach, the "A" CFT, which contains the LCSA components, has been assigned a total of approximately 2.4 kg (References 5.9 through 5.13) of residual fuel, distributed as follows:

Components	Fuel (kg)
Lower Grid Rib Section	<0.1
Lower Grid Distributor Plate	<0.3*
Lower Grid Forging	1.7
Incore Guide Support Plate	<0.2*
Flow Distributor Plate	0.1
TOTAL	2.4

* = MDL value

The portion of the "B" core flood line between the CFT and the check valve was measured for fuel debris using both a directional gamma probe and a cadmium telluride gamma spectrometer. This measurement determined a maximum residual fuel quantity of 130 grams (Reference 2.12).

Measurement of the residual fuel in the "B" CFT and the "A" core flood line are planned and will be provided in a subsequent DCR submittal. Based on the residual fuel content in the "B" core flood line, the residual fuel quantity in these areas is not expected to substantially increase the current core flood system estimate. There are no post-defueling plans to remove the LCSA components stored in the "A" CFT due to the relatively small quantity of residual fuel involved.

spray water, decontamination water, condensation, and additional leakage from the RCS. The basement remained flooded for approximately two (2) years. During this period, sediment and fuel fines settled into a sludge on the basement floor. As discussed in Section 4.2, a significant portion of this sludge was removed during cleanup operations in the RB basement.

The sludge remaining after desludging operations was analyzed by sampling and gamma spectroscopy methods. Uranium concentrations measured in three (3) samples were combined with estimates of residual sediment volume to calculate the total residual fuel on the basement floor excluding the RCDT discharge area. A gamma scan was performed in the RCDT area since the maximum amount of fuel was initially expected to be located in the RCDT. The total fuel contained in the remaining basement sludge following cleanup operations is estimated to be approximately 1.1 kg.

Additionally, fuel particles from washdown of defueling tools was transported to the RB sump. Reference 5.18 provides an initial estimate that 0.2 kg of fuel could have been added to the basement inventory from this activity. Thus, the total fuel in the RB basement is currently estimated to be 1.3 kg.

5.2.10 Miscellaneous Systems and Equipment

In addition to the residual fuel quantities reported in Sections 5.2.1 through 5.2.9, residual fuel is expected to be contained in various systems/equipment located in the RB which were utilized during the defueling effort. Included are the DWCS, the Defueling Tool Rack which contains the various long-handled tools used to defuel the RV, the TRVFS, and the RB drain system. Residual fuel contained in these operating cleanup systems/equipment is expected to amount to a very small fraction of the SFML and will pose no criticality concern. For example, the NRC approved DWCS Technical Evaluation Report (TER) (Reference 5.19) states that the DWCS has been designed to prevent a possible critical configuration of fuel. Further, the DWCS will be internally flushed and partially disassembled prior to being decommissioned. This action will remove a portion of the internal deposits of residual fuel contained in the DWCS. Additionally, as discussed in Section 5.2.9, defueling tools are generally flushed prior to removal from the RV in order to remove any loose residual fuel. The estimate of residual fuel in these cleanup systems will be provided in a subsequent DCR submittal.

5.2.11 Criticality Assessment

Table 5-3 lists the total quantity of residual fuel in the RB exclusive of the RCS and RV. This table will be updated following the completion of remaining fuel measurements. As indicated, the total fuel mass remaining in the RB is well below the SFML of 140 kg presented in Appendix B. Subcriticality is further enhanced since most of the residual fuel is tightly adhered to RV

5.3 Reactor Coolant System

As described in Section 2.0, during the accident fuel was transported to the RCS as a result of the core degradation event and operation of the RCPs. Section 2.2 reported that approximately 230 kg of fuel was transported throughout the RCS during the accident. Section 4.3 describes the defueling operations performed on these RCS components.

The following sections provide the current estimate of residual fuel in the RCS excluding the RB (i.e., Section 5.2) and RV (i.e., Section 5.4). These estimates are based on fuel measurements and extensive evaluations of RCS components. The residual fuel measurements in the RCS hot legs, RCS cold legs, RCPs, and core flood lines cannot be determined at this time as measurement activities would interrupt ongoing defueling operations in the RV and further defueling activities could affect the final quantity of residual fuel in regions of interest. The residual fuel quantity for these areas will be provided at the end of defueling. The basis for each approach is provided within each section.

5.3.1 Pressurizer (Reference 5.20)

Following the completion of Pressurizer defueling operations in June 1988 (see Section 4.3.3.1), a small amount of core debris, consisting of small particles, remained in the Pressurizer. A video examination of the debris at the bottom of the Pressurizer was used to determine the volume of core debris.

A 100 gram sample was removed from the Pressurizer in March 1988. Neutron interrogation and gamma spectrometry were used to analyze the sample. The neutron counts were compared to a natural uranium standard and the gamma counts were compared to standard Ce-144 and Eu-154 sources. From these comparisons, the uranium content of the sample was calculated. Scaling from the sample to the total quantity of residual debris in the Pressurizer yielded the total fuel in the Pressurizer. From this analysis, it has been calculated that 0.3 kg of fuel remains in the pressurizer.

As described in Section 4.3.3.2, debris in the Pressurizer spray line was flushed back into the Pressurizer and was subsequently removed during defueling operations. Therefore, there is no measurable quantity of residual fuel in the Pressurizer spray line.

5.3.2 Decay Heat Drop Line (Reference 5.21)

A video inspection and gross gamma measurement of the decay heat drop line was performed after defueling of the decay heat drop line was completed in January 1989. This video inspection and gamma probing data indicated that the radiation levels measured in the horizontal portion of the decay heat drop line corresponded to small amounts of debris on the bottom internal surface of the line.

A sample of the decay heat line debris was analyzed by gamma spectrometry to determine the radionuclide distribution. The line was then modeled with a shielding code using the sample information as the source. By matching the model to the measured gamma exposures, it is calculated that 1.5 kg of fuel remains in the decay heat drop line.

5.3.3 Once Through Steam Generators

5.3.3.1 Tubesheets/Upper Heads (References 4.22 and 5.22)

The estimate of fuel remaining on the "B" upper tubesheet was generated based on copper foil activation measurements performed in January 1989 (Reference 4.22). Four (4) copper foils were placed inside the "B" OTSG above the tubesheet. They were activated by exposure to the fuel in this environment and were measured with a coincidence counting system. In addition, foils were positioned to measure background at the counting station and inside the "A" OTSG upper head. The "A" OTSG and background foils were activated to the same level, indicating an undetectable quantity of fuel on the "A" tubesheet using this method. Using the background and "A"tubesheet measurements as calibration data, the "B" tubesheet was calculated to contain 36 kg of fuel.

The "A" OTSG upper tubesheet had less than one (1) liter of debris on it following the accident. Following defueling, the quantity of fuel on the tube sheet was so low as to be undetectable via copper foil activation coupons. An estimate of record of the residual fuel quantity in the "A" OTSG upper tubesheet has not yet been performed. However, based on an analysis of debris samples, it can be reasonably estimated that the residual fuel quantity in the "A" OTSG upper tubesheet is less than 1 kg (Reference 5.22).

5.3.3.2 Tube Bundles (Reference 5.23)

Fuel in the OTSG tube bundles was measured using a gross gamma probing technique. Preliminary shielding code work showed that the gamma detectors proposed for these measurements could detect a tube plugged with fuel to a radius of 8 inches. By probing a grid of 52 tubes, the whole OTSG tube bundle could be measured. The data was collected at 1-foot increments down the length of the 52 chosen tubes in each OTSG.

Analysis of the probing data indicates that there are no significant radiation sources within the tube region that are attributable to large fuel blockages. High radiation fields within the upper 6 feet of the "B" tube bundle are attributed to the upper tubesheet debris. Additionally, high dose rates were also associated with the water/air interface approximately half-way down the tube, possibly corresponding to a "bathtub ring" of boron and crud. Dose rates for all other areas were relatively uniform within the calculated deviation.

Based on the modeled steam generator fuel debris and corresponding dose rates, the residual fuel in the "A" and "B" OTSG tube bundles were calculated to be 1.7 kg and 9.1 kg, respectively.

5.3.3.3 Lower Heads/J-Legs (Reference 5.24)

The "A" and "B" OTSG lower head and J-leg fuel measurements were performed using GM probe fuel measurement strings containing copper coupons which were inserted through the generator tube bundle to the lower head and associated J-legs. Miniature lights and videoprobes were also inserted through surrounding tubes and used to verify placement of the strings and location of debris. Fuel estimates based on in-situ exposure rates for the "A" and "B" lower heads and J-legs are 1.0 kg and 6.3 kg, respectively.

The copper coupons were removed from the strings and transferred to the DOE for subsequent independent fuel measurement assessment. The DOE estimated residual fuel quantities in the "A" and "B" OTSG lower head and J-legs of 5.2 kg and 5.4 kg, respectively (Reference 5.25). For purposes of the DCR, the GPU Nuclear fuel estimates are reported. The GPU Nuclear fuel estimates are believed to be more representatives of the residual fuel in the "A" and "B" lower head and J-legs based on the location of the GM counters and the sensitivity of the fuel measurements (i.e., Reference 5.25 states that the DOE fuel measurements have an uncertainty by a factor of two).

5.3.4 Criticality Assessment

Table 5-4 lists the total quantity of residual fuel in the RCS exclusive of the RB and RV. This table will be updated following the completion of remaining fuel measurements; however, it is anticipated that the total quantity of fuel in the RCS will be below the SFML of 140 kg. Subcriticality is further enhanced since most of the residual fuel is tightly adhered to RCS components. Fuel in this configuration is significantly less reactive than in the optimum conditions assumed in Appendix B (i.e., fuel pellets, optimum moderation with unborated water, and spherical geometry). Additionally, the current configuration prevents any significant debris transport, thus minimizing any interactive effects of the various fuel accumulations. The potential for fuel transport and interaction with the RB components and RV will be described in the final DCR submittal.

5.3.5 Summary

Table 2-1 indicates that approximately 230 kg of fuel was deposited in RCS components as a result of the accident. Subsequently, extensive defueling operations were performed in the RCS as described in Section 4.3. RCS defueling operations were

performed in the Pressurizer, the Pressurizer spray line, the "A" and "B" OTSG upper tube sheet, the RCS hot legs, and the decay heat drop line. As a result of these defueling operations, the residual fuel in RCS components has been reduced significantly and does not pose a criticality concern. Currently, the largest measured quantity of residual fuel in the RCS is in the "B" OTSG upper tubesheet (i.e., 36 kg). A variety of defueling techniques have been used on the tubesheets (e.g., pick and place, vacuuming, scraping). It has been determined that the remaining fuel in the "B" OTSG upper tubesheet is a crust of tightly adherent debris not readily removable by available dynamic defueling techniques. Further assessment of the residual fuel in the "B" OTSG upper tubesheets is provided in Section 6.0.

The total estimated quantity of fuel in those portions of the RCS, listed in Table 5-4, is less than the SFML. There is no potential for transport of fuel within the RCS which could result in a critical mass. Thus, subcriticality is assured. GPU Nuclear has concluded that no further efforts to remove fuel from these portions of the RCS are appropriate or necessary to preclude criticality or otherwise demonstrate that defueling has been completed to the extent reasonably achievable. However, the RCS will be drained as part of post-defueling activities and this activity may result in the removal of additional small quantities of fuel.

TABLE 5-1

AFHB CUBICLES WHICH CONTAIN NO RESIDUAL FUEL

DESIGNATION	NAME	EXPLANATION
AX001	RB Emergency Pumps	No fuel transport pathway
AX002	Access Corridor	No waste piping in area
AX003	Access Area	No waste piping in area
AX013	Evaporator Condensate Tank Pumps	All pathways isolated prior to and following the accident
AX022	North Stairwell	No waste piping in area
AX023	Elevator Shaft	No waste piping in area
AX027	South Stairwell	No waste piping in area
AX101	Radwaste Disposal Panel	No waste piping in area
AX103	MCC 2-11 EB	No waste piping in area
AX104	MCC 2-21 EB	No waste piping in area
AX105	Substation 2-11E	No waste piping in area
AX106	Substation 2-21E	No waste piping in area
AX107	MCC 2-11 EA	No waste piping in area
AX108	MCC 2-21 EA	No waste piping in area
AX109	Nuclear Service Coolers and Pump	All pathways isolated since accident
AX110	Intermediate Coolers	All pathways isolated since accident
AX111	Intermediate Cooling Pump	All pathways isolated since accident
AX113	Waste Gas Analyzer	System design prevents fuel transport
AX118	Spent Fuel Coolers	All pathways isolated since accident
AX120	Spent Fuel Filters	All pathways isolated since accident
AX121	Elevator Shaft	No waste piping in area
AX122	North Stairwell	No waste piping in area
AX123	Access Area	No waste piping in area
AX125	Waste Gas Decay TK-1B	System design prevents fuel transport
AX126	Waste Gas Filter Room	System design prevents fuel transport
AX127	Waste Gas Decay TK-1A	System design prevents fuel transport
AX128	Valve and Instrument Room	System design prevents fuel transport
AX132	Corridor Between U1 & U2	All pathways isolated since accident
AX133	South Stairwell	No waste piping in area

TABLE 5-1 (Cont'd)

AFHB CUBICLES WHICH CONTAIN NO RESIDUAL FUEL

DESIGNATION	NAME	EXPLANATION
AX135	Radwaste Disposal Control Panel	No waste piping in area
AX201	North Stairwell	No waste piping in area
AX202	Elevator Shaft	No waste piping in area
AX203	4160 Switchgear 2-1E	No waste piping in area
AX204	4160 Switchgear 2-2E	No waste piping in area
AX205	RB Purge Air Supply	System design prevents fuel transport
AX206	RB Purge Exhaust - B	System design prevents fuel transport
AX207	RB Purge Exhaust - A	System design prevents fuel transport
AX208	AB Exhaust Unit B	System design prevents fuel transport
AX209	AB Exhaust Unit A	System design prevents fuel transport
AX210	FHB Exhaust Unit B	System design prevents fuel transport
AX211	FHB Exhaust Unit A	System design prevents fuel transport
AX212	Decay Heat Surge Tank	No fuel transport pathway
AX213	Unit Substation	No waste piping in area
AX214	Decon Facility	No fuel transport pathway
AX215	FHB Supply Unit	System design prevents fuel transport
AX216	AB Supply Unit	System design prevents fuel transport
AX217	Access Area	No waste piping in area
AX219	Instrument Racks	System design prevents fuel transport
AX220	Caustic Mixing Area	All pathways isolated since accident
AX221	Caustic Mixing Area	All pathways isolated since accident
AX222	South Stairwell	No waste piping in area
AX223	Air Handling Units	System design prevents fuel transport
AX301	Elevator Shaft	No waste piping in area
AX302	North Stairwell	No waste piping in area
AX303	Elevator and Stairwell Access	No waste piping in area
AX401	Roof	No waste piping in area
AX402	Cooling Water Storage Tanks	No fuel transport pathway
AX403	Damper Room	System design prevents fuel transport
FH002	Access Corridor	No waste piping in area

TABLE 5-1 (Cont'd)

AFHB CUBICLES WHICH CONTAIN NO RESIDUAL FUEL

DESIGNATION	NAME	EXPLANATION
FH004	West Valve Room	All pathways isolated since accident
FH005	Mini Decay Heat Sevice Coolers	All pathways isolated since accident
FH006	Decay Heat Service Coolers	All pathways isolated since accident
FH007	Neutralizer and Reclaimed Boric Acid	All pathways isolated since accident
FH010	Reclaimed Boric Acid Tank	All pathways isolated since accident
FH011	Reclaimed Boric Acid Pump	All pathways isolated since accident
FH013	Oil Drum Storage	No waste piping in area
FH102	East Corridor	No waste piping in area
FH103	Sample Room	System flushed periodically no deposits
FH104	West Corridor	No waste piping in area
FH105	Model Room A	No waste piping in area
FH107	Trash Compactor	No waste piping in area
FH108	Truck Bay	No waste piping in area
FH111	Fuel Cask Storage	See Section 5.1.2.9
FH201	East Corridor	No waste piping in area
FH202	West Corridor	No waste piping in area
FH203	Surge Tank Area	All pathways isolated since accident
FH204	Standby Pressure Control Area	System design prevents fuel transport
FH302	SDS Operating Area	See Section 5.1.2.9
FH303	Upper SPC Area	System design prevents fuel transport
FH305	Spent Fuel Pool Access	System design prevents fuel transport

TABLE 5-2

AFHB CUBICLES WHICH POTENTIALLY CONTAIN RESIDUAL FUEL(1) (2)

FUEL QUANTITY (kg)	DESIGNATION	NAME	REFERENCE
0.13	AX004	Seal Injection Valve Room	Section 5.1.2.1
<0.003**	AX005	Makeup Pump - 1C	TB SNM 89-03*
0.066	AX006	Makeup Pump - 1B	TB SNM 87-02
<0.062**	AX007	Makeup Pump - 1A	Eng. Calculation 4550-3211-87-027
	AX008	Spent Resin Storage TK-1B	Section 5.1.2.2
	AX009	Spent Resin Storage TK-1A	Section 5.1.2.2
	AX010	Spent Resin Storage Tank Pump	Section 5.1.2.2
	AX014	Reactor Coolant Evaporator	Section 5.1.2.2
	AX015a	Cleanup Filters	Section 5.1.2.2
	AX015b	Cleanup Filters	Section 5.1.2.2
0.8	AX016	Cleanup Demineralizer - 2A	Section 5.1.2.2
	AX017	Cleanup Demineralizer - 2B	Section 5.1.2.2
	AX114	MU&P Demin - 1A	Section 5.1.2.2
	AX115	MU&P Demin - 1B	Section 5.1.2.2
	AX119	Spent Fuel Demineralizer	Section 5.1.2.2
	AX129	Deborating Demineralizer - 1B	Section 5.1.2.2
	AX130	Deborating Demineralizer - 1A	Section 5.1.2.2
	FH001	MU Suction Valves	Section 5.1.2.2
<0.002**	AX011	AB Sump Pump and Valve	TB 86-28
<0.300**	AX012	AB Sump Pumps and Tank	TB 86-28
<0.01**	AX018	Waste Transfer Pump	TB 86-38

* - TB refers to a TMI-2 Technical Bulletin
** - Denotes Minimum Detectable Level

(1) - Based on current available data, this table will be updated as necessary as further data become available. Wherever uncertainties exist as to the quantity of fuel, the upper bound estimate is used.

(2) - The predominant form of residual fuel identified in the AFHB is finely divided, small particle size, sediment material with minor amounts of fuel found as adherent films on metal oxide surfaces.

TABLE 5-2 (Cont'd)

AFHB CUBICLES WHICH POTENTIALLY CONTAIN RESIDUAL FUEL(1) (2)

FUEL QUANTITY (kg)	DESIGNATION	NAME	REFERENCE
<0.005**	AX019	WDL Valves	TB 86-38
14	AX020	RCBTs 1B and 1C	TB 87-12
<1	AX021	RCBT 1A	Section 5.1.2.3
0.005	AX024	AB Sump Filters	TB SNM 89-02
<0.002**	AX026	Seal Injection Filters	TB SNM 87-04
0.300	AX102	RB Sump Pump Filters	Section 5.1.2.4
0.292	AX112	Seal Return Coolers	TB SNM 88-03
0.309	AX116	Makeup Tank	Eng. Calculation 4550-3211-87-038
0.04	AX117	MU&P Filters	TB 86-38
1	AX131	Miscellaneous Waste Holdup Tank	Section 5.1.2.5
	AX134	Miscellaneous Waste Tank Pumps	Section 5.1.2.5
0.5	AX124	Concentrated Liquid Waste Pump	Section 5.1.2.5
	AX218	CWSTs	Section 5.1.2.5
0.002	AX501	RB Spray Pump - 1A	TB 86-47
0.002	AX502	RB Spray Pump - 1B	TB 86-47
0.002	AX503	DHR Cooler & Pump - 1A	TB 86-47
0.002	AX504	DHR Cooler & Pump - 1B	TB 86-47
<0.008**	FH003a	MU Discharge Valves	TB 86-38
<0.060**	FH003b	MU Discharge Valves	TB 86-38

* - TB refers to a TMI-2 Technical Bulletin
** - Denotes Minimum Detectable Level (MDL)

(1) - Based on current available data, this table will be updated as necessary as further data become available. Wherever uncertainties exist as to the quantity of fuel, the upper bound estimate is used.

(2) - The predominant form of residual fuel identified in the AFHB is finely divided, small particle size, sediment material with minor amounts of fuel found as adherent films on metal oxide surfaces.

TABLE 5-2 (Cont'd)

AFHB CUBICLES WHICH POTENTIALLY CONTAIN RESIDUAL FUEL(1) (2)

FUEL QUANTITY (kg)	DESIGNATION	NAME	REFERENCE
1	FH008	Neutralizer Tank Pump	Section 5.1.2.5
	FH009	Neutralizer Tank	Section 5.1.2.5
	FH012	Neutralizer Tank Filers	Section 5.1.2.5
<1	FH014	Annulus	Section 5.1.2.6
	FH112	Annulus	Section 5.1.2.6
	FH205	Annulus	Section 5.1.2.6
0.71	FH101	MU&P Valve Room	TB 86-38/86-21
1	FH106	SDS Monitor Tanks	Section 5.1.2.7
	FH110	Spent Fuel Pool "B"	
------ (3)	FH109	Spent Fuel Pool "A"	Section 5.1.2.8
<23 kg = TOTAL			

(1) - Based on current available data, this table will be updated as necessary as further data become available. Wherever uncertainties exist as to the quantity of fuel, the upper bound estimate is used.

(2) - The predominant form of residual fuel identified in the AFHB is finely divided, small particle size, sediment material with minor amounts of fuel found as adherent films on metal oxide surfaces.

(3) - No Value Assigned; See Section 5.1.2.8 for details.

TABLE 5-3

RESIDUAL FUEL QUANTIFICATION IN THE REACTOR BUILDING[a]

COMPONENT	RESIDUAL FUEL QUANTITY (KG)
RV Head	1.4[b]
RV Plenum	2.1
Fuel Transfer Canal	(b)
Core Flood System	2.4[b]
D-Rings	23
Upper Endfittings	< 54[b]
Reactor Coolant Drain Tank	0.1
Letdown Coolers	< 4 [c]
RB Basement/Sump	1.3
Cleanup Systems/Equipment (e.g. DWCS, TRVFS, RB Drains)	(b)
TOTAL	< 88 kg[b]

(a) - Excluding the RV and RCS.

(b) - To Be Updated in a Subsequent DCR Submittal.

(c) - MDL

TABLE 5-4

RESIDUAL FUEL QUANTIFICATION IN THE RCS[a]

COMPONENT	RESIDUAL FUEL QUANTITY (kg)
"A" Side	
Hot Leg	(b)
OTSG Upper Tubesheet	<1.0
Tube Bundle	1.7
Lower Head and J-Legs	1.0
Reactor Coolant Pumps	(b)
Cold Legs	(b)
Core Flood Line[c]	(b)
"B" Side	
Hot Leg	(b)
OTSG Upper Tubesheet	36
Tube Bundle	9.1
Lower Head and J-Legs	6.3
Reactor Coolant Pumps	(b)
Cold Legs	(b)
Core Flood Lines[c]	(b)
Pressurizer	0.3
Decay Heat Drop Line	1.5
TOTAL =	<57[d]

(a) - Excluding the RV.
(b) - To Be Provided
(c) - Between the RV and First Check Valve
(d) - To Be Updated

FIGURE 5-1
AUXILIARY BUILDING 280'-6" ELEVATION

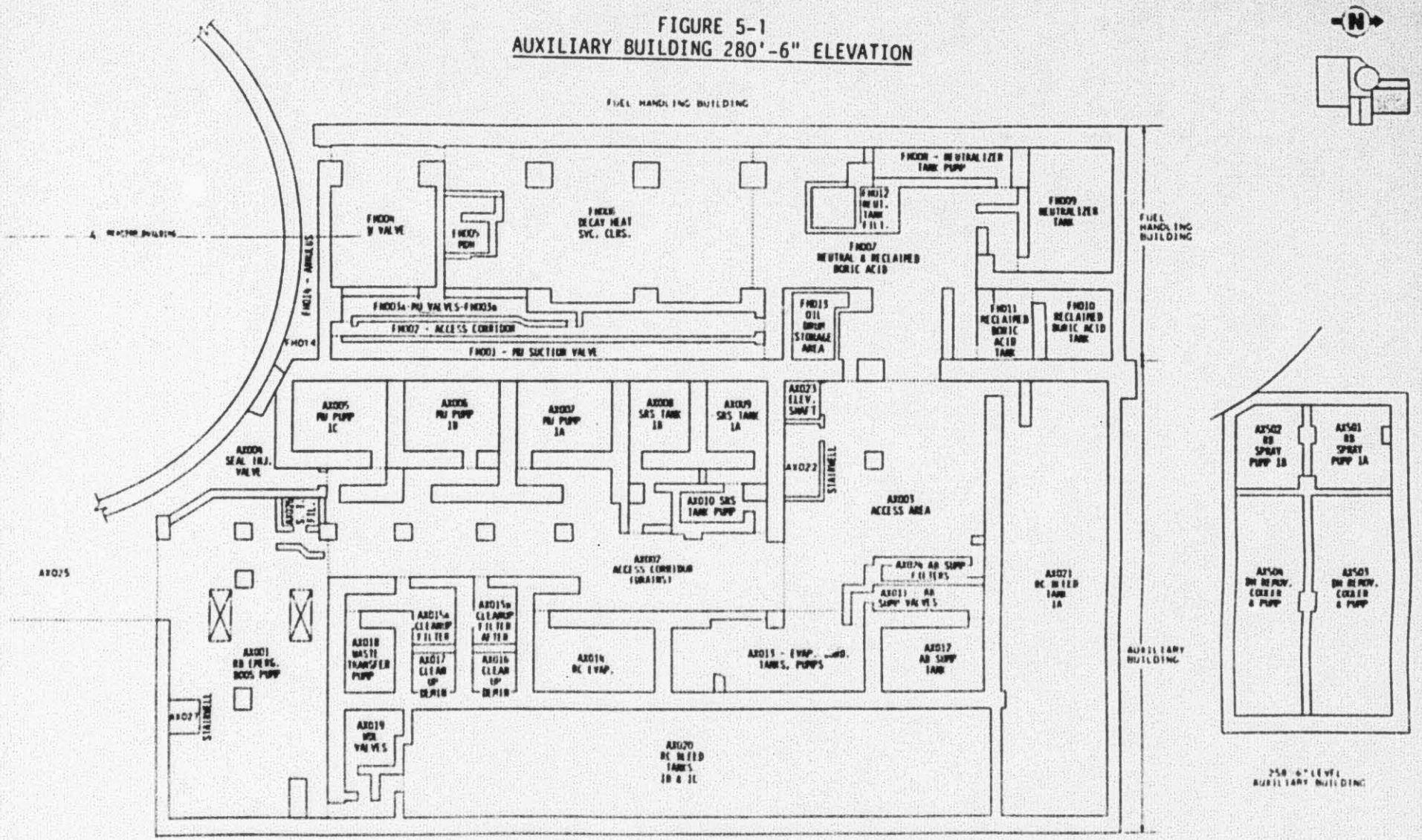
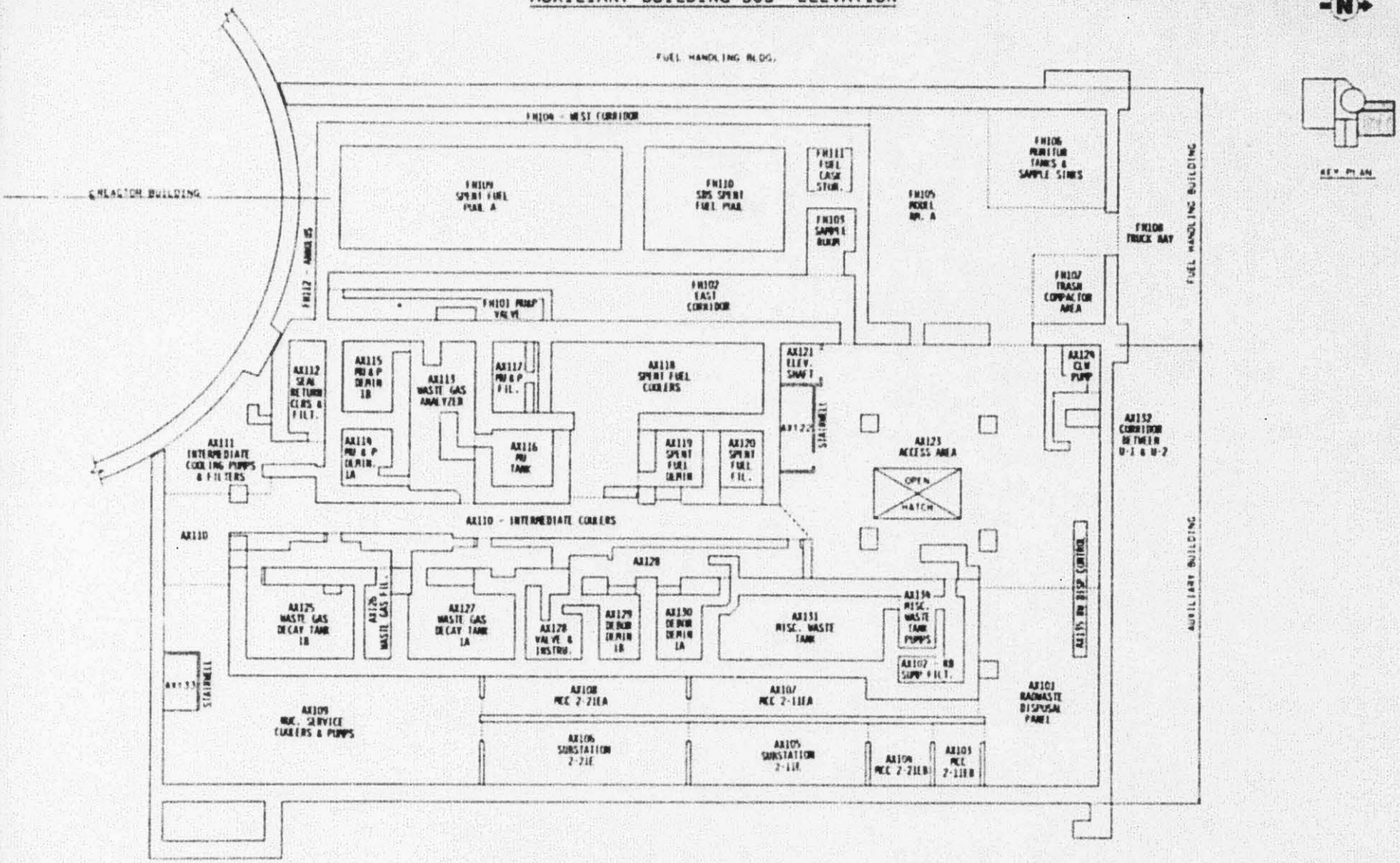
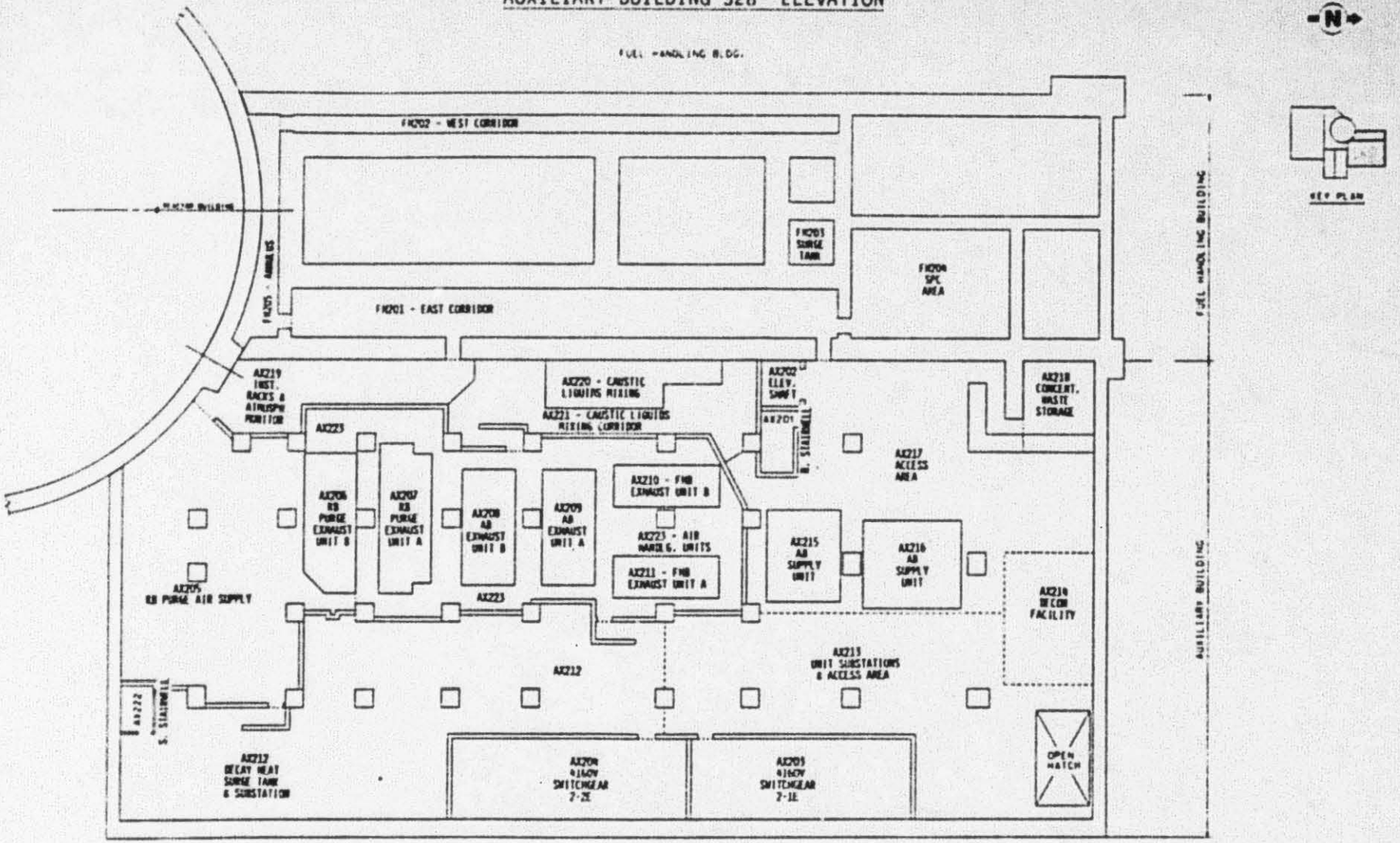


FIGURE 5-2
AUXILIARY BUILDING 305' ELEVATION



Rev. 2/0496P

FIGURE 5-3
AUXILIARY BUILDING 328' ELEVATION



328' LEVEL AUXILIARY BLDG.

Rev. 2/0496P

FIGURE 5-4
AUXILIARY BUILDING 347'-6" ELEVATION

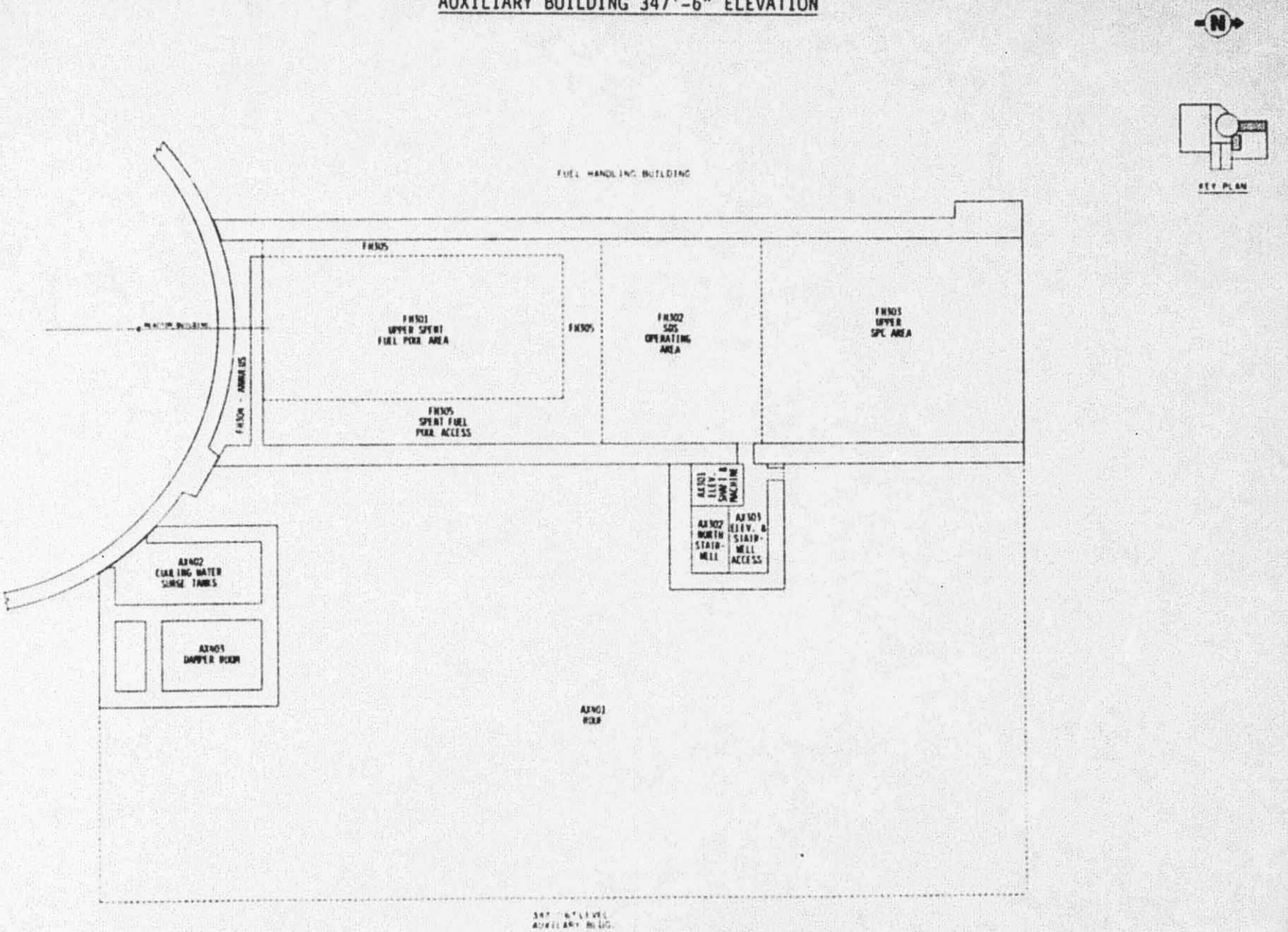


FIGURE 5-5

TMI-2 REACTOR - UPPER HALF

(Simplified)

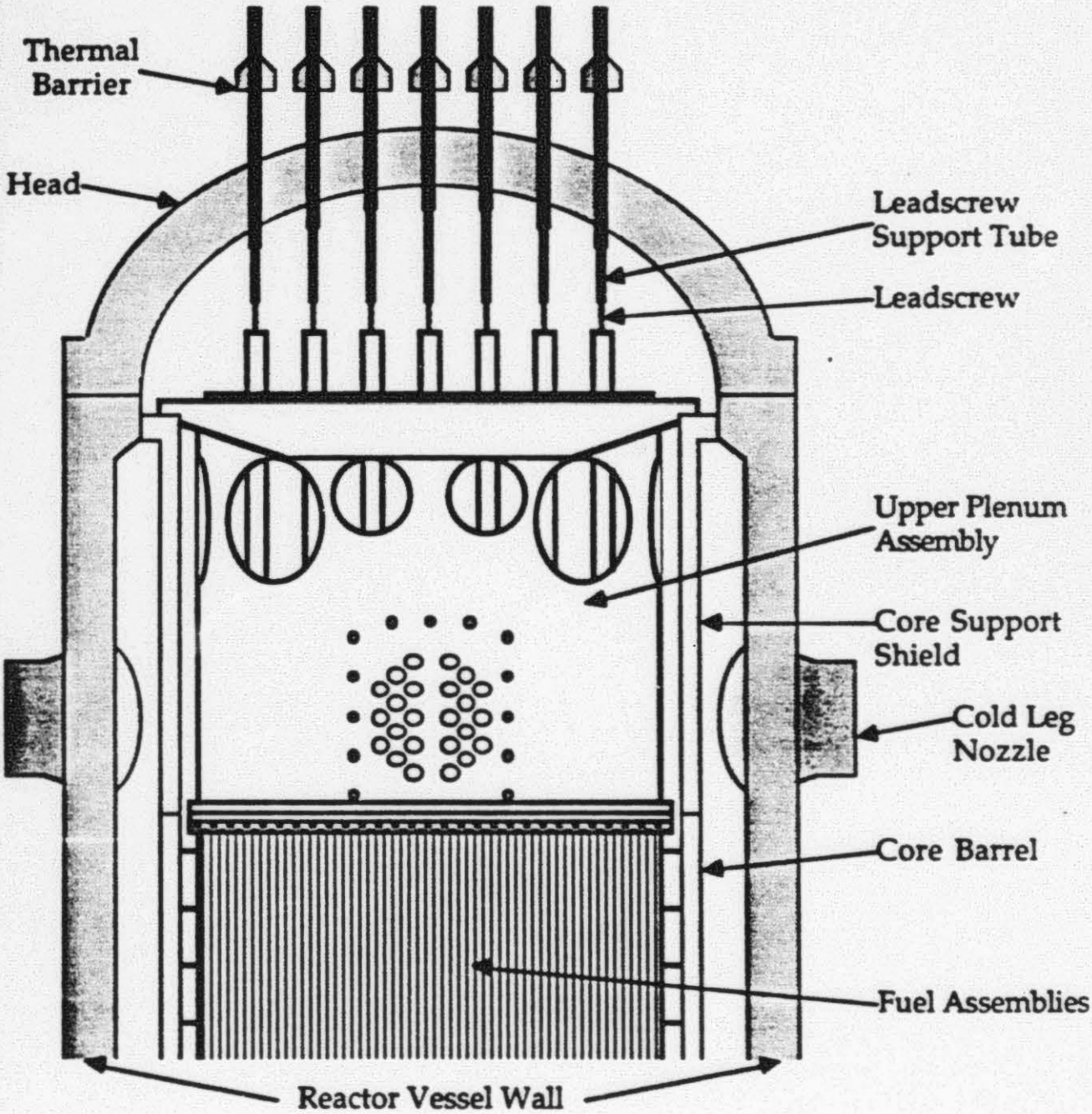
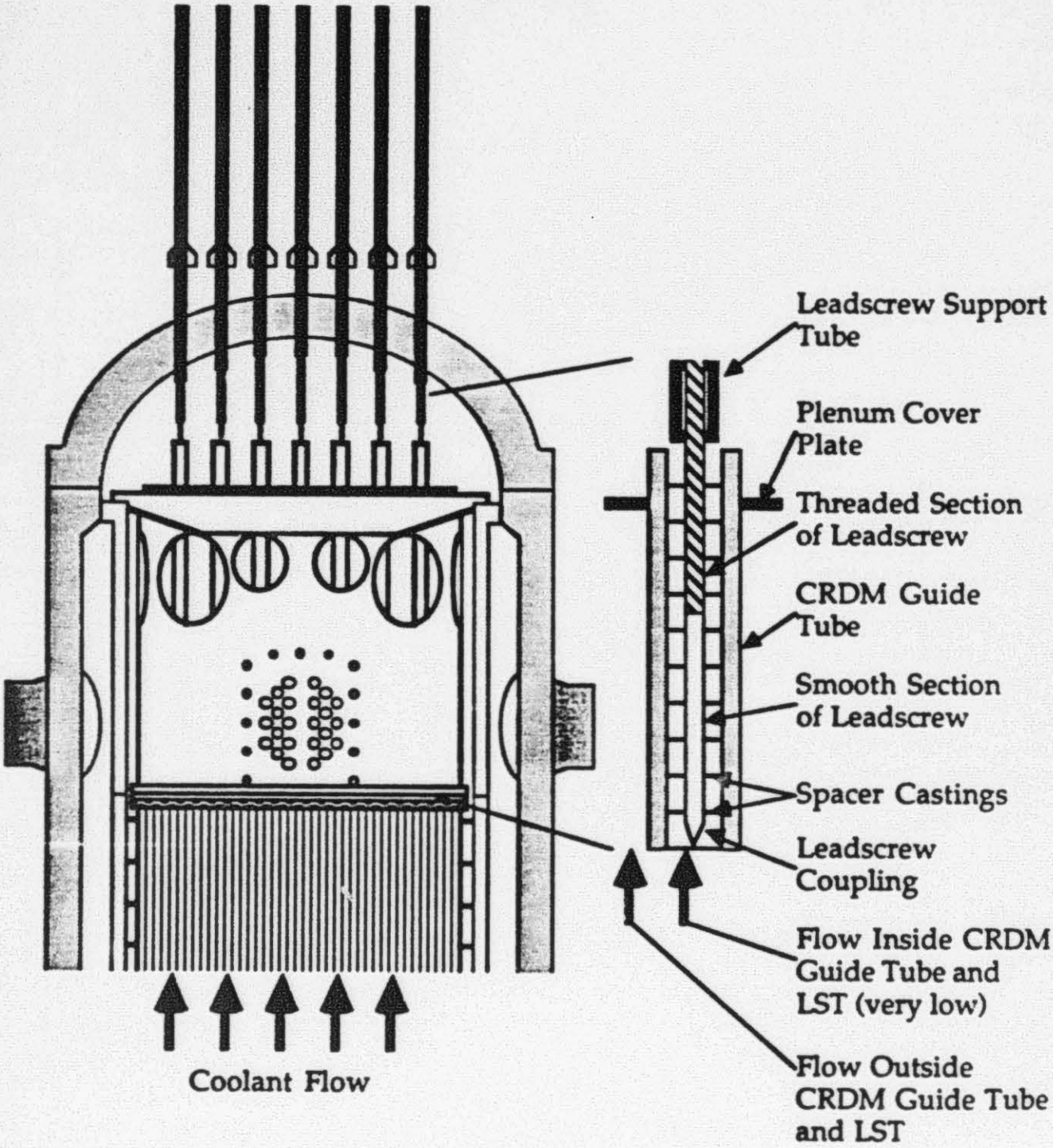


FIGURE 5-6

LEADSCREW AND LS SUPPORT TUBE

(Simplified)



4.26 GPU Nuclear letter 4410-86-L-0049, Defueling Safety Evaluation Report, Revision 10, dated May 15, 1986.

4.27 Technical Bulletin 86-40, Swiss Cheese Drilling of Core, Revision 0, GPU Nuclear, Middletown, PA, September 1986.

5.1 Technical Bulletin SNM 87-04, "Seal Injection Filter (MUF-4A/B) Room/AX026 SNM Accountability Summary," Revision 1, October 22, 1987.

5.2 Technical Bulletin 86-38, "Summary of Fuel Quantities External to the Reactor Vessel," Revision 3, January 24, 1989.

5.3 Technical Bulletin 86-48, "Cleanup Filters (WDL-F6A & B and WDL-F9A & B) Fuel Quantification," Revision 0, dated December 8, 1986.

5.3.1 GPU Nuclear Calculation 4800-3232-89-077, "Reactor Coolant Bleed Holdup Tank 1A (WDL-T-1A)," Revision 0, August 21, 1989.

5.4 Technical Bulletin 86-28, "Auxiliary Building Sump, Sump Tank and Valve Gallery Reactor Fuel Quantification," Revision 0, May 16, 1986.

5.5 GPU Nuclear Calculation No. 4550-3211-87-038, "Makeup Tank Room (AX116) SNM Accountability Calculation," Revision 1, February 1, 1988.

5.6 Technical Evaluation for Defueling Canisters, 3527-016, Revision 4, September 22, 1987.

5.7 TMI-2 Post-Defueling Survey Report for the Reactor Vessel Head (Draft).

5.8 TMI-2 Post-Defueling Survey Report for the Reactor Vessel Plenum.

5.9 Technical Bulletin SNM 88-06, "Lower Core Support Assembly Grid Rib Section," Revision 0, October 12, 1988.

5.10 Technical Bulletin 88-16, "Removal of Lower Grid Distributor Plate," Revision 0, July 21, 1988.

5.11 Technical Bulletin SNM 89-01, "Lower Core Support Assembly Lower Grid Forging SNM Accountability Summary," Revision 0, January 25, 1989.

5.12 Technical Bulletin SNM 89-04, "Incore Guide Support Plate SNM Accountability Summary," Revision 0, January 30, 1989.

5.13 Technical Bulletin 89-07, "Video Inspections of Incore Instrument Guide Tubes," Revision 0, May 23, 1989.

5.14 GPU Nuclear letter 4410-86-L-0132, "Storage of Upper Endfittings," dated August 16, 1986.

5.15 GPU Nuclear letter 4410-86-L-0160, "End Fitting Storage," dated September 9, 1986.

5.16 GPU Nuclear letter 4410-89-L-0041, "Program for Surveying the Endfitting Storage Containers," dated May 10, 1989.

5.17 TMI-2 Post-Defueling Survey Report for the Letdown Coolers (Revision 1).

5.18 TMI-2 Post-Defueling Survey Report for the Reactor Building Basement PDSR Reactor Fuel.

5.19 Technical Evaluation Report for Defueling Water Cleanup System, 3525-015, Revision 12, dated May 12, 1989.

5.20 TMI-2 Post-Defueling Survey Report for the Pressurizer.

5.21 GPU Nuclear Calculation 4800-3212-89-010, "Decay Heat Line Fuel Estimate," Revision 0, dated May 16, 1989.

5.22 Technical Bulletin 86-24, "OTSG-A Upper Tube Sheet Debris Samples," Revision 0, April 25, 1986.

5.23 GPU Nuclear Calculation 4800-3224-89-006, "OTSG Tube Bundle Fuel Estimates," Revision 0, dated May 3, 1989.

5.24 Technical Bulletin 88-19, "A and B OTSG Lower Head and J-Leg Fuel Estimate," Revision 0, dated October 26, 1988.

5.25 "Neutron Measurement of the Fuel Remaining in the TMI-2 OTSGs," Pacific Northwest Laboratory Operated for hte U.S. Department of Energy by Battelle Memorial Institute, PNL-6807, January 1989.