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Hazard Assessment Document

for the

Materials Test Reactor Vessel Structure

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9. Document Control Release Signature: ____ Date: ____

RECORDS MANAGEMENT

CONTENTS

FIGURES

ACRONYMS

ASA	auditable safety analysis
CFR	Code of Federal Regulations
DD&D	deactivation, decontamination, and decommissioning
DOE	Department of Energy
DOE-ID	Department of Energy, Idaho Operations Office
INEEL	Idaho National Engineering and Environmental Laboratory
ISMS	Integrated Safety Management System
M&O	management and operations
MTR	Materials Test Reactor
NRASA	not requiring additional safety analysis
R&D	research and development
TRA	Test Reactor Area

1. INTRODUCTION

Department of Energy (DOE) Idaho Operations Office (DOE-ID) Order 420.D, "Requirements and Guidance for Safety Analysis,"[1] requires that a hazard assessment be performed for all facilities and activities at the Idaho National Engineering and Environmental Laboratory (INEEL). Hazards are screened in accordance with Table 1 of DOE Order 420.D to determine the proper level of safety documentation and approval.

This document presents the hazard classification of the Material Test Reactor (MTR) Vessel Structure located in the Test Reactor Area (TRA) in Building TRA-603 (Figure 1). The existing hazard classification of the inactive MTR Vessel Structure is as a "low hazard, radiological facility."[2] The hazard classification was based on DOE guidance documents that have since been discontinued or revised; thus, an updated hazard assessment is necessary. This document incorporates the requirements of DOE-ID Order 420.D, Rev. 1 and removes references to the cancelled DOE-EM-STD-5502. This document also provides the justification for cancellation of the auditable safety analysis Auditable Safety Analysis (ASA)-136, "Auditable Safety Analysis for the MTR Vessel Structure,"[2] which has become obsolete due to the evaluation and hazard designation presented herein.

The MTR Vessel Structure is defined as the outer concrete biological shielding and all that it encloses, including the following:

- Reactor internals, which include the beryllium reflector and the core lattice and supports
- Reactor vessel, which consists of five connected vertical tanks, the top plug (which is in the reactor room), and the bottom plug (which is in the subpile room)
- Graphite reflector
- Steel thermal shield
- Biological shield, which consists of high-density concrete and lead bricks.

2. FACILITY/ACTIVITY DESCRIPTION

Criticality was first attained March 31, 1952, and design reactor power of 30 MW(t) was attained May 22, 1952. The reactor was shut down for the last time on August 21, 1970, with a total lifetime operating history of just under 180,000 MWd. The fuel was immediately removed from the reactor and placed in the MTR canal for temporary storage, therefore there is no potential for a criticality in the MTR Vessel Structure. The fuel has since been removed from the canal and transported to another INEEL facility.

HAZARD ASSESSMENT DOCUMENT FOR THE MATERIALS TEST REACTOR VESSEL STRUCTURE	Identifier: HAD-207 Revision: 1 Page: **4** of 17

TRA SITE PLOT PLAN

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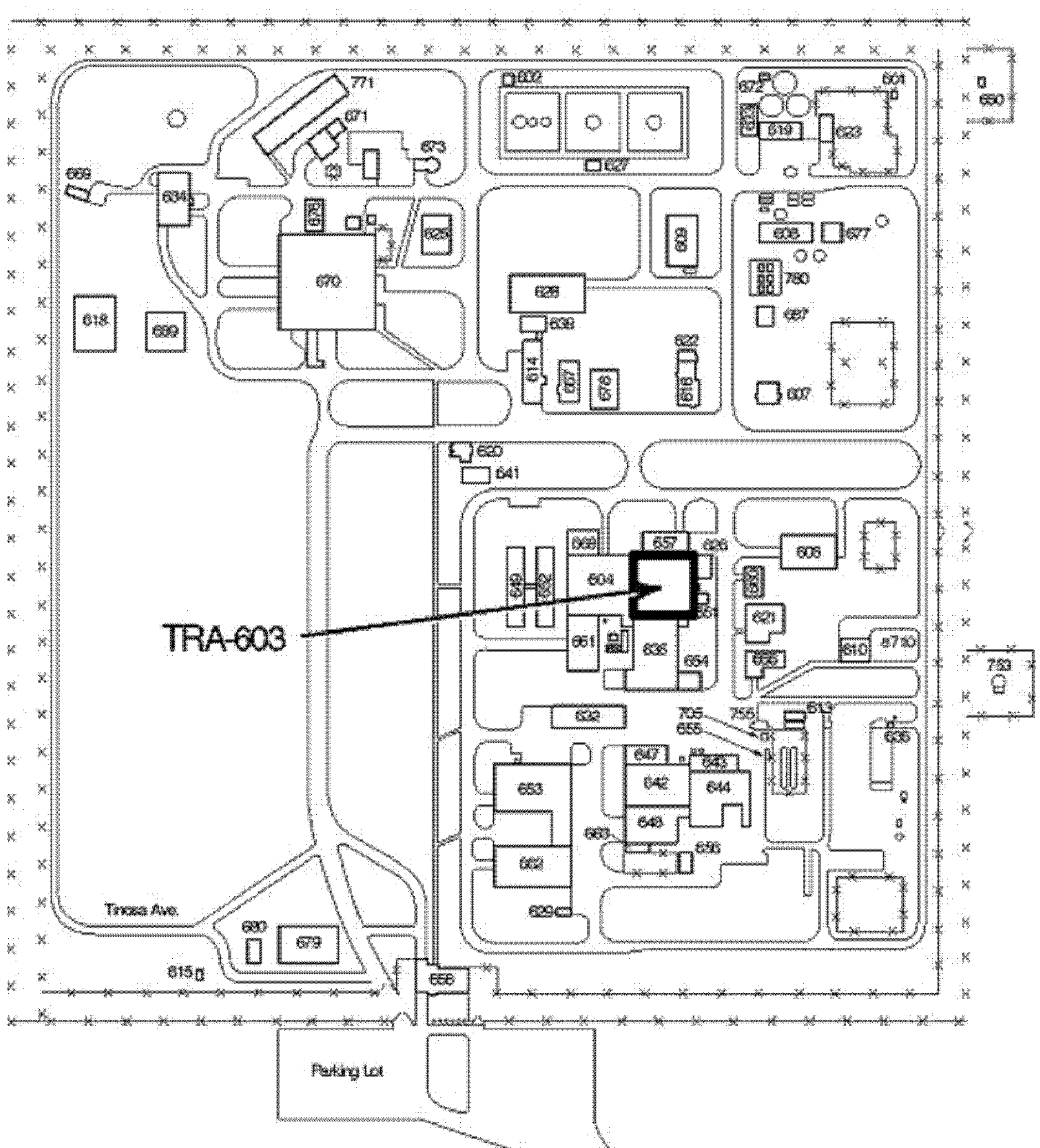
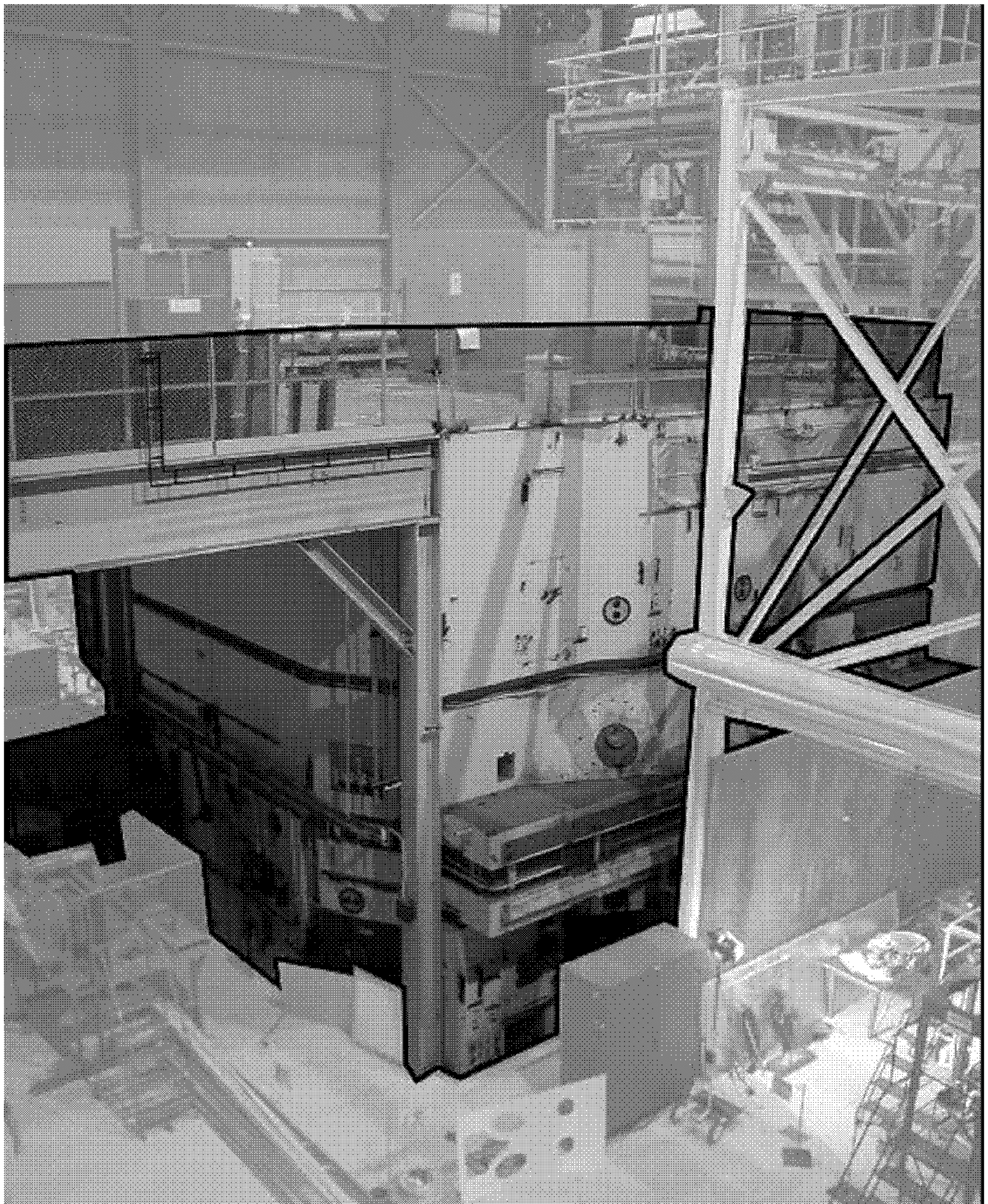
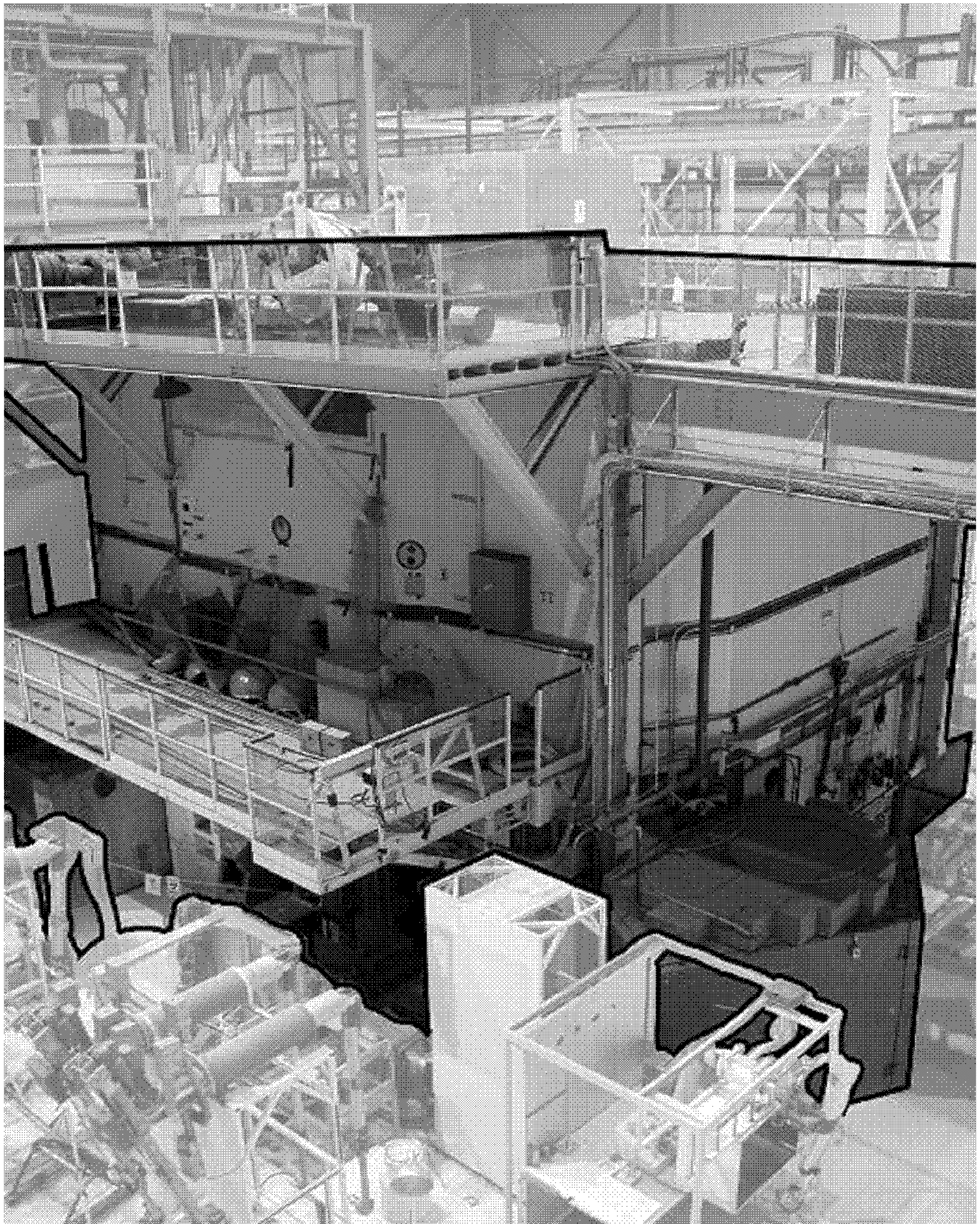
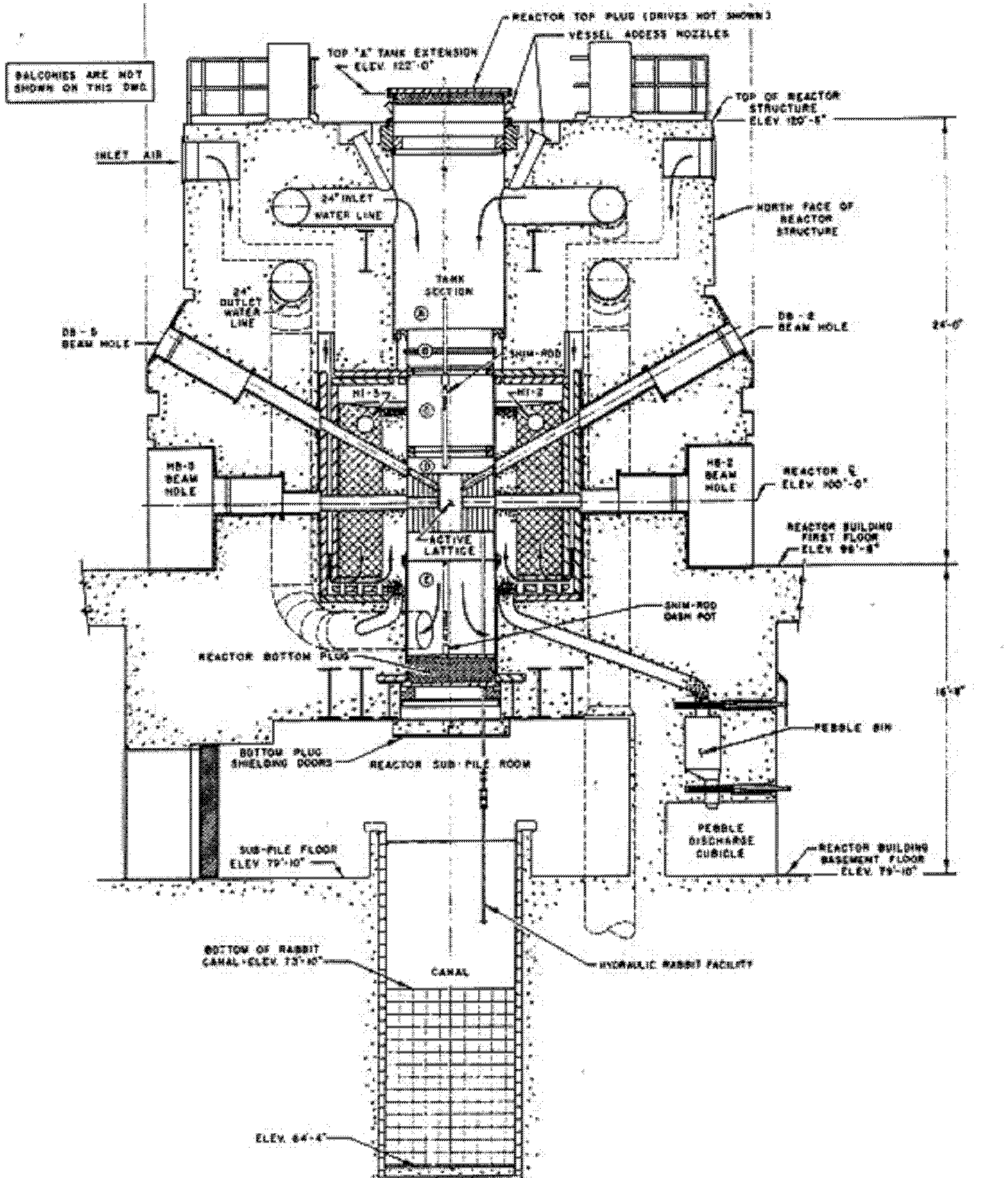








REACTOR TOP PLUG (DRIVES NOT SHOWN)
VESSEL ACCESS NOZZLES
TOP "A" TANK EXTENSION ELEV. 122'-0"
BALCONIES ARE NOT SHOWN ON THIS DWG.
TOP OF REACTOR STRUCTURE ELEV. 120'-5"
INLET AIR
24" INLET WATER LINE
NORTH FACE OF REACTOR STRUCTURE
TANK SECTION
24" OUTLET WATER LINE
DB-5 BEAM HOLE
DB-2 BEAM HOLE
24'-0"
SHIM-ROD
HI-3
HI-2
HB-5 BEAM HOLE
HB-2 BEAM HOLE
REACTOR ℄ ELEV. 100'-0"
ACTIVE LATTICE
REACTOR BUILDING FIRST FLOOR ELEV. 96'-8"
SHIM-ROD DASH POT
REACTOR BOTTOM PLUG
16'-8"
PEBBLE BIN
BOTTOM PLUG SHIELDING DOORS
REACTOR SUB-PILE ROOM
PEBBLE DISCHARGE CUBICLE
SUB-PILE FLOOR ELEV. 79'-10"
REACTOR BUILDING BASEMENT FLOOR ELEV. 79'-10"
BOTTOM OF RABBIT CANAL-ELEV. 73'-10"
CANAL
HYDRAULIC RABBIT FACILITY
ELEV. 64'-4"

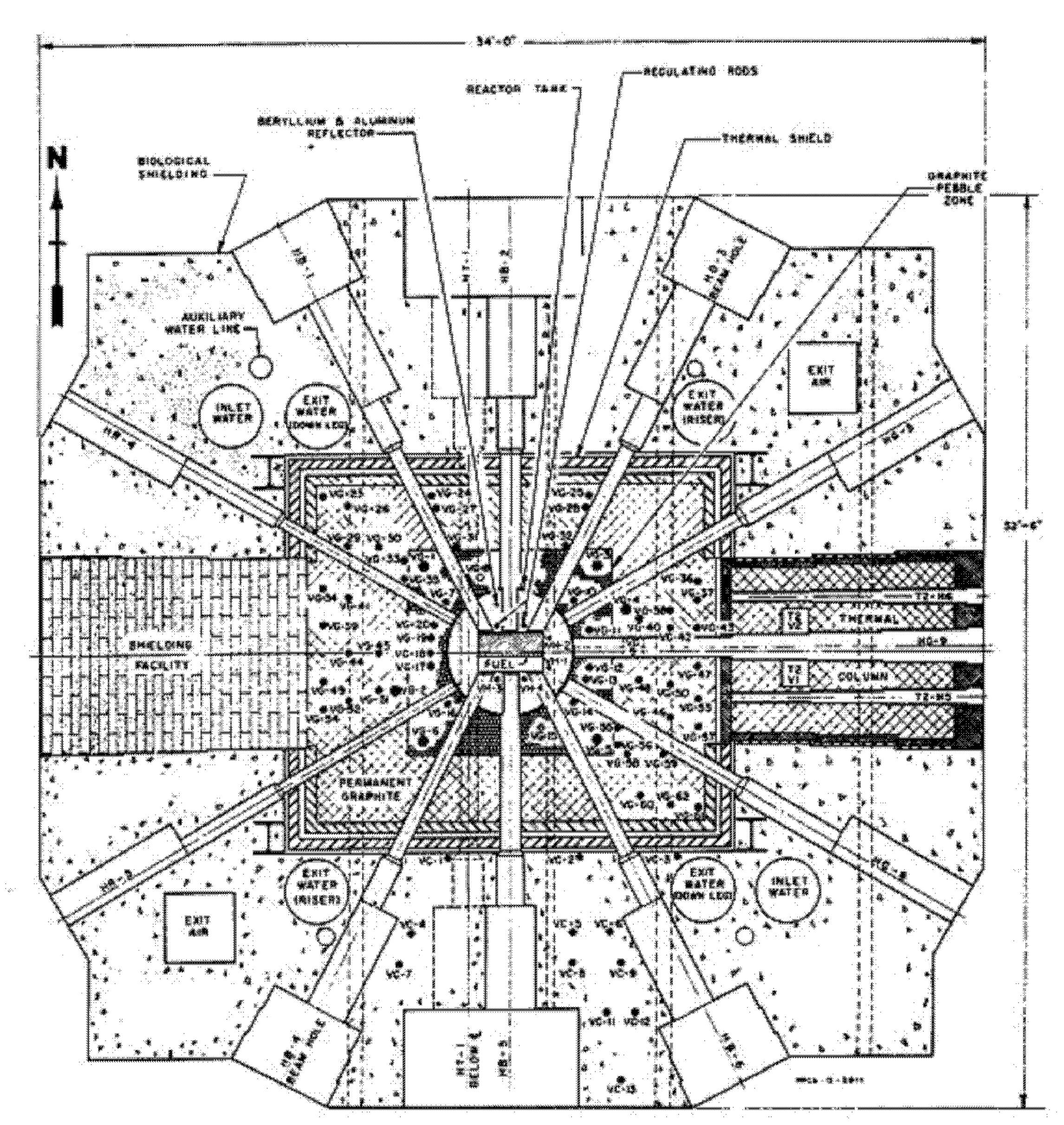
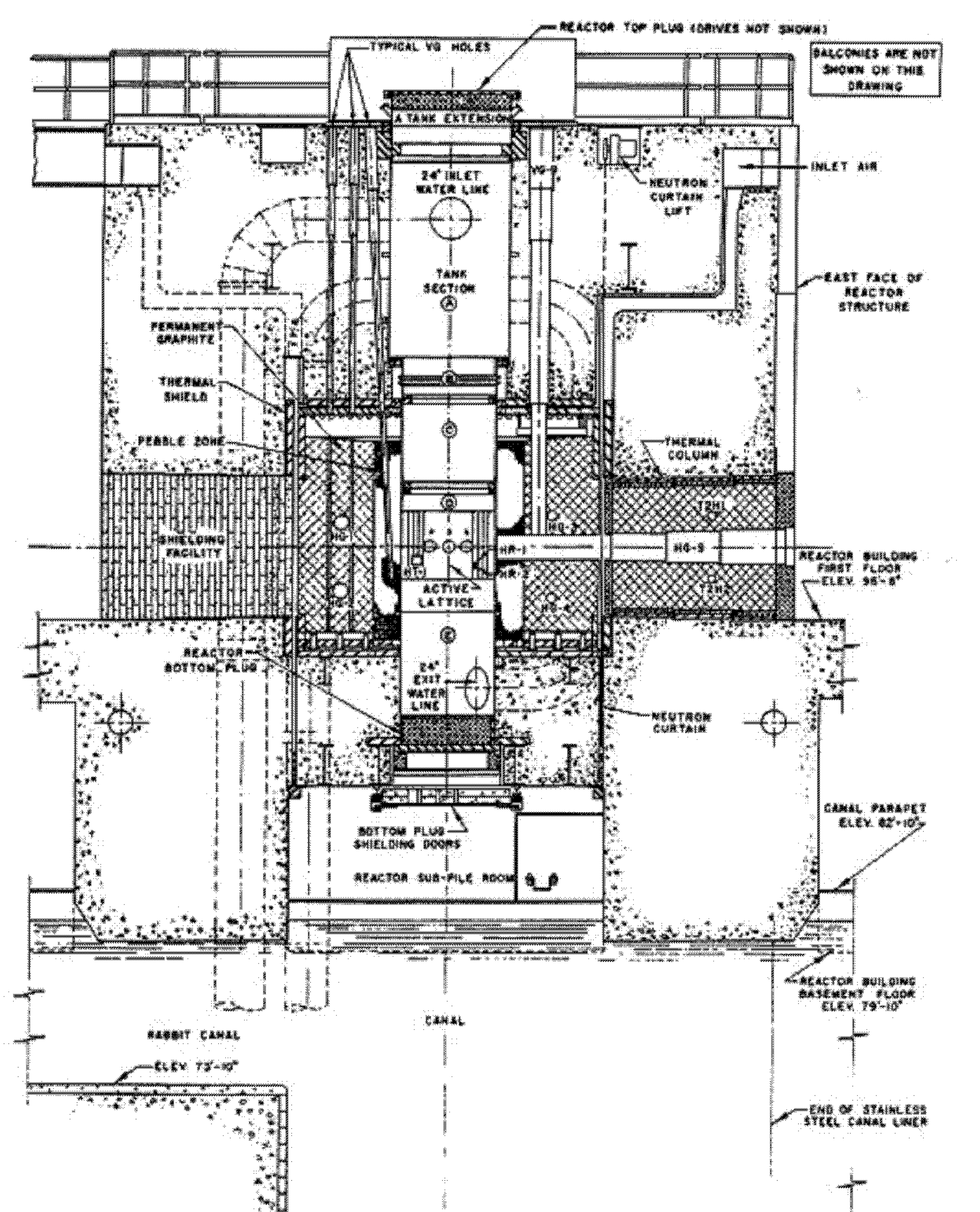
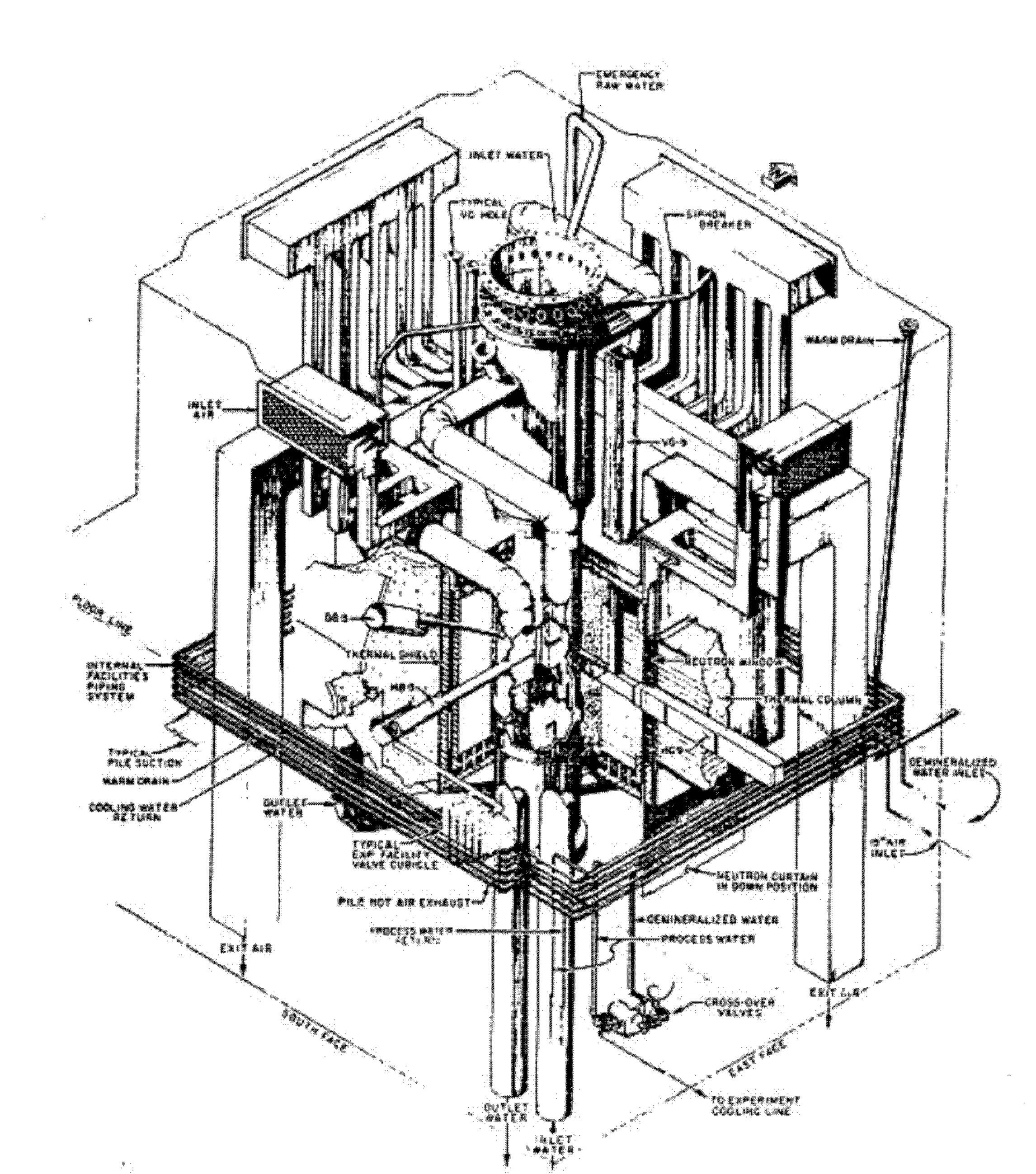


Figure 5. Horizontal cross section at core midplane.


REACTOR TOP PLUG (DRIVES NOT SHOWN)
TYPICAL VG HOLES
BALCONIES ARE NOT SHOWN ON THIS DRAWING
A TANK EXTENSION
24" INLET WATER LINE
NEUTRON CURTAIN LIFT
INLET AIR
TANK SECTION
EAST FACE OF REACTOR STRUCTURE
PERMANENT GRAPHITE
THERMAL SHIELD
PEBBLE ZONE
THERMAL COLUMN
SHIELDING FACILITY
ACTIVE LATTICE
REACTOR BUILDING FIRST FLOOR ELEV. 95'-8"
REACTOR BOTTOM PLUG
24" EXIT WATER LINE
NEUTRON CURTAIN
CANAL PARAPET ELEV. 82'-10"
BOTTOM PLUG SHIELDING DOORS
REACTOR SUB-PILE ROOM
REACTOR BUILDING BASEMENT FLOOR ELEV. 79'-10"
CANAL
RABBIT CANAL
ELEV. 73'-10"
END OF STAINLESS STEEL CANAL LINER


EMERGENCY RAW WATER
INLET WATER
TYPICAL VG HOLE
SIPHON BREAKER
WARM DRAIN
INLET AIR
VG-9
FLOOR LINE
THERMAL SHIELD
NEUTRON WINDOW
INTERNAL FACILITIES PIPING SYSTEM
THERMAL COLUMN
TYPICAL PILE SUCTION
WARM DRAIN
DEMINERALIZED WATER INLET
COOLING WATER RETURN
OUTLET WATER
TYPICAL EXP. FACILITY VALVE CUBICLE
NEUTRON CURTAIN IN DOWN POSITION
PILE HOT AIR EXHAUST
DEMINERALIZED WATER
PROCESS WATER
EXIT AIR
CROSS-OVER VALVES
SOUTH FACE
EAST FACE
TO EXPERIMENT COOLING LINE
OUTLET WATER
INLET WATER

The MTR Vessel Structure is located in the center of the MTR Reactor Building (TRA-603). The reactor building is 130 × 130 ft, rises 80 ft above grade, and extends about 17 ft below grade. The reactor structure occupies more than 1,100 square ft in the center of the first floor and basement. The main floor of the reactor building is reinforced concrete. The floor area surrounding the reactor structure measures 78 × 78 ft and is 3 ft thick.

The reactor building was designed to enclose the reactor structure and canal and to furnish space for experimental facilities on the main floor level and in the basement. In addition, the second and third floors (balconies above the main floor) contained the control room, a room to house associated electrical equipment, and operations personnel offices. The equipment has been removed, and the MTR control room on the third floor and the reactor switchgear room on the second floor have been converted to office space. These two rooms, along with the normal office area, are used by various organizations for offices.

Heating, ventilating, and lighting systems have been maintained in TRA-603. Some areas within the building have restricted use due to residual radioactivity. Ventilation system flow is for building air to be drawn from the reactor room, through the graphite reflector and steel thermal shield in the MTR Vessel Structure, and exhausted through the stack. Depending on activities in the MTR canal, this airflow path may be blocked. There is no filter on the exhaust.

Two overhead cranes are above the reactor building first floor. The larger is a compound bridge-and-trolley crane of 30- and 5-ton capacities. It was used to lift off the top plug with the drives and to move the heavy casks that were used to transport radioactive fuel and other equipment. The smaller crane is also a bridge-and-trolley type, but with an 800-lb capacity. It is directly over the reactor vessel and was used during reactor shutdown for handling tools, core components, etc. Currently these cranes are used to support activities performed around the reactor vessel structure.

2.1 MTR Vessel Structure

The outermost boundary of the MTR Vessel Structure is the biological shielding, which consists of an 80-ft high concrete structure (see Figures 6 and 7). The high-density concrete enclosing the reactor is in the center of the building. The shielding structure measures 32 ft 6 in. (north to south) × 34 ft (east to west) and rises 24 ft above the building's first-floor level. A concrete base enclosing the reactor subpile room supports the shielding structure in the reactor building basement. This concrete base is 35 ft (north to south) × 36 ft 6 in. (east to west). In the basement is also a water-filled canal (MTR Canal) that extends from beneath the reactor structure eastward about 141 ft. The portion of the canal beneath the reactor has been drained and is isolated by a bulkhead. The MTR canal is currently addressed in a separate safety analysis (ASA-188). Numerous concrete piers below the basement floor support the reactor and canal structures as well as the building columns; the piers extend down to bedrock.

2.1.1 Reactor Internal Components

The beryllium reflector, which surrounded the reactor core lattice to reflect neutrons back into the core, remains in the D tank. The beryllium reflector is approximately 54 in. in diameter and 39.3 in. high. Its total weight is about 5,750 lb. The reflector is assembled from a large number of individual pieces. The majority of these pieces rest on spacers on the lower support casting.

An upper support casting and the upper grid assembly positioned the reactor core components. The upper support casting was mounted on six internal lugs cast on the inside of the D tank upper flange.

The core lattice and beryllium reflector are supported by the lower support casting together with other grids and supports, which were mounted and positioned by that casting. In turn, this component is supported by a segmented stainless-steel ring that is bolted to the bottom face of the D tank lower flange. The core was supported on a lower assembly grid, which rests in a recess in the center of the lower support casting. This casting also supported the lower guide grid, which is hung from the casting by the lower cradle. All components except the weight-bearing assemblies were made of a high-strength aluminum alloy.

2.1.2 Reactor External Components

The reactor tank consisted of five tanks connected vertically. Tanks B, C, D, and E are mounted consecutively beneath the A tank. The top tank of the reactor vessel (A tank) is 18 in. higher than the top of the concrete biological shield. The bottom of E tank is located in the subpile room ceiling as shown in Figures 4 and 6. The top of B tank is attached to the bottom flange of A tank and serves, by means of a bellows section, as an expansion joint between the A tank and the tanks below. Tank B is made of stainless steel and is located just above the top, steel, thermal shield plates surrounding the graphite reflector. The C tank is made of aluminum and is the upper part of the “ball” zone of the graphite reflector. The D tank is made of aluminum and encloses the core lattice and beryllium reflector. The use of aluminum for D tank minimized capture and allowed more neutrons to pass beyond the beryllium reflector into the graphite reflector zone, which increased the flux and the value of the experimental facilities placed in this zone. The E tank is made of stainless steel, is located below the D tank, and extends down into the subpile room.

The reactor vessel is closed at each end (top and bottom) by lead-filled stainless-steel flat-head plugs. The top plug of the reactor vessel served as a top sealing head and as a base upon which the drive mechanisms for the shim-safety and regulating rods were mounted. The plug is a flat head about 10-3/4 in. thick. The upper plate of the top plug (2-1/4 in. thick) and the lower plate of the top plug (1/2 in. thick) are separated by an exterior cylindrical shell and spacers (1 in. thick), as well as by heavy-walled tubes through which the drive rods passed. The space enclosed by these plates was filled with lead shot for biological shielding purposes. Fifty-two bolts (1-1/8 in. in diameter) attach the top plug to the vessel; however, not all of the bolt threads are engaged in the threaded holes in the vessel flange. While it appears that some of them are finger-tight, others appear to have simply been dropped into the associated top-plug penetration and provide no support. It is not known how these three drive rods are being supported or what these rods may be resting on in the reactor vessel.

The top plug of the reactor vessel has an east and west manhole penetration. The manhole covers were constructed similarly to the top plug; however, the west cover has been modified to include a large viewing port that allowed visual inspection of the inside of the reactor vessel during operation. The viewing port now has lead bricks stacked in and over it to attenuate gamma radiation coming from radioactive material (mostly Co-60) inside the reactor tank.

The reactor vessel bottom plug is made similarly to the top plug. The plug is 20-1/2 in. thick and is filled with the lead shot for biological shielding. Fifty-two bolts (1-1/8 in. in diameter) attach it to the vessel. There are penetrations for 31 monitor tubes and the VH-1 through VH-6 experimental holes.

A discharge chute was positioned under a large, removable beryllium reflector piece on the east side of the reactor core. The chute passes through the bottom plug and made the connection to the canal directly below. A hydraulically operated valve closes off the discharge chute. Fuel assemblies, control and regulating rods, reflector pieces, experiment components, or irradiated slugs were passed into the canal by use of this device. The bottom of the reactor bottom plug is accessible from the subpile room.

The function of the graphite reflector surrounding the reactor and vessel was to thermalize neutrons and reflect the neutrons back into the core lattice, and to contain the thermal neutron flux in a zone large enough to allow the placement of numerous experimental facilities. The graphite reflector, external to the reactor tank, formed the boundary of the usable irradiation space around the reactor core. The graphite reflector measures 12 ft (north to south) × approximately 15 ft (east to west) and rises from an elevation near the top of E tank, past D tank, to the bottom of C tank for a total height of 9 ft 4 in. so that the graphite extends approximately 4.5 ft above and below the core horizontal center line.

Graphite exposed to a neutron flux rises in temperature and increases in volume. It also "grows" by capturing neutrons. A solid mass of graphite forming this reflector, therefore, would pose numerous problems. Using graphite balls 1 in. in diameter in the zone immediately surrounding the tanks precluded the problem of thermal expansion. As seen in Figure 6, a graphite pebble zone extends from the reactor tank wall out to the inside edge of a permanent graphite zone. This zone is 7 ft 4 in. square and is filled with approximately 700,000 1-in.-diameter graphite balls. The small graphite balls provided a relatively free path for airflow and large surface areas for efficient cooling. The balls can be drained through pipes to storage bins, allowing either the replacement of the balls or the replacement of any of the three center tanks, B, C, or D, if necessary. The balls are presently secured by a hydraulically operated valve that is locked closed. The installed graphite balls weigh 19 ton.

The graphite reflector formed the boundary of the usable irradiation space around the reactor core. Thus, some experimental facility liners penetrate the ball graphite zone. Surrounding the graphite ball

The shields, shown in Figures 5 and 6, are made of two layers of steel plates, each 4 in. thick, which surround the reflector. The inner plates are separated from the graphite reflector by a 1/2-in. gap filled with soft asbestos and from the outer plates by a 3-in. air gap. The outer side plates are separated from the concrete by a steel form. The outer top and bottom plates contact the concrete.

Cooling air from the reactor building was designed to be drawn from the reactor room, through the thermal shields and graphite reflector by the ventilation system, and discharged into the atmosphere through the 250-ft-high exhaust gas stack located about 400 ft east of the reactor building (TRA-710).

The biological shield surrounds the reactor vessel, graphite reflector, and thermal shields and serves as a barrier between the radiation source terms and the areas inhabited by personnel. This high-density barytes concrete shield extends from a point near the top of A tank to a point below the basement floor. The horizontal dimensions above the main floor of the reactor building are 32 ft 6 in. north to south × 34 ft east to west. In the basement, the shield measures 35 ft north to south × 36 ft 6 in. east to west. Concrete piers extending from below the basement floor to bedrock support this structure. The structure in the basement that supports the upper portion of the biological shield is a concrete base enclosing the reactor subpile room. These concrete base and access barriers are considered part of the biological shield and, hence, the MTR Vessel Structure.

The external surfaces of the biological shield are formed by steel plates 1/2 in. thick above the first floor and 3/4 in. thick in the basement. The cubicles and face plates of the beam holes and other facilities are welded integral with these forms, which supply a convenient and substantial support. The permanent facility liners extend from the face plates to an inner steel form surrounding the thermal shield. The experimental facility hole liners extending through the thermal shield and the graphite reflector are fabricated of aluminum. The reactor Tanks A and E were supported by structural steel, which also supported the thermal shield plates, the coolant piping, exit air ducts, etc. These tanks became an integral part of the reactor structure when the high-density aggregate was placed and the fluid grout was pumped into the aggregate to form the solid shield.

The reactor top, at the third-floor balcony level of the reactor building, is accessible from the balcony and is controlled in accordance with contractor procedures.

Experiment facility penetrations through the biological shield and graphite reflector used steel and aluminum liners, respectively. The arrangement of many of these penetrations is shown in Figures 4, 5, and 6. Seventeen large experimental holes lead from the reactor faces either to the D tank wall or to the core area. In addition to these main experiment holes, six more horizontal through-holes penetrate the biological shield and permanent graphite. The MTR also had 66 experiment and instrument holes accessible from the top of the reactor. Some of these penetrate into the graphite pebble zone and, some, into the permanent graphite. Two were also accessible from the subpile room. In addition, four instrument holes and 12 experiment holes penetrate the biological shielding from the top of the reactor structure.

column, penetrate from the north face to the south face of the reactor structure. In addition, two vertical holes (12 × 12 in.) penetrate the thermal column from the top of the reactor. At one time there was a second thermal column planned for the west face of the reactor. Later it was converted to a facility for testing shielding materials. At present, the 6-ft-square hole is filled with barytes concrete blocks.

Two pneumatic shuttle (rabbit) tubes were provided. These are horizontal tubes of 1-in. inside diameter that extend completely through the structure and pass within 1 in. of the core lattice.

Hydraulically operated shuttles were also provided. These were for irradiation of small samples, which required irradiation times of up to two weeks. The two hydraulic facilities are vertical tubes of 1-in. inside diameter running through the bottom plug into the beryllium reflector adjacent to and east of the active lattice. In addition, tubes 1.31 in. in diameter and located in the two south regulating rod positions in the reflector were used as experiment facilities.

In addition to the experiment facility liners, other reactor supporting equipment is embedded in the biological shield as seen in Figure 6. The ducts, which carried air to cool the thermal shields and graphite reflector, run from all four faces of the reactor structure. Four 24-in. process-water lines enter the reactor structure under the basement floor; two enter A tank, and furnished inlet water for cooling the reactor core, and two are connected to E tank, and carried the heated water back to the process water building (TRA-605) for degassing and cooling. These are all currently securely terminated by valves, plugs, or pipe end caps. Structural steel used during construction to support and align A and E tanks, and other components such as piping, thermal shields, etc., are also embedded in the concrete structure. Due to the complicated and close-packed array of facilities, pipes, etc., in this structure, the conventional method of pouring a plastic concrete mixture inside the steel forms was accomplished with a semiliquid grout pumped in at the bottom of the high-density aggregate that previously had been placed dry. This forced out all entrapped air and ensured a void-free shield. It also allowed maintenance of the correct ratio of grout to aggregate, which was important for shielding requirements.

Several horizontal experiment facility penetrations in the biological shield are located on the vertical center line of the core. The first floor is positioned 3-1/2 ft below the reactor core midplane for convenient handling of the heavy plugs in these facilities.

2.1.3 Activities

Since MTR Vessel Structure was removed from service and retired in place in 1970,[3] areas near it have been and are being used in a variety of activities that are unconnected with the MTR Vessel Structure. In some cases, these activities have been or are very close to the MTR Vessel Structure, but since the activities do not involve the MTR structure directly, they are covered by separate safety analysis documents. These activities have included:

- Conference rooms
- Weight-lifting room
- Underwater (canal) equipment and spent fuel handling and storage (ASA-188)
- Decontamination and staging area (ASA-188).

Operations within the MTR Vessel Structure are typically those required to ensure the integrity of the structure and systems. These operations include "walk through" surveillances required by institutional safety programs. Likewise, since the facility is in a shutdown condition, minimal maintenance is necessary. There is no scheduled preventive maintenance required for the MTR Vessel Structure. Any corrective maintenance is controlled in accordance with institutional safety programs. Facility characterization activities done to support future closure tasks are also performed in accordance with institutional safety programs.

3. HAZARD IDENTIFICATION AND ANALYSIS

3.1 Hazard Material Inventory

3.1.1 Radioactive Material

The inventory of radioactive material in the MTR vessel structure is given in Engineering Design File (EDF)-4870,[4] Table 1. There is no fissile material listed in the inventory. The comparison of the radioactive material quantities in the MTR Vessel Structure, assuming the entire inventory is releasable, to the threshold quantities of DOE-STD-1027-92[5] is also given in Table 1. The sum of the ratios is 1.55E-01; therefore, the structure is a less than Hazard Category 3 facility.

3.1.2 Chemicals

There are no chemicals used or stored in the MTR Vessel Structure that exceed the Title 29 Code of Federal Regulations (CFR) Part 1910.119[6] threshold quantities or the 40 CFR 355[7] threshold planning quantities; therefore, no additional controls are necessary.

3.2 Hazard Evaluation

The inventories of radioactive materials in the MTR Vessel Structure consist of activated structural and shielding materials that are not readily releasable. Personnel exposures to the radiation emitted by these materials are readily controlled through the Radiation Protection Program and present no unusual or

These programs include environmental management, radiation protection, criticality safety, safety and industrial hygiene, and quality assurance programs, as appropriate, to protect the public, the workers, and the environment. The Integrated Safety Management System (ISMS) provides for identification and analysis of hazards, development and implementation of hazard controls, and safe performance of work with feedback and continuous improvement. Future deactivation, decontamination, and decommissioning (DD&D) activities will be evaluated on a case-by-case basis to ensure compliance with the appropriate hazard identification and work control programs.

5. CONCLUSIONS

Based on the considerations discussed above and in accordance with Reference 8, the MTR Vessel Structure is designated as not requiring additional safety analysis (NRASA). Only management and operations (M&O) contractor-level approval of this designation is required, and no further safety documentation is required.

6. REFERENCES

1. DOE-ID Order 420.D, "Requirements and Guidance for Safety Analysis," U.S. Department of Energy, Idaho Operations Office, Rev. 1, July 25, 2003.

2. ASA-136, "Auditable Safety Analysis for the MTR Vessel Structure," March 2003.

3. R. L. Rolfe, and E. L. Wills, *Characterization of the Materials Testing Reactor*, WM-F1-83-016, April 1984.

4. EDF-4870, "HAD-207, Rev. 1, Inventories," T. L. Cook, June 1, 2004.

5. DOE-STD-1027-92, "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports," U.S. Department of Energy, December 1992 (including Change 1, September 1997).

6. 29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals," *Code of Federal Regulations,* Office of the Federal Register, February 6, 2002.

7. 40 CFR 355, Appendix A, "Emergency Planning and Notification," *Code of Federal Regulations,* Office of the Federal Register, February 6, 2002.

8. T. L. Hobbes, "Interim Guidance for Less Than Hazard Category 3 (LTHC3) Safety Basis Documentation," April 20, 2004.