12.3 RADIATION PROTECTION DESIGN FEATURES

12.3.1 FACILITY DESIGN FEATURES

Specific design features for maintaining personnel exposures ALARA are discussed in this subsection.

12.3.1.1 Common Equipment and Component Designs for ALARA

This subsection describes the design features used for several general classes of equipment or components. These classes of equipment are common to many of the plant systems; thus, the features employed for each system to maintain minimum exposures are similar and are discussed by equipment class in the following paragraphs.

Filters: Whenever practicable, filters that accumulate radioactive material are supplied with the means either to backflush the filter remotely or to perform cartridge replacement with semi-remote tools (i.e., long handled tools). For cartridge filters, adequate space is provided to allow removing, cask loading, and transporting the cartridge to the solid radwaste area.

Demineralizers: Demineralizers for radioactive systems are designed so that spent resins can be remotely and hydraulically transferred to spent resin tanks prior to dewatering or solidification and that fresh resin can be loaded into the demineralizer remotely. Underdrains and downstream strainers are designed for full system pressure drop. The demineralizers and piping are designed with provisions for being flushed.

Evaporators: Evaporators are provided with chemical addition connections to allow the use of chemicals for descaling operations. Space is provided to allow uncomplicated removal of heating tube bundles. To the extent practicable, the more radioactive components are separated from those that are less radioactive by a shield wall.

Pumps: Wherever practicable, pumps, in radioactive areas are purchased with mechanical seals to reduce seal servicing time. Pumps and associated piping are arranged to provide adequate space for access to the pumps for servicing. Small pumps are installed in a manner that allows easy removal if necessary. All pumps in radioactive waste systems are provided with flanged connections for ease in removal. Generally, pump casings are provided with drain connections for draining the pump for maintenance.

Tanks: Whenever practicable, tanks are provided with sloped bottoms and bottom outlet connections. Overflow lines are directed to the waste collection system in order to control contamination within plant structures.

Heat Exchangers: Heat exchangers are provided with corrosion-resistant tubes of stainless steel or other suitable materials with tube-to-tube sheet joints welded to minimize leakage. Impact baffles are provided and tube side and shell side velocities are limited to minimize erosive effects.

Instruments: Instrument devices are located in low radiation zones and away from radiation sources when practicable. Where practicable primary instrument devices, which for functional reasons are located in high radiation zones, are designed for easy removal to a lower radiation zone for calibration. Where practicable transmitters and readout devices are located in low radiation zones, such as corridors and the control room, for servicing. Some instruments in high radiation zones are provided in duplicate to reduce access and service time required.

Seals are provided on instrument sensing lines on process piping that may contain highly radioactive materials to reduce the servicing time required to keep the lines free of solids. Instrument and sensing line connections are located in such a way as to avoid corrosion product and radioactive gas buildup.

Valves: To minimize personnel exposures from valve operations, motor-operated, air operated, or other remotely actuated valves are used to the maximum extent practicable.

When practicable, valves are located in valve galleries so that they are shielded separately from the major components that accumulate radioactivity. Long runs of exposed piping are minimized in valve galleries. In areas where manual valves are used on frequently operated process lines, either remote valve operators or shielding is normally provided to minimize personnel exposure.

For equipment located in Zone V areas, remote actuators are provided for frequently operated valves associated with system operation. All other valve operations are either infrequent or performed with equipment in the shutdown mode. To the maximum practicable extent, simple straight reach rods will be used to allow operators to retain the feel of whether the valves are tightly closed or not. Where practicable valves with reach rods are installed with their stems horizontal so that the reach rods are also horizontal but above the heads of personnel to allow ready access.

For valves in radiation areas, provisions are made to drain adjacent radioactive components where practicable.

Wherever practicable, valves for clean, non-radioactive systems are separated from radioactive sources and are located in readily accessible areas.

Manually operated valves in the filter/demineralizer valve compartments required for normal operation and shutdown are equipped with reach rods extending through or over the valve gallery wall. Personnel are not required to enter the valve gallery during flushing operations. The valve gallery shield walls are designed for maximum expected filter backflush activities during flushing operations.

Full ported valves are used in systems expected to contain radioactive solids.

Special valve designs with minimum internal crevices are normally used where crud trapping could become a problem, especially for piping carrying spent resin or evaporator bottoms.

Piping: The piping in pipe chases is designed for the lifetime of the unit. The number of valves or instrumentation in the pipe chases has been reduced to maximum extent practicable. Where radioactive piping is routed through areas that require routine maintenance, pipe chases are normally provided to reduce the radiation contribution from these pipes. Wherever practicable, piping containing radioactive material is routed to minimize radiation exposure to the unit personnel.

Floor Drains: Floor drains and properly sloped floors are provided for each room or cubicle, within which are serviceable components containing radioactive liquids. If a radioactive drain line must pass through a zone lower than that at which it will terminate, proper shielding is provided. Local gas traps or porous seals are not used on radwaste floor drains. Gas traps are provided at the common sump or tank.

Lighting: Multiple electric lights are provided for each cell or room containing highly radioactive components so that the burnout of a single lamp will not require entry and immediate replacement of the defective lamp. Lights that require less time for servicing are provided to minimize personnel exposure. The fluorescent or LED lights used in some areas do not require frequent service because of the increased life of the tubes.

HVAC: The HVAC system design provides for rapid replacement of the filter elements and housings.

Sample Stations: Sample stations for routine sampling of process fluids are located in accessible areas. Shielding is provided at the sample stations as required to maintain radiation zoning in proximate areas and minimize personnel exposure during sampling. Ventilation, drains or other means of contamination control are provided where necessary. The counting room and laboratory facilities are described in Section 12.5.

Clean Services: Whenever practicable, active components of clean services and equipment such as compressed air piping, clean water piping, ventilation ducts, and cable trays are not routed through radioactive pipeways.

12.3.1.2 Common Facility and Layout Designs for ALARA

This subsection describes the design features used for standard type plant processes and layout situations. These features are used in conjunction with the general equipment designs described in Subsection 12.3.1.1 and include the features discussed in the following paragraphs.

Valve Galleries: Valve galleries are provided with shielded entrances for personnel protection. In many cases the valve galleries are divided by shielding or distance into subcompartments that service only two or three components and are further subdivided by fin walls so that personnel are only exposed to the valves and piping associated with one component at any given location. Threshold berms and floor drains are provided to control radioactive leakage. To facilitate decontamination in valve galleries, concrete surfaces are covered with a smooth surfaced coating which will allow easy decontamination.

Piping: Pipes carrying radioactive materials are routed through controlled access areas zoned for that level of activity. Each piping run is analyzed to determine the potential radioactivity level and surface dose rate. Where radioactive piping must be routed through corridors or other low radiation zone areas, shielded pipeways are normally provided. Whenever practicable, valves and instruments are not placed in radioactive pipeways. Whenever practicable, equipment compartments contain only piping associated with equipment in that compartment.

Where practicable piping is designed to minimize low points and dead legs. Drains are provided on piping where low points and dead legs cannot be eliminated. Where possible, thermal expansion loops are raised rather than dropped. In radioactive systems, the use of non-removable backing rings in the piping joints is minimized to eliminate a potential crud trap for radioactive materials. Piping carrying resin slurries or evaporator bottoms is run vertically as much as possible.

Whenever possible, branch lines having little or no flow during normal operation are connected above the horizontal midplane of the main pipe.

Field Run Piping: All routing of radioactive process piping, large and small, is reviewed by the design engineering office.

Penetrations: To minimize radiation streaming through penetrations, as many penetrations as practicable are located with an offset between the source and the accessible areas. If offsets are not practicable, penetrations are located as far as possible above the floor elevation to reduce the exposure to personnel. If these two methods are not used, then baffle shield walls or grouting the area around the penetration are provided.

Contamination Control: Access control and traffic patterns are considered in the basic plant layout to minimize the spread of contamination. Equipment vents and drains from certain radioactive systems are piped directly to the collection system instead of allowing any contaminated fluid to flow across to the floor drain. All-welded piping systems are used on contaminated systems to the maximum extent practicable to reduce system leakage and crud buildup at joints. The valves in some radioactive systems are provided with leak-off connections piped directly to the collection system.

Decontamination of potentially contaminated areas within the plant is facilitated by the application of suitable smooth surfaced coatings to the concrete floors and walls.

Floor drains with properly sloping floors are provided in potentially contaminated areas of the plant. In addition, radioactive and potentially radioactive drains are separated from non-radioactive drains.

Systems that become highly radioactive, such as the radwaste slurry transport system, are provided with flush and drain connections. Certain systems have provisions for chemical and mechanical cleaning prior to maintenance.

Equipment Layout: In systems where process equipment is a major radiation source (such as fuel pool cleanup, radwaste, condensate demineralizer, etc.), pumps, valves, and instruments are normally separated from the process component. This allows servicing and maintenance of items in reduced radiation zones. Control panels are located in lowest practicable radiation zones.

Major components (such as tanks, demineralizers, and filters) in radioactive systems are isolated in individual shielded compartments insofar as practicable.

Provision is made on some major plant components for removal of these components to lower radiation zones for maintenance.

Labyrinth entrance way shields or shielding doors are provided for compartments from which radiation could stream to access areas and exceed the radiation zone dose limits for those areas. For potentially high radiation components (such as filters and demineralizers), completely enclosed shielded compartments with hatch openings are used.
Equipment in non-radioactive systems that requires lubrication is located outside radiation areas. Wherever practicable, lubrication of equipment in radiation areas is achieved with the use of tube type extensions to reduce exposure during maintenance.

Figures 12.3-1, 12.3-2, 12.3-3, 12.3-4, 12.3-5, and 12.3-6 provide layout arrangements for demineralizers, filters, spent resin storage tanks, hydrogen recombiners, and their associated valve compartments or galleries.

Exposure from routine in-plant inspection is controlled by locating, whenever possible, inspection points in shielded low background radiation areas. Radioactive and non-radioactive systems are separated as far as practicable to limit radiation exposure from routine inspection of non-radioactive systems. For radioactive systems, emphasis is placed on space and ease of motion in a shielded inspection area. Where longer times for routine inspection are required and permanent shielding is not feasible, sufficient space for portable shielding is normally provided. In high radiation areas where routine surveillance is required, remote viewing devices are provided when practicable.

Facilities for Handling Sealed and Unsealed Radioactive Material:

As discussed in Subsection 12.2.1.9, special material used in the radiochemistry laboratory require the design of special handling equipment. For unsealed materials, the following is provided:

a) Exhaust hoods that exhaust to the ventilation system are located in areas such as sample stations and the radiochemistry laboratory.

b) Decontamination facilities, radiochemistry laboratory, controlled zone shop, instrument repair shops and washdown area are situated at various locations in the plant and are described in Subsection 12.5.2.

c) An area for the repair and maintenance of removed control rod drives is provided in the reactor building in close proximity to the control rod drive removal hatch.

12.3.1.3 Radiation Zoning and Access Control

Access to areas inside the plant structures and plant yards is regulated and controlled. Each radiation zone defines the radiation level range to which the aggregate of all contributing sources must be attenuated by shielding.

All plant areas are categorized into radiation zones according to expected radiation levels and anticipated personnel occupancy, with consideration given toward maintaining personnel external exposures ALARA and within the standards of 10CFR20. Each room, corridor, and pipeway of every plant building is evaluated for potential radiation sources during normal operation and shutdown; for maintenance occupancy requirements, and for general access requirements to determine appropriate zoning. Radiation zone categories used and their descriptions are given in Table 12.3-1 and the specific zoning for each plant area is shown on Dwgs. A-511, Sh. 1, A-512, Sh. 1, A-513, Sh. 1, A-514, Sh. 1, A-515, Sh. 1, A-516, Sh. 1, A-517, Sh. 1, A-518, Sh. 1, A-519, Sh. 1, A-520, Sh. 1, A-521, Sh. 1, A-522, Sh. 1, A-523, Sh. 1, A-524, Sh. 1, A-525, Sh. 1, A-526, Sh. 1, A-527, Sh. 1, A-528, Sh. 1, A-529, Sh. 1, A-530, Sh. 1, and B1N-100, Sh. 1. Note that the radiation zoning for Unit 1 is not significantly different from those for Unit 2, therefore Dwgs. A 511, Sh. 1, A-512, Sh. 1, A-513, Sh. 1, A-514, Sh. 1, A-515, Sh. 1, A-516, Sh. 1, A-517, Sh. 1, A-518, Sh. 1, A-519, Sh. 1, A-520, Sh. 1, A-521, Sh. 1, A-522, Sh. 1, A-523, Sh. 1, A-524, Sh. 1, A-525, Sh. 1, A-526, Sh. 1, A-527, Sh. 1, A-528, Sh. 1, A-529, Sh. 1, A-530, Sh. 1, and B1N-100, Sh. 1 are also representative of Unit 2. Attachment of the new common tool room facility to Unit 2 turbine building (Ref. Dwg. M-231, Sh. 1) represents a unique feature not represented by the radiation zoning for Unit 1 turbine building at elevation 676' (Dwg. A-514, Sh. 1). The radiation zoning for the tool room is Zone II. Where possible, frequently accessed areas, i.e., corridors, are shielded for Zone I and Zone II access.

The control of ingress or egress of plant operating personnel to controlled access areas and procedures employed to ensure that radiation levels and allowable working time are within the limits prescribed by 10CFR20 as described in Section 12.5.

12.3.1.4 Control of Activated Corrosion Products

In order to minimize the radiation exposure associated with the deposition of activated corrosion products in reactor coolant and auxiliary systems, the following steps have been taken:

(1) The reactor coolant system consists mainly of austenitic stainless steel, carbon steel and low alloy steel components. Nickel content of these materials is low, and it is controlled in accordance with applicable ASME material specifications.

A small amount of nickel base material (Inconel 600) is employed in the reactor vessel internal components. Inconel 600 is required where components are attached to the reactor vessel shell and the coefficient of expansion must match the thermal expansion characteristics of the low alloy vessel steel. Inconel 600 was selected because it provides the proper thermal expansion characteristics, adequate corrosion resistance and can be readily fabricated and welded.

(2) Materials employed in the reactor coolant system are purchased to ASME material specification requirements. No special controls on levels of cobalt impurities are specified.

(3) Hardfacing and wear materials having a high percentage of cobalt are restricted to applications where no satisfactory alternate materials are available. The EPRI cobalt reduction guidelines (Ref. 12.3-24) are utilized to the extent practical.

(4) A high temperature filtration system was not employed in the Reactor Water Clean-up System. The reasons for this included:

a) Lack of quantitative data on the removal efficiency for insoluble cobalt by the high temperature filter;

b) Uncertainty in the deposition model including the relative effectiveness of cobalt removal on deposition rate;

c) Doubtful cost-effectiveness in an area where other methods under study (such as decontamination) may prove better at reducing dose rates while also being more cost-effective.

(5) Items 1, 2, and 3 above also apply to valve materials in contact with reactor coolant. Valve packing materials are selected primarily for their properties in the particular environment.

(6) Subsections 12.1.2.2, 12.3.1.1, and 12.3.1.2 describe the various flushing, draining, testing, and chemical addition connections which have been incorporated into the design of piping and equipment which handle radioactive materials. If decontamination is to be performed, these connections would be used for that purpose.

(7) The plant is designed with a powdered resin, pressure precoat clean-up system for the primary coolant in the reactor and a full flow deep bed condensate demineralizer and filter vessel system for the feedwater. See Dwgs. M-116, Sh. 1, M-116, Sh. 2, M-116, Sh. 3, M-144, Sh. 1, M-144, Sh. 2, M1-G33-16, Sh. 1, M1-G33-18, Sh. 1 and M-145, Sh. 1.

(8) A chemistry control program has been developed and implemented at SSES to reduce crud buildup.

12.3.2 SHIELDING

In this subsection the bases for the nuclear radiation shielding and the shielding configurations are discussed.

12.3.2.1 Design Objectives

The basic objective of the plant radiation shielding is to reduce personnel exposures, in conjunction with a program of controlled personnel access to and occupancy of radiation areas, to levels that are within the dose regulations of 10CFR50 and are as low as reasonably achievable (ALARA) within the dose regulations of 10CFR20. Shielding and equipment layout and design are considered in ensuring that exposures are kept ALARA during anticipated personnel activities in areas of the plant containing radioactive materials.

Basic plant conditions considered in the nuclear radiation shielding design are normal operation at full-power, and plant shutdown.

The shielding design objectives for the plant during normal operation, including anticipated operational occurrences, and for Shutdown operations are:

a. To ensure that radiation exposure to plant operating personnel, contractors, administrators, visitors, and proximate site boundary occupants are ALARA and within the limits of 10CFR20

b. To ensure sufficient personnel access and occupancy time to allow normal anticipated maintenance, inspection, and safety-related operations required for each plant equipment and instrumentation area

c. To reduce potential equipment neutron activation and mitigate the possibility of radiation damage to materials.

d. To sufficiently shield the control room so that the total dose from all post-accident sources (Rem-TEDE).(calculated in Chapter 15) in the event of design basis accidents will not exceed the limits of 10CFR50.67.

12.3.2.2 General Shielding Design

Shielding is provided to attenuate direct radiation through walls and penetrations and scattered radiation to less than the upper limit of the radiation zone for each area shown in Dwgs. A-511, Sh. 1, A-512, Sh. 1, A-513, Sh. 1, A-514, Sh. 1, A-515, Sh. 1, A-516, Sh. 1, A-517, Sh. 1, A-518, Sh. 1, A-519, Sh. 1, A-520, Sh. 1, A-521, Sh. 1, A-522, Sh. 1, A-523, Sh. 1, A-524, Sh. 1, A-525, Sh. 1, A-526, Sh. 1, A-527, Sh. 1, A-528, Sh. 1, A-529, Sh. 1, A-530, Sh. 1, and B1N-100, Sh. 1. Since the layout for Unit 2 is not significantly different from that of Unit 1, the minimum shielding requirements (see Subsection 12.3.2.3) indicated on those drawings are applicable to both Units. General locations of the plant areas and equipment discussed in this subsection are also shown on those drawings.

The material used for most of the plant shielding is ordinary concrete with a minimum bulk density of 145 lb/ft^3. Whenever poured-in-place concrete has been replaced by concrete blocks or other material, design ensures protection on an equivalent shielding basis as determined by the characteristics of the concrete block selected. Compliance of concrete radiation shield design with Regulatory Guide 1.69 is discussed in Section 3.13. Water is used as the primary shield material for areas above the spent fuel transfer and storage areas.

Special features employed to maintain radiation exposures ALARA in routinely occupied areas such as valve operating stations and sample stations are described in Subsections 12.3.1.1 and 12.3.1.2.

12.3.2.2.1 Reactor Building Shielding Design

During reactor operation, the steel-lined, reinforced concrete drywell wall and the reactor building walls protect personnel occupying adjacent plant structures and yard areas from radiation originating in the reactor vessel and associated equipment within the reactor building. The reactor vessel shield wall, drywell wall, and various equipment compartment walls together with the reactor building walls minimize the radiation levels outside the reactor building.

Where personnel and equipment hatches or penetrations pass through the drywell wall, additional shielding is designed to attenuate the radiation to below the required level defined by the radiation zone outside the drywell wall during normal operation and shutdown and to acceptable emergency levels as defined by 10CFR50 during design basis accidents.

12.3.2.2.2 Reactor Building Interior Shielding Design

Inside Drywell Structure: Areas within the drywell are designed as Zone V areas and are normally inaccessible during plant operation. The reactor vessel shield provides shielding for access in the drywell during shutdown, and reduces the activation of and radiation damage to drywell equipment and materials.

Outside Drywell Structure: The drywell wall is designed to reduce radiation levels in normally occupied areas of the reactor building from sources within the drywell to less than the maximum level for Zone II.

Penetrations and hatch openings in the drywell wall are shielded, as necessary, to meet adjacent area radiation zoning levels. Shielding requirements for the personnel, equipment, and CRD removal hatch openings are shown on Dwg. A-522, Sh. 1 in the areas numbered 412, 413, and

402, respectively. Drywell piping and electrical penetrations are shielded by providing either local shields within the penetration assembly or a shielded penetration room. Shielded piping penetration room locations and bulk shielding requirements are shown on Dwgs. A-521, Sh. 1, A-522, Sh. 1, and A-523, Sh. 1. These rooms, numbered 202, 204, 205; 403, 411, 501, 504, 506, 515; are designated radiation Zone V during reactor power operation and are provided with personnel access controls. Electrical penetrations which are not located within these rooms are provided with supplementary local shielding as needed to meet outside zoning levels.

The components of the reactor water cleanup (RWCU) system described in Section 5.4.8 are located in shielded compartments which are designed as Zone V, restricted access areas. Shielding is provided for each piece of equipment in the RWCU system consistent with its postulated maximum activity Subsection 12.2.1 and with the access and zoning requirements of the adjacent areas. This equipment includes:

a) Regenerative heat exchanger

b) Non-regenerative heat exchanger

c) RWCU pumps and piping

d) RWCU filter demineralizers and holdup pumps

e) RWCU backwash receiving tank and piping.

The traversing in-core probe (TIP) system is located inside a shielded compartment to protect personnel from the neutron activated portion of the TIP cable.

Main steamlines are located within shielded structures from the drywell wall to the reactor building wall.

Spent fuel is a primary source of radiation during refueling. Because of the extremely high activity of the fission products contained in the spent fuel assemblies and the proximity of Zone II areas, shielding is provided for areas surrounding the fuel transfer canal and pool to ensure that radiation levels remain below zone levels specified for adjacent areas.

After reactor shutdown, the Residual Heat Removal (RHR) System pumps and heat exchangers are in operation to remove heat from the reactor water. It is anticipated that the radiation levels in the vicinity of this equipment will temporarily reach Zone V levels due to corrosion and fission products in the reactor water. Shielding is designed to attenuate radiation from RHR equipment during shutdown cooling operations to levels consistent with the radiation zoning requirements of adjacent areas.

During functional testing operations of the Reactor Core Isolation Cooling (RCIC) System and the High Pressure Coolant Injection (HPCI), the steam driven turbine and the inlet and exhaust piping are shielded consistent with the maximum steam activities in the lines and the access zone requirements of surrounding areas.

The concrete shield walls surrounding the spent fuel cask loading, storage, and transfer areas, as well as the shield walls surrounding the fuel transfer and storage areas, are designed to provide Zone II maximum dose rates in accessible areas outside of the shield walls.

Water in the spent fuel pool provides shielding above the spent fuel transfer and storage areas. Direct radiation levels at the fuel handling equipment are calculated to be less than 2.5 mrem/hr from spent fuel during normal operations.

Water is also used as shielding material above the steam dryer and separator storage area. Concrete walls and water in the pool are designed to provide Zone II dose rates in adjacent accessible areas during storage of the dryer and separator.

The Fuel Pool Cooling and Cleanup (FPCC) System (see Section 9.1.3) shielding is based on the maximum activity discussed in Subsection 12.2.1 and the access and zoning requirements of adjacent areas. Equipment in the FPCC system to be shielded includes the FPCC heat exchangers, pumps and piping, filter demineralizers, and backwash receiving tank.

12.3.2.2.3 Radwaste Building Shielding Design

Shielding is provided as necessary around the following equipment in the radwaste building to ensure that the radiation zone and access requirements are met for surrounding areas.

a) Laundry drain tank and pumps
b) Chemical waste tank and pumps
c) Radwaste evaporators
d) Radwaste evaporator tanks and pumps
e) Liquid radwaste collection tanks and pumps
f) Liquid radwaste surge tanks
g) Liquid radwaste sample tanks and pumps
h) Reactor water cleanup phase separator and pumps
i) Waste sludge phase separator and pumps
j) Spent resin tank
k) Waste filling and capping station
l) Waste liner transfer and storage areas
m) Liquid radwaste demineralizer and piping
n) Waste mixing tanks
o) Liquid radwaste filters
p) Gaseous radwaste equipment.

12.3.2.2.4 Turbine Building Shielding Design

Radiation shielding is provided around the following equipment in the turbine building to ensure that zone access requirements (Dwgs. A-513, Sh. 1, A-514, Sh. 1, A-515, Sh. 1, A-516, Sh. 1, A-517, Sh. 1, and A-518, Sh. 1) are met for the following surrounding areas:

a) Condensate filter demineralizers and piping

b) Regeneration waste surge tanks and pumps

c) Chemical waste neutralizing tanks and pumps

d) Reactor feed pump turbines and piping

e) Condensate pumps and piping

f) Main condensers and hotwell

g) Mechanical vacuum pump

h) Recombiners and piping

i) Steam packing exhauster

j) Condensate demineralizer resin regeneration tanks

k) Air ejectors and gland steam condensers

l) Feedwater heaters, heater drains, and piping

m) Main steam piping

n) Steam seal evaporator and drain tank

o) Moisture separator and drain tanks

p) High pressure and low pressure turbines

q) Offgas piping

r) Ultrasonic resin cleanser

s) Condensate filter vessels

t) Condensate filter vessel backwash receiving tank

Areas within most of these shield walls have high radiation levels and limited access.

12.3.2.2.5 Control Room Shielding Design

"Radiation shielding is provided, as necessary, for the control building and the control structure envelope in order to ensure that the radiation zoning and access requirements as presented on Dwgs. A-511, Sh. 1 and A-512, Sh. 1 are satisfied during normal operation. In addition, shielding is provided to permit access and occupancy of the areas of the control structure envelope in which critical safety functions are performed under post accident conditions with radiation doses limited to 5 rem TEDE from all contributing modes of exposure for the duration of any accident described in Chapter 15 (in accordance with 10CFR50.67).

An isometric drawing of the control and reactor building shielding is provided on Figure 12.3-29 to show the relationship of potential post accident sources to control structure habitability zones. The parameters used in the assessment of control structure envelope habitability during normal and abnormal station operating conditions, including post accident requirements as discussed in Sections 6.4.9.4, and in Appendix 15B."

12.3.2.2.6 Diesel Generator Building Shielding Design

There are no radiation sources in the diesel generator building; therefore, no shielding is required for the building.

12.3.2.2.7 Miscellaneous Plant Areas and Plant Yard Areas

Sufficient shielding and/or radiation protection controls are provided for all plant buildings and designated yard areas containing radiation sources or radioactive material such that radiation levels are maintained within regulatory Units. Some operations, such as loading solidified waste into shield casks, and storage of radiation materials, require access controls. These areas are surrounded by a security fence and closed off from areas accessible to the general public.

12.3.2.2.8 Counting Room Shielding

Because the counting room contains sensitive instruments to radioactivity measurements, it is imperative that the background radiation levels are minimized. To accomplish this, no fly ash was used in the concrete mix for the walls and slabs surrounding the counting room. Fly ash normally contains a relatively large amount of slow decaying radioactive isotopes. In addition, the shield walls and slabs were sized to maintain a background radiation level of less than 130 mrem/year for anticipated operational occurrences and 45 mrem/year for normal operation.

12.3.2.3 Shielding Calculational Methods

The shielding thicknesses provided to ensure compliance with plant radiation zoning and to minimize plant personnel exposure are based on maximum equipment activities under the plant operating conditions described in Subsection 12.2.1. The thickness of each shield wall surrounding radioactive equipment is determined by approximating as closely as possible the actual geometry and physical condition of the source or sources. The isotopic concentrations are converted to energy group sources using data from standard Refs. 12.3-1, 12.3-2, 12.3-3, 12.3-4, and 12.3-5.

The geometric model assumed for shielding evaluation of tanks, heat exchangers, filters, demineralizers, and evaporators is a finite cylindrical volume source. For shielding evaluation of piping, the geometric model is a finite shielded cylinder. In cases where radioactive materials are deposited on surfaces such as pipe, the latter is treated as an annular cylindrical surface source. Typical computer codes that are used for shielding analysis are listed in Table 12.3-2. Shielding attenuation data used in those codes include gamma class attenuation coefficients (Ref. 12.3-6), gamma buildup factors (Ref. 12.3-7), neutron-gamma multigroup cross sections (Ref. 12.3-20), and albedos (Ref. 12.3-12).

The shielding thicknesses are selected to reduce the aggregate computed radiation level from all contributing sources below the upper limit of the radiation zone specified for each plant area. Shielding requirements are evaluated at the point of maximum radiation dose through any wall. Therefore, the actual anticipated radiation levels in the greater region of each plant area is less than this maximum dose and therefore less than the radiation zone upper limit.

Where shielded entryways to compartments containing high radiation sources are necessary, labyrinths or mazes are designed using a general purpose gamma-ray scattering code G^3 (Ref. 12.3-11). The mazes are constructed so that the scattered dose rate plus the transmitted dose rate through the shield wall from all contributing sources is below the upper limit of the radiation zone specified for each plant area.

2.3.3 VENTILATION

The plant heating, ventilating, and air conditioning (HVAC) systems are designed to provide a suitable environment for personnel and equipment during normal operation and anticipated operational occurrences. Detailed HVAC system descriptions are provided in Section 9.4. Control Structure habitability is discussed in Section 6.4.

12.3.3.1 Design Objectives

The systems are designed to operate such that the in-plant airborne activity levels for normal operation (including anticipated operational occurrences) in the general personnel access areas are within the limits of 10CFR20. The systems operate to reduce the spread of airborne radioactivity during normal and anticipated abnormal operating conditions.

During post-accident conditions, the ventilation system for the plant control room provides a suitable environment for personnel and equipment and ensures continuous occupancy in this area. The plant ventilation systems are designed to comply with the airborne radioactivity release limits for offsite areas during normal operation.

12.3.3.2 Design Criteria

Design criteria for the plant HVAC systems include the following:

a) During normal operation and anticipated operational occurrences, airborne radioactivity levels to which plant personnel are exposed is ALARA and within the limits specified in 10CFR20.

b) During normal operation and anticipated operational occurrences, the dose from concentrations of airborne radioactive material in unrestricted areas beyond the site boundary will be ALARA and within the limits specified in 10CFR20 and 10CFR50.

c) The plant siting dose guidelines of 10CFR50.67 will be satisfied following those hypothetical accidents, described in Chapter 15, which involve a release of radioactivity from the plant.

d) The dose to control room personnel shall not exceed the limits specified in 10CFR50.67 following those hypothetical accidents, described in Chapter 15, which involve a release of radioactivity from the plant.

12.3.3.3 Design Guidelines

In order to accomplish the design objectives, the following guidelines are followed wherever practicable.

12.3.3.3.1 Guidelines to Minimize Airborne Radioactivity

a) Access control and traffic patterns are considered in the basic plant layout to minimize the spread of contamination.

b) Equipment vents and drains are piped directly to a collection device connected to the collection system instead of allowing any contaminated fluid to flow across the floor to the floor drain.

c) All-welded piping systems are used on contaminated systems to the maximum extent practicable to reduce system leakage. If welded piping systems are not used, drip trays are provided at the points of potential leakage. Drains from drip trays are piped directly to the collection system.

d) The valves in some systems are provided with leak-off connections piped directly to the collection system.

e) Suitable coatings are applied to the concrete floors of potentially contaminated areas to facilitate decontamination.

f) Where practicable, metal diaphragm or bellows seat valves are used on those systems where essentially no leakage can be tolerated.

g) Contaminated equipment has design features that minimize the potential for airborne contamination during maintenance operations. These features may include flush connections on pump casings for draining and flushing the pump prior to maintenance or flush connections on piping systems that could become highly radioactive.

h) Exhaust hoods are used in plant areas to facilitate processing of radioactive samples by drawing contaminants away from the personnel breathing areas and into the ventilation and filtering systems.

i) Equipment decontamination facilities are ventilated to ensure control of released contamination and minimize personnel exposure and the spread of contamination.

12.3.3.3.2 Guidelines to Control Airborne Radioactivity

a) The airflow is directed from areas with lesser potential for contamination to areas with greater potential for contamination under normal conditions.

b) In building compartments with a potential for contamination, a greater volumetric flow is exhausted from the area than is supplied to the area to minimize the amount of uncontrolled exfiltration from the area.

c) Floor and equipment drain collector tank vents are piped to a collection header and processed by the tank vent filter system.

d) Exhaust air is routed through a prefilter and HEPA filters or a combination of prefilter, HEPA and charcoal filters where necessary before release to the atmosphere to reduce onsite and offsite airborne concentrations.

e) Air is supplied to each principal building via separate supply intakes and duct systems.

f) Redundant, Seismic Category I systems and components are provided for portions of the ventilation system required for safe shutdown of the reactor and to mitigate the consequences of design basis accidents. Included herein are the plant control room ventilation system, the reactor building recirculation system, the standby gas treatment system, and coolers and selected engineered safety feature equipment rooms.

g) Air being discharged from potentially contaminated areas of the Turbine Building and the Reactor Building is passed through prefilters, HEPA filters and charcoal adsorbing filters. Air being discharged from the Radwaste Building is passed through prefilters and HEPA filters. Means are provided to isolate these areas upon indication of contamination to prevent the discharge of contaminants to the environment.

h) Suitable containment isolation valves are installed in accordance with General Design Criteria 54 and 56, including valve controls, to ensure that the containment integrity is maintained. See additional discussion in Subsections 3.1.2.5.5, 3.1.2.5.7 and 6.2.4.

12.3.3.3.3 Guidelines to Minimize Personnel Exposure from HVAC Equipment

a) Ventilation fans and filters are provided with adequate access space to permit servicing with minimum personnel radiation exposure. The HVAC system is designed to allow rapid replacement of components.

b) Ventilation ducts are designed to minimize the buildup of radioactive contamination within the ducts to the maximum extent practicable. Welded seams are used to join ductwork segments and internal obstructions are avoided wherever practicable.

c) Access and service of ventilation systems in potentially radioactive areas are provided by component location to minimize operator exposure during maintenance, inspection, and testing as follows:

    1) The outside air supply units and building exhaust system components are enclosed in ventilation equipment rooms. These equipment rooms are located in radiation Zone II and are accessible to the operators. Work space will be provided around each unit for anticipated maintenance, testing, and inspection. Filter-adsorber units generally comply with the access and service requirements of Regulatory Guide 1.52. (Refer to response to Regulatory Guide 1.52 in Section 3.13.)

       Local cooling equipment, servicing the building requirements, will normally be located in areas of low contamination potential radiation Zones I or II.

d) While the majority of the activity in the filter train is removed by simply removing the contaminated filters, further decontamination of the internal structure is facilitated by the proximity of electrical outlets for operation of decontamination equipment, and water supply for washdown of the interior, if necessary. Drains are provided on the filter housing for removal of contaminated water.

e) Active elements of the atmospheric cleanup systems are designed to permit easy removal.

f) Access to active elements is direct from working platforms to simplify element handling. Space is provided on the platforms for accommodating safe personnel movement during replacement of components, including the use of necessary material-handling facilities and during any in-place testing operations.

g) The clear space for doors is a minimum of 3 ft by 7 ft.

h) The filters are designed with replaceable units that are clamped in place against compression seals. The filter housing is designed, tested, and proven to be airtight with bulkhead type doors that are closed against compression seals.

i) Filter systems in which radioactive materials could accumulate to produce significant radiation fields external to the ductwork are appropriately located and shielded to reduce exposure to personnel and equipment.

j) Filters in all systems are changed based upon the airflow and the pressure drop across the filter bank. Charcoal adsorbers are changed based on the residual adsorption capacity of the bed as measured by the testing of carbon samples taken from the removable canisters located in the carbon bed. The testing of the carbon adsorbers and all other components is described in Table 9.4-1.

12.3.3.4 Design Description

The ventilation systems serving the following structures are assumed to be potentially radioactive and are discussed in detail in Section 9.4.

a) Reactor Building

b) Radwaste Building

c) Turbine Building

Although the control room is considered to be a non-radioactive area, radiation protection is provided to ensure habitability (see Section 6.4).

Ventilation system design parameters for the four systems are given in Tables 9.4-2, 9.4-3, 9.4-6, and 9.4-7.

A typical layout of a potentially radioactive filter unit is given on Figure 12.3-3.

12.3.4 AREA RADIATION AND AIRBORNE RADIOACTIVITY MONITORING INSTRUMENTATION

12.3.4.1 Area Radiation Monitoring

The area radiation monitoring system supplements the personnel and area radiation survey provisions of the plant health physics program described in Section 12.5 to ensure compliance with the personnel radiation protection guidelines of 10CFR20, 10CFR50, 10CFR70, and Regulatory Guides 1.21, 8.2, 8.8 and 8.12 as discussed below.

The area radiation monitors function to:

a) Alert plant personnel of abnormally high radiation levels which, if unnoticed, could result in inadvertent exposures.

b) Inform the control room operator of the occurrence and approximate location of abnormal radiation level increase.

c) Comply with the requirements of 10CFR50 Appendix A, General Design Criterion 63 for monitoring fuel and waste storage and handling areas.

d) Assist in the detection of unauthorized or inadvertent movement of radioactive material in the plant.

e) Supplement other systems including process radiation monitoring, leak detection, etc., in detecting abnormal migrations of radioactive material in or from the process streams.

The area radiation monitoring system has no function related to the safe shutdown of the plant, or to the quantitative monitoring of the release of radioactive material to the environment.

The combination of the airborne radioactivity monitoring system in conjunction with administrative controls restricting and limiting personnel access, standard health physics practices, ventilation flow patterns throughout the plant, plant equipment layout, lack of significant radioactive airborne sources in normally occupied areas (radiation Zones I and II), and administrative control of access into applicable radiation and high radiation areas is sufficient to ensure that airborne radioactivity levels are safe in terms of the required duration of personnel access. A general review of these concepts follows:

a) Significant releases of airborne radioactive materials within the plant are detected by effluent monitors as described in Table 11.5-1 in Section 11.5. Air flow patterns are normally from occupied areas to non-occupied areas and from low airborne radioactive material areas to high airborne radioactive material areas. Readouts and alarms are located locally and in the control room.

b) Additional Continuous Air Monitors (CAMS) with local readout and alarm are located in selected areas of potential airborne concentrations throughout the reactor turbine and radwaste building (s).

c) Administrative controls for limiting exposure to airborne radioactivity concentrations greater than 10 Derived Air Concentration (DAC)-HRS. as specified in 10CFR20 Appendix B to Sections 20.1001 - 20.2401, Table 1 Col. 3 are as follows:

    1) Routine airborne radioactivity surveys of various accessible radiation zones within the plant. The routine monitoring schedule and frequency is delineated in Station Health Physics Procedures. These locations may be modified with consideration of plant operating status.

2) Access to airborne radioactivity areas with concentrations greater than 30% of the applicable Derived Air Concentration and/or Derived Air Concentration mixture are controlled via a Radiation Work Permit (RWP). Entry into and/or work in the area are preceded by a survey sufficient to determine the radiological conditions present and protection required for these conditions. This information is specified on the RWP.

3) Access to areas where the potential for high radioactive airborne concentration exist due to work conditions is controlled via the RWP process.

12.3.4.1.1 Criteria for Area Monitor Selection

The following design criteria are applicable to the area radiation monitoring system.

Energy Dependence: The detector-indicator and trip unit should be responsive to gamma radiation over an energy range of 80 KeV to 6 MeV. The energy dependence should not exceed ±20 percent of point for an exposure rate of approximately 50 mr/hr from 100 KeV to 3 MeV and there should be response from 80 KeV to 6 MeV.

Accuracy: The overall accuracy within the design range of temperature, humidity, line voltage, and line frequency variation should be such that the actual reading relative to the true reading, including susceptibility and energy dependence (100 KeV to 3 MeV), should be within 9.5 percent of equivalent linear full scale recorder output for any decade.

Reproducibility: At design center the reading shall be reproducible within ±10 percent of point with constant geometry.

ENVIRONMENTAL CONDITIONS				
PARAMETER	SENSOR LOCATION		CONTROL ROOM	
	DESIGN CENTER	RANGE	DESIGN CENTER	RANGE
Temperature (degrees C)	25	0 to 60	25	5 to 50
Relative Humidity (Percent)	50	20 to 100	50	20 to 90

12.3.4.1.2 Criteria for Location of Area Monitors

Generally, area radiation monitors are provided in areas to which personnel normally have access and for which there is a potential for personnel unknowingly to receive high radiation doses (e.g., in excess of 10CFR20 limits) in a short period of time because of system failure or improper personnel action. Any plant area that meets one or more of the following criteria is monitored:

a) Zone I areas which, during normal plant operation, including refueling, could exceed the radiation limit of 0.5 mrem/hr upon system failure or personnel error or which will be continuously occupied following an accident requiring plant shutdown

b) Zone II areas where personnel could otherwise unknowingly receive high levels of radiation exposure due to system failure or personnel error

c) Area monitors are in accordance with General Design Criterion 63 of 10CFR50 Appendix A.

12.3.4.1.3 System Description (Area Radiation Monitoring)

General

The area radiation monitoring system is shown in diagram form in Dwgs. M-137, Sh. 1 and M-137, Sh. 2. Each channel consists of a combined sensor/converter unit, a local auxiliary unit (readout with visual and audible alarm), a combined indicator/trip unit, a shared power supply, and a shared multipoint recorder. The exception to this is that the accident range monitors, channels 48 through 57, do not have audible alarms. The location of each area radiation detector is indicated on the shielding and zoning drawings, Dwgs. A-511, Sh. 1, A-512, Sh. 1, A-513, Sh. 1, A-514, Sh. 1, A-515, Sh. 1, A-516, Sh. 1, A-517, Sh. 1, A-518, Sh. 1, A-519, Sh. 1, A-520, Sh. 1, A-521, Sh. 1, A-522, Sh. 1, A-523, Sh. 1, A-524, Sh. 1, A-525, Sh. 1, A-526, Sh. 1, A-527, Sh. 1, A-528, Sh. 1, A-529, Sh. 1, A-530, Sh. 1, and B1N-100, Sh. 1, and with the exception of the LLRW Holding Facility, is listed in Table 12.3-7. With the exception of channels 11 and 12, the detector locations are the same for both Units 1 and 2. In Unit 1 the channel 11 monitor is located adjacent to the Reactor Building sample station which is located just outside room I-508 and in Unit 2 the channel 11 monitor is located adjacent to the Reactor Building sample station which is inside room II-508. In Unit 1, channel 12 monitors the spent fuel hoistway during transfer operations. This hoistway does not exist in Unit 2.

Circuit Description

Sensor/Converter: Each sensor/converter contains all silicon semiconductors in sealed enclosure with a Cooke-Yarborough courtyard circuit which combines a long integrating time constant at low radiation levels with fast overall response at high radiation levels.

Auxiliary Unit: Each auxiliary unit gives instant local readout at the sensor location with a visual alarm. An audible alarm is connected to the auxiliary unit to alert personnel of excessive area radiation.

Indicator and Trip Unit: The indicator and trip unit provides channel control for the area radiation monitoring system. Its circuitry provides an upscale trip that indicates high radiation and a downscale trip that may indicate instrument trouble or loss of power. The module has an analog readout, a low and high trip indicating light, a trip test device, an alarm reset and an output for a multipoint recorder.

Ranges and Sensitivity: Ranges and sensitivities are selected for each location based on the anticipated radiation level as provided by experimental measurements of levels in similar plants and shielding calculations. Refer to Table 12.3-7 for detail. Additional range (10^2 - 10^6 mR) was added for Licensing Commitment to Regulatory Guide 1.97, Rev. 2.

Accuracy: The overall accuracy is such that the actual reading relative to the true reading is within ±7.5 percent of equivalent full scale.

12.3.4.1.4 Area Radiation Monitoring Instrumentation

Power Sources: The power source for the area radiation monitoring system is the 120V AC instrument bus and local lighting panels. The area radiation monitor instrumentation is powered by a high and low voltage electrically regulated power supply capable of handling up to 10 channels. The system has no emergency power supply.

Alarm Setpoints: Alarm setpoints may vary depending on operational considerations and will be determined by measured radiation levels in accordance with controlled station procedures.

Recording Devices: Two multipoint recorders are located in the control room for recording channels pertaining to Unit 1, Unit 2, and channels which are common to both units. This data is also stored in computer history files and can be retrieved and printed using the PMS Historical Recording service program.

Location of Devices: Refer to details in Table 12.3-7.

Readouts and Alarms: Readouts, visual and audible alarms are provided locally for each monitoring channel. The accident range monitors, Channels 48 through 57, serve as indicating channels only and do not have audible alarms. The normal range channels in the same locations serve as the alarm monitors. Readouts and visual alarms are provided by each indicator/trip unit in the Control Structure (Upper Relay Room). Multipoint recorders, visual alarms and PMS displays are provided in the Control Structure (Control Room), with the exception of the three Technical Support Center channels (43, 44, 45). The following annunciators are located in the main control room to alert the operator:

a) Reactor Building Area High Radiation (Units 1 and 2)

b) Turbine Building Area High Radiation (Units 1 and 2)

c) Radwaste Building Area High Radiation

d) Refueling Floor Area High Radiation (Units 1 and 2)

e) Spent Fuel Pool Area High Radiation (Units 1 and 2)

f) Reactor Building Common Area High Radiation

g) Administration Building Area High Radiation

h) Control Structure Area High Radiation

i) Area Radiation Monitoring Downscale (ganged for all channels)

12.3.4.1.5 Safety Evaluation

The area radiation monitoring system is designed to operate unattended for extended periods and is designed for high reliability. Failure of one monitor has no effect on any other.

The system is not essential for safe shutdown of the plant, and serves no active emergency function during operation. The system is not safety related and is constructed to Quality Group D Requirements.

12.3.4.1.6 Calibration Method and Testability

Facilities for calibrating these monitor units are provided, which include a test unit designed for use in the adjustment procedure for the area radiation monitor sensor and converter unit. These provide several gamma radiation levels between 1 and 250 mrem/hr.

A cavity in the calibration unit receives the sensor and converter unit. A window through which radiation from the source emanates is located on the back wall of the cylindrical lower half of the cavity. A chart on each calibration unit indicates the radiation levels available from the unit for the various control settings.

An internal trip test circuit, adjustable over the full range of the trip circuit, is provided. The test signal is fed into the indicator and trip unit input so that a meter reading is provided in addition to a real trip. All trip circuits are the latching type and must be manually reset in the Upper Relay Room.

The radiation monitors will be calibrated at regular time intervals in accordance with station procedures.

12.3.4.2 Airborne Radioactivity Monitoring

Refer to Subsections 12.5.2.2.3 and 12.5.3.5.4 for information on air borne radioactivity monitoring.

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TABLE 12.3-1

PLANT RADIATION ZONE DESCRIPTION

Designation	Max. Design Dose Rate (mRem/Hr)	Description
I	< 0.5	No radiation sources, no radiological control required.
II	≤ 2.5	Low radiation sources, radiological control required.
III	≤ 15	Low-to-moderate radiation sources, radiological control required.
IV	< 100	Moderate radiation sources, radiological control required.
V	≥ 100	High radiation sources, radiological control required.

Table 12.3-2

LIST OF COMPUTER CODES USED IN SHIELDING DESIGN CALCULATIONS

Security-Related Information
Table Withheld Under 10 CFR 2.390

Table 12.3-7

Area Radiation Monitoring System

Channel No.	Monitor Description	Building	Approximate Location	Elevation	Range (mR/hr)
	UNIT 1 & COMMON				
1&56	Chan 1&56 Rx Bldg. Residual Heat Removal Area	RB	(56)T23.5 (1)T/23	645'	(56)10^2-10^6 (1)0.1-1000
2&57	Chan 2&57 Rx Bldg. RCIC Pump And Turbine Room	RB	(57)T20.6 (2)T/21	645'	(57)10^2-10^6 (2)0.01-100
3&48	Chan 3&48 Rx Bldg. HPCI Pump Turbine Room	RB	(48)S/22 (3)S/22	645'	(48)10^2-10^6 (3)0.01-100
4	Chan 4 Rx Bldg. Radwaste Sump Area	RB	R/28	645'	0.1-1000
5&50	Chan 5&50 Rx Bldg. Contr. Rod Drive Hyd. Units North	RB	(50)R/21 (5)R/21	719'	(50)10^2-10^6 (5)0.1-1000
6&51	Chan 6&51 Rx Bldg. Contr. Rod Drive Hyd. Units South	RB	(51)S/29 (6)R/29	719'	(51)10^2-10^6 (6)0.1-1000
7	Chan 7 Off-Gas Bypass Line	TB	G/25	656'	0.1-1000
8&52	Chan 8&52 Rx Bldg. Cleanup Recirc. Pump Access Area	RB	(52)R/21 (8)S/21	749'	(52)10^2-10^6 (8)0.01-100
9	Chan 9 Rx Bldg. Crd Repair Area	RB	T/27	719'	0.1-1000
10&54	Chan 10&54 Rx Bldg. Fuel Pool Pump Room Area	RB	(54)R/27 (10)R/27	749'	(54)10^2-10^6 (10)0.1-1000
11	Chan 11 RX Bldg. Sample Station (1C210A-B) Outside Room I-508	RB	T/27.5	749'-1"	0.01-100
12	Chan 12 Recirc Fan Room -Spent Fuel Cast Hoist Area	RB	U/29	799'	0.01-100
13&46	Chan 13&46 Rx Bldg. New Fuel Vault Criticality	RB	(46)P/29 (13)P/27.5	818' 818'	(46)10^2-10^6 (13)0.1-100
14&47	Chan 14&47 Rx Bldg. Spent Fuel Pool Vault Criticality	RB	(47)Q/26.5 (14)S/27	818'	(47)10^2-10^6 (14)0.1-1000
15&49	Chan 15&49 Rx Bldg. Refueling Floor Area	RB	(49)Q/22 (15)Q/22	818'	(49)10^2-10^6 (15)0.01-100
16&53	Chan 16&53 Rx Bldg. Access To Remote Shutdown Panel	RB	(16)Q/21 (53)Q/21	670'	(53)10^2-10^6 (16)0.01-100
17	Chan 17 TB Bldg. Condensate Pumps Area	TB	J/26	656'	0.01-100
18	Chan 18 TB Bldg. RFPT Area	TB	L/21	676'	0.01-100
19	Chan 19 TB Bldg. Air Ejector Room	TB	Hb/24	682'	0.1-1000
20	Chan 20 TB Bldg. Feedwater Heater Area	TB	N/21	699'	0.1-1000
21	Chan 21 TB Bldg. Reactor Recirc Pump M.G. Area	TB	M/20	729'	0.01-100
22	Chan 22 TB Bldg. Generator Bay Area	TB	J/26	729'	0.01-100

Table 12.3-7

Area Radiation Monitoring System

Channel No.	Monitor Description	Building	Approximate Location	Elevation	Range (mR/hr)
23	Chan 23 TB Bldg. Heat And Vent. Equip. Room	TB	L/23	762'	0.01-100
24	Chan 24 TB Bldg. Turbine Front End	TB	K/15	729'	0.01-100
25&55	Chan 25&55 Rx Bldg. Residual Heat Removal Area	RB	(55)T/26 (25)T/26	645'	(55)10^2-10^6 (25)0.1-1000
26	Chan 26 Rx Bldg. TIP Drive Area	RB	Q/22	719'	0.1-1000
27	Chan 27 Admin. Bldg Access (TB)	TB	N/13	729'	0.01-100
28	Chan 28 Admin Bldg. Access (RW)	ADM BLDG	N/10	691'	0.01-100
29	Chan 29 RW Bldg. Corridor Pers. Access Area	RW	K/3	646'	0.1-1000
30	Chan 30 RW Bldg. Opt. Surveillance Control Area	RW	G/8	646'	0.1-1000
31	Chan 31 RW Bldg. Corridor To Collection Tank	RW	J/12	646'	0.1-1000
32	Chan 32 RW Bldg. Controlled Zone Shop	RW	K/12	676'	0.1-1000
33	Chan 33 RW Bldg. RW Control Room	RW	J/9	676'	0.1-1000
34	Chan 34 RW Bldg. Storage And Equip. Area	RW	G/6	676'	0.1-1000
35	Chan 35 Rx Bldg. Shipping Cask Storage Area	RB	S/29	818'	0.01-100
36	Chan 36 Rx Bldg. Railroad Access Area	RB	U/29	670'	0.01-100
37	Chan 37 Ctr. Twr. Standby Gas Treatment Room	CTR TWR	K/27	806'	0.01-100
38	Chan 38 Ctr. Twr. Rad. Chem. Laboratory	CTR TWR	M/27	676'	0.01-100
39	Chan 39 Ctr. Twr. Control Room	CTR TWR	L/29	725'	0.01-100
40	Chan 40 Admin Bldg. Access Unit 2 (Railroad Bay)	TB	N/12	676'	0.01-100
41	Channel 41 Tip Chamber Shield Area	RB	P/22	719'	10^2-10^6
42	Channel 42 Refueling Floor Area	RB	P/26	818'	0.01-100
43	Channel 43 Observation Deck	CTR TWR	L/30	741'	0.01-100
44	Channel 44 Document Control Area	CTR TWR	M/32	741'	0.01-100
45	Channel 45 Conference Room	CTR TWR	M/26	741'	0.01-100

Table 12.3-7

Area Radiation Monitoring System

Channel No.	Monitor Description	Building	Approximate Location	Elevation	Range (mR/hr)
46	See Channel 13				
47	See Channel 14				
48	See Channel 3				
49	See Channel 15				
50	See Channel 5				
51	See Channel 6				
52	See Channel 8				
53	See Channel 16				
54	See Channel 10				
55	See Channel 25				
56	See Channel 1				
57	See Channel 2				
	UNIT 2				
1&56	Chan 1&56 Rx Bldg. Residual Heat Removal Area	RB	(56)T/31 (1)T/31	645'	(56)10^2-10^6 (1)0.1-1000
2&57	Chan 2&57 Rx Bldg. RCIC Pump Turbine Room	RB	(57)T/30 (2)T/29	645'	(57)10^2-10^6 (2)0.01-100
3&48	Chan 3&48 Rx Bldg. HPCIi Pump And Turbine Room	RB	(48)T/30 (3)R/30	645'	(48)10^2-10^6 (3)0.01-100
4	Chan 4 Rx Bldg. Radwaste Sump Area	RB	R/37	645'	0.1-1000
5&50	Chan 5&50 Rx Bldg. Contr. Rod Drive Hyd. Units North	RB	(50)S/29 (5)S/29	719'	(50)10^2-10^6 (5)0.1-1000
6&51	Chan 6&51 Rx Bldg. Contr. Rod Drive South	RB	(51)R/37 (6)R/37	719'	(51)10^2-10^6 (6)0.1-1000
7	Chan 7 Off-Gas Bypass Line	TB	G/33	656'	0.1-1000
8&52	Chan 8&52 Rx Bldg. Cleanup Recirc Pump Access Area	RB	(52)S/37 (8)S/37	749'	(52)10^2-10^6 (8)0.01-100
9	Chan 9 Rx Bldg. CRD Repair Area	RB	U/34	719'	0.1-1000
10&54	Chan 10&54 Rx Bldg. Fuel Pool Pump Room Area	RB	(54)R/30 (10)R/30	749'	(54)10^2-10^6 (10)0.1-1000

Table 12.3-7

Area Radiation Monitoring System

Channel No.	Monitor Description	Building	Approximate Location	Elevation	Range (mR/hr)
11	Chan 11 Rx Bldg. Sample Station (2C210A&B) Room II-508	RB	U/37.4	749.1'	0.01-100
12	Chan 12 Rx Bldg. Recirc Fan Room	RB	U/37	799'	0.01-100
13&43	Chan 13&43 Rx Bldg. New Fuel Storage Vault Criticality	RB	(43)P/29 (13)Q/31	818'	(43)10^2-10^6 (13)0.1-1000
14&44	Chan 14&44 Rx Bldg. Spent Fuel Pool Vault Criticality	RB	(44)Q/29 (14)S/31	818'	(44)10^2-10^6 (14)0.1-1000
15&49	Chan 15&49 RX Bldg. Refueling Floor Area	RB	(49)Q/36 (15)Q/36	818'	(49)10^2-10^6 (15)0.01-100
16&53	Chan 16&53 Rx Bldg. Access To Remote Shutdown Panel	RB	(53)Q/34 (16)P/37	670'	(53)10^2-10^6 (16)0.01-000
17	Chan 17 TB Bldg. Condensate Pumps Area	TB	K/33	656'	0.01-100
18	Chan 18 TB Bldg. RFPT Area	TB	L/37	676'	0.01-100
19	Chan 19 TB Bldg. Air Ejector Room	TB	J/33	682'	0.1-1000
20	Chan 20 TB Bldg. Feedwater Heater Area	TB	P/37	699'	0.1-1000
21	Chan 21 TB Bldg. Reactor Recirc. Pump M.G. Area	TB	M/36	729'	0.01-100
22	Chan 22 TB Bldg. Generator Bay Area	TB	K/33	729'	0.01-100
23	Chan 23 TB Bldg. Heat And Vent. Equip. Room	TB	L/35	762'	0.01-100
24	Chan 24 Tb Bldg. Turbine Front End	TB	K/43	729'	0.01-100
25&55	Chan 25&55 Rx Bldg. Residual Heat Removal Area	RB	(55)T/34 (25)T/34	645'	(55)10^2-10^6 (25)0.1-1000
26	Chan 26 Instrument Gas Accumulator Area	RB	Q/30	733'	0.1-1000
41	Channel 41 TIP Chamber Shield Area	RB	P/30	719'	10^2-10^6
42	Channel 42 Refueling Floor Area	RB	P/31	818'	0.01-100
43	See Channel 13				
44	See Channel 14				
48	See Channel 3				
49	See Channel 15				
50	See Channel 5				

Table 12.3-7

Area Radiation Monitoring System

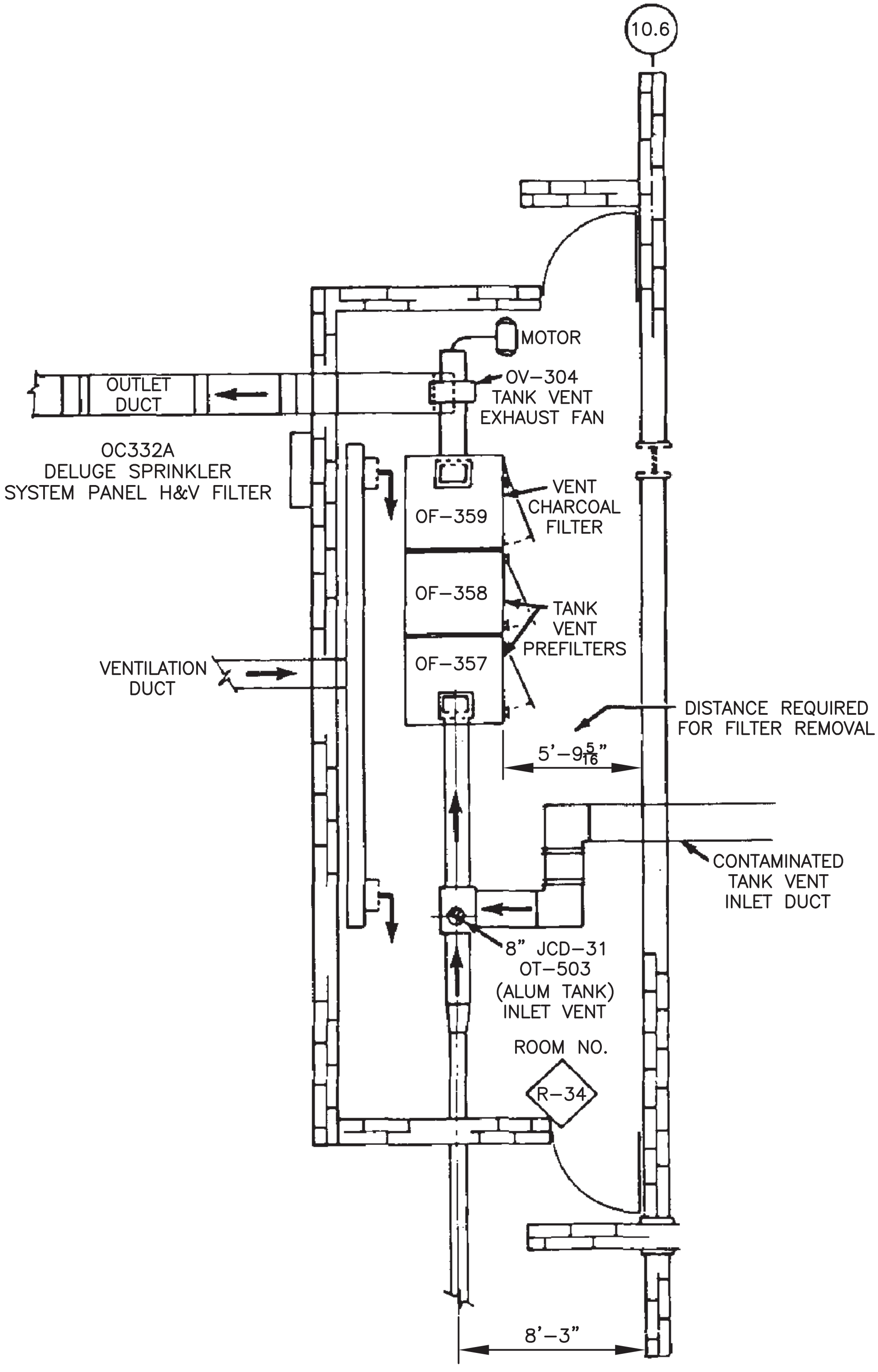
Channel No.	Monitor Description	Building	Approximate Location	Elevation	Range (mR/hr)
51	See Channel 6				
52	See Channel 8				
53	See Channel 16				
54	See Channel 10				
55	See Channel 25				
56	See Channel 1				
57	See Channel 2				

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
TYPICAL SHIELDING ARRANGEMENT FOR LIQUID RADWASTE FILTERS AND VALVE GALLERY FIGURE 12.3-1

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
TYPICAL SHIELDING ARRANGEMENT FOR RADWASTE DEMINERALIZER
FIGURE 12.3-2



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TYPICAL SHIELDING
ARRANGEMENT FOR
CHARCOAL AND PARTICULATE
FILTER

FIGURE 12.3-3, Rev 47

AutoCAD: Figure Fsar 12_3_3.dwg

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
TYPICAL SHIELDING ARRANGEMENT FOR OFFGAS RECOMBINERS FIGURE 12.3-4

Security-Related Information
Figure Withheld Under 10 CFR 2.390

<table>
<tr><td>SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT</td></tr>
<tr><td>TYPICAL SHIELDING
ARRANGEMENT FOR
RADWASTE TANKS AND PUMPS

FIGURE 12.3-5</td></tr>
</table>

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
TYPICAL SHIELDING ARRANGEMENT FOR RADWASTE EVAPORATOR FIGURE 12.3-6

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-511, Sh. 1

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Figure 12.3-8 replaced by dwg.
A-511, Sh. 1

FIGURE 12.3-8, Rev. 55

AutoCAD Figure 12_3_8.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-512, Sh. 1

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SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
Figure 12.3-9 replaced by dwg. A-512, Sh. 1 FIGURE 12.3-9, Rev. 49

AutoCAD Figure 12_3_9.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-513, Sh. 1

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SUSQUEHANNA STEAM ELECTRIC STATION
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Figure 12.3-10 replaced by dwg.
A-513, Sh. 1

FIGURE 12.3-10, Rev. 57

AutoCAD Figure 12_3_10.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-514, Sh. 1

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Figure 12.3-11 replaced by dwg.
A-514, Sh. 1

FIGURE 12.3-11, Rev. 56

AutoCAD Figure 12_3_11.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-515, Sh. 1

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Figure 12.3-12 replaced by dwg.
A-515, Sh. 1

FIGURE 12.3-12, Rev. 57

AutoCAD Figure 12_3_12.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-516, Sh. 1

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Figure 12.3-13 replaced by dwg.
A-516, Sh. 1

FIGURE 12.3-13, Rev. 56

AutoCAD Figure 12_3_13.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-517, Sh. 1

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Figure 12.3-14 replaced by dwg.
A-517, Sh. 1

FIGURE 12.3-14, Rev. 57

AutoCAD Figure 12_3_14.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-518, Sh. 1

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SUSQUEHANNA STEAM ELECTRIC STATION
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Figure 12.3-15 replaced by dwg.
A-518, Sh. 1

FIGURE 12.3-15, Rev. 57

AutoCAD Figure 12_3_15.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-519, Sh. 1

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Figure 12.3-16 replaced by dwg.
A-519, Sh. 1

FIGURE 12.3-16, Rev. 56

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-520, Sh. 1

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Figure 12.3-17 replaced by dwg. A-520, Sh. 1 FIGURE 12.3-17, Rev. 56

AutoCAD Figure 12_3_17.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-521, Sh. 1

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SUSQUEHANNA STEAM ELECTRIC STATION
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Figure 12.3-18 replaced by dwg.
A-521, Sh. 1

FIGURE 12.3-18, Rev. 56

AutoCAD Figure 12_3_18.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-522, Sh. 1

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Figure 12.3-19 replaced by dwg.
A-522, Sh. 1

FIGURE 12.3-19, Rev. 57

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-523, Sh. 1

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Figure 12.3-20 replaced by dwg.
A-523, Sh. 1

FIGURE 12.3-20, Rev. 57

AutoCAD Figure 12_3_20.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-524, Sh. 1

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Figure 12.3-21 replaced by dwg.
A-524, Sh. 1

FIGURE 12.3-21, Rev. 57

AutoCAD Figure 12_3_21.doc

THIS FIGURE HAS BEEN
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A-525, Sh. 1

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Figure 12.3-22 replaced by dwg.
A-525, Sh. 1

FIGURE 12.3-22, Rev. 56

AutoCAD Figure 12_3_22.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-526, Sh. 1

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SUSQUEHANNA STEAM ELECTRIC STATION
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Figure 12.3-23 replaced by dwg.
A-526, Sh. 1

FIGURE 12.3-23, Rev. 57

AutoCAD Figure 12_3_23.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-527, Sh. 1

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SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
Figure 12.3-24 replaced by dwg. A-527, Sh. 1 FIGURE 12.3-24, Rev. 57

AutoCAD Figure 12_3_24.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-528, Sh. 1

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SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
Figure 12.3-25 replaced by dwg. A-528, Sh. 1 FIGURE 12.3-25, Rev. 57

AutoCAD Figure 12_3_25.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-529, Sh. 1

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SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
Figure 12.3-26 replaced by dwg. A-529, Sh. 1 FIGURE 12.3-26, Rev. 57

AutoCAD Figure 12_3_26.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
A-530, Sh. 1

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SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
Figure 12.3-27 replaced by dwg. A-530, Sh. 1 FIGURE 12.3-27, Rev. 48

AutoCAD Figure 12_3_27.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
BIN-100

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SUSQUEHANNA STEAM ELECTRIC STATION
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Figure 12.3-28 replaced by dwg.
BIN-100

FIGURE 12.3-28, Rev. 55

AutoCAD Figure 12_3_28.doc

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Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
SCALED ISOMETRIC OF CONTROL BUILDING WITH RELATIONSHIP TO CONTAINMENT FIGURE 12.3-29

THIS FIGURE HAS BEEN
REPLACED BY DWG.
M-137, Sh. 1

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Figure 12.3-30-1 replaced by dwg.
M-137, Sh. 1

FIGURE 12.3-30-1, Rev. 56

AutoCAD Figure 12_3_30_1.doc

THIS FIGURE HAS BEEN
REPLACED BY DWG.
M-137, Sh. 2

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Figure 12.3-30-2 replaced by dwg.
M-137, Sh. 2

FIGURE 12.3-30-2, Rev. 56

AutoCAD Figure 12_3_30_2.doc