SUMMARY OF THE TESTIMONY OF GERALD P. LAHTI
REGARDING CONTENTIONS 42, 111 AND 112

Gerald P. Lahti is the Assistant Division Head of the Nuclear Safeguards and Licensing Division in charge of Shielding and Radiological Safety at Sargent & Lundy. As such Mr. Lahti is responsible for the design of radiation shielding and other radiation protection features at the Byron Station. His testimony addresses those portions of Contentions 42, 111 and 112 which assert that plant design for reducing occupational radiation exposure was not considered in the Byron design.

Sargent & Lundy is responsible for the design of the so-called "balance of plant", i.e. all structures and components other than nuclear steam supply system, the steam generators and ancillary equipment. The design of radiation protection features for Byron assures that operation and maintenance of the plant do not result in doses of radiation in excess of those allowed by NRC regulations and are in compliance with regulatory ALARA principles. Mr. Lahti states that there are 4 well-known design principles which reduce radiation exposure: shielding, distance, reduction of the time spent by the worker in a radiation area and removal of the radioactive source. Each of these principles has been applied as appropriate to the Byron Station design. Lahti Exhibit 1 contains extracts from the FSAR for Byron which detail the manner in which the Byron design reduces occupational radiation exposure.

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TESTIMONY OF GERALD P. LAHTI

REGARDING CONTENTIONS 42, 111 AND 112

Q.1. State your name and present occupation.

A.1. My name is Gerald P. Lahti. I am Assistant Division Head of the Nuclear Safeguards and Licensing Division in charge of Shielding and Radiological Safety at Sargent & Lundy in Chicago, Illinois.

Q.2. Briefly state your educational and professional qualifications.

A.2. I received a BSCE in Civil Engineering from Wayne State University in 1959. I received a MSE (Nuclear Engineering) from the University of Michigan in 1960, and completed additional part time course work in Mechanical and Nuclear Engineering at the University of Delaware, Case Western Reserve University, and the University of Toledo. From 1960 to 1963 I was employed by E. I. duPont deNemours & Co., Inc., and mathematically analyzed and designed polymer transfer systems and extrusion dies. From 1963 to 1973 I was a member of the National Aeronautics and Space Administration (NASA) staff at Lewis Research Center, Cleveland, Ohio. There, I evaluated radiation hazards and designed radiation shields for nuclear reactors considered for power or propulsion systems in space vehicles. In 1968 I assumed supervisory responsibilities in this area. In 1973 I joined Sargent & Lundy and have been employed in the Shielding and Radiological Safety Section continuously since that time. The Shielding and Radiological Safety Section, which is under my supervision, designs and evaluates all radiation shielding and other radiation protection features incorporated in nuclear power plant design. I am also responsible for assessing the radiological impact of radionuclides released during normal and abnormal power plant operations. I am a Registered Professional Engineer in the State of Illinois and a member of the American Nuclear Society and Health Physics Society. I am a past Chairman of the ANS's Radiation Protection and Shielding Division.

Q.3. What is the scope of your testimony?

A.3. My testimony addresses those portions of Contentions 42, 111 and 112 which assert that plant design for reducing occupational radiation exposure were not considered in the design of the Byron Station.

Q.4. What have been your duties and responsibilities with respect to the design of radiation protection features for Commonwealth Edison Company's Byron Nuclear Station?

A.4. To supervise the activities of engineers assigned to the Shielding and Radiological Safety Section to make certain that the design of Byron Station is such that operation and expected maintenance does not result in radiation doses in excess of the levels specified in 10 CFR § 20.101 and takes account of other NRC regulations regarding occupational radiation exposure, specifically the ALARA (as-low-as-reasonably-achievable) provision of 10 CFR § 20.1.

Q.5. What is the scope of the Sargent & Lundy design effort in connection with compliance with NRC regulations regarding occupational radiation exposure?

A.5. Westinghouse is responsible for the design of the nuclear steam supply system, that is the nuclear reactor, the steam generators and ancillary equipment. Generally, Sargent and Lundy is responsible for the design of what is designated "balance of plant". The balance of plant includes the structure to house the NSSS and the design of mechanical systems other than the NSSS. Some of these systems, such as the radwaste system, will routinely contain radioactive materials over the operating life of the plant. Others, although not themselves handling radioactive materials, are in proximity to radioactivity.

Q.6. Are there certain design principles which reduce radiation exposure and which have been taken into account in the design of Byron Station?

A.6. Yes. There are four means of reducing radiation exposure. They are: (1) provide shielding between the radioactive source and accessed area; (2) provide distance between the radioactive source and workers; (3) reduce the time spent by the worker in the radiation field; and (4) removal of the radioactive source material.

Q.7. Please describe generally the application of these principles to the design of a nuclear power plant such as Byron.

A.7. Example of the use of each of the above is as follows:

1. Shielding can be interposed between radioactive areas and those areas containing systems which do not have radioactivity permitting general access in these latter areas; and shielding can be interposed between radioactive components to permit maintenance on one component without undue hazard from the other component. But in some cases it is not practical to interpose shielding; for example, consider work on a pump containing radioactive material. Other principles are then called upon.

2. Perhaps distance can be provided by remote handling tools or remote operations.

3. Or in our pump example, the ALARA guideline can be met more effectively by the reduction of the time spent by the worker in the radiation field. This can be done by providing, in design, enough laydown space for

removed mechanical parts, maintenance tools and supplies, permanent galleries for ready access to radioactive areas when necessary, cranes for efficient handling of materials in a radioactive area and removable shield walls to improve access to radioactive components when maintenance is required; or

4. Providing draining and backflushing provisions to remove the source from the work area.

Generally, it is a combination of all of the above design features which contribute to ALARA. The plant procedures as described in the testimony of Mr. Van Laere further help keep doses ALARA.

Q.8. Is the manner in which specific features of Byron Station have been designed to take account of ALARA principles described in the FSAR?

A.8. Yes. Attached to my testimony as Lahti Exhibit 1 are section 12.3 through section 12.3.2.1.8. These sections were prepared under my supervision and control and describe the detailed application of the design principles described above to the Byron Station.

12.3 RADIATION PROTECTION DESIGN FEATURES

Radiation protection design features are provided to reduce direct radiation, control airborne radioactivity, identify radiation areas, decontaminate personnel and equipment, calibrate radiation monitors, and maintain personnel radiation exposure as low as is reasonably achievable (ALARA).

12.3.1 Description of Facility Design Considerations

12.3.1.1 Equipment Selection, Layout, and Segregation

In selecting and shielding equipment and components containing radioactive materials, prime consideration is given to protecting the operating and maintenance personnel from radiation, and to maintain personnel exposures ALARA.

Equipment containing radioactive materials is located in separate rooms or cubicles, where practicable, to protect operating and maintenance personnel from radiation associated with other equipment. Components are remotely operated and/or remotely serviced whenever practicable.

Items which require frequent maintenance and which are radioactive or potentially radioactive, such as pumps, valves, and instrumentation are to the extent practicable, separated from passive radioactive components such as tanks, filters, demineralizers, etc.

Areas containing more than one piece of radioactive equipment are, where practicable, designed and provided with shielding such that maintenance of one item is not restricted by radiation from other pieces of equipment. Where it is not practicable to provide permanent shielding, provisions (discussed in Subsection 12.3.2) for temporary shielding to minimize maintenance doses are provided.

Components which are not radioactive or potentially radioactive are physically separated, to the extend practicable, from components which are radioactive or potentially radioactive.

Radiation detector probe access holes are provided in shield walls (e.g., shield hatches) for all isolated equipment cubicles where access is only by means of removable shield walls.

Partially shielded configurations are reviewed for radiation scattering.

12.3.1.2 Cubicle Access

Access to radioactive or potentially radioactive cubicles or compartments is through entrances designed, where practicable, to permit access to an area of the room which has the lowest or relatively lowest radiation level. Entrances are designed to prevent source radiation from passing directly through entrance openings and into occupied areas. This is done, where practicable, by providing labyrinthine entrances to radioactive and potentially radioactive cubicles.

Typical labyrinthine entrances are seen in Figures 12.3-1 and 12.3-2. Radiation traveling through such labyrinthine entrances collides with the shield walls and consequently can be attenuated to some small fraction of the incident quantity.

Cubicle access for Byron/Braidwood is either through a labyrinthine entrance with an overlap of 1 to 1 1/2 times the passageway width as seen in Figure 12.3-1 or through a double labyrinth arrangement as seen in Figure 12.3-2.

Not all entrances to radioactive areas are designed with labyrinthine entrances. Where labyrinthine entrances are not feasible, other alternatives include:

a. shield doors installed at personnel entrances,

b. removable concrete block walls, and

c. wall and floor removable shield hatches and plugs (such as for the radwaste filter and demineralizer compartments).

The following considerations govern the design of labyrinths:

a. A labyrinth is located and sized to cause unscattered radiation to be attenuated by the required amount of shielding, as shown in Figure 12.3-1. Normally, the labyrinth overlap is designed so that (with worst-case sources) the streaming leaving the labyrinthine entrance due to scattered radiation gives a dose rate which is less than three to five times the design dose rate of the surrounding area. Where strong sources of low energy gamma radiation are encountered, a double labyrinthine entrance such as depicted in Figure 12.3-2 is used in order to meet this criterion.

b. When the design of the labyrinth is determined by other design considerations, a shield door, isolation of the entrance (e.g., rope off area), extended labyrinth overlap, or a removable labyrinth is also specified.

c. If the labyrinth height is shorter than the ceiling height, as is often the case, a roof is provided above the labyrinth section.

d. Galleries and other elevated occupied areas are protected from radiation passing through the roof of the labyrinth. The roofs have a thickness which will maintain the design dose rate of these elevated areas.

e. Labyrinths inside source cubicles require roofs if any part of a source is higher than the top of the labyrinth. The roof thickness is dependent upon the location of the source, and the thickness is calculated on a cubicle-by-cubicle basis.

12.3.1.3 Draining and Flushing Capability of Equipment

Consideration is given in the radiation protection design to identifying the need for adequate draining and flushing capability of equipment designed for radioactive or potentially radioactive service.

The potentially high activity radwaste storage tanks were selected and their designs reviewed to assure adequate draining capability to minimize activity buildup and excessive radiation levels over the plant lifetime. Tanks containing radioactive material have sloped bottoms wherever practicable so that sludge accumulation is minimized and ease of drainage is enhanced.

Where practicable, equipment is selected and the design reviewed to assure that there are no obvious ledges or pockets where radioactivity may be trapped or accumulated.

To the extent practicable, drain piping is of welded construction and is welded in a manner, e.g., using consumable inserts, to minimize crevices which might collect radioactive material. (Use of backing rings in the welds or use of socket welds may be acceptable if the weld is embedded in concrete.)

The design of the spent resin storage and exchange systems is reviewed to assure that the layout and components are such as to prevent the retention of resin beads or fragments in connections, bends, horizontal sections, reducers, etc.

All equipment drains which are considered to be radioactive are directed to appropriate liquid radwaste storage tanks. Sumps are used as intermediate collection points. Such sumps and tanks are appropriately shielded or appropriately located within radiation areas.

The design of the radwaste filters was checked to assure that the filters can be drained and flushed prior to filter element replacement.

Flushing capability of radioactive service equipment is important to assure a minimum of radioactive crud or sludge retention in the equipment prior to maintenance or removal of the equipment.

All potentially high activity source storage vessels were selected and their designs checked to assure adequate draining capability. These tanks include the volume control tank, the spent resin storage tank, the concentrates holding tank, the regeneration waste drain tank, the auxiliary building floor and equipment drain tanks, and the recycle holdup tanks.

Draining capability is assured:

a. to minimize personnel exposure during testing, surveillance, and maintenance activities and

b. to minimize activity (crud) buildup and avoid excessive radiation levels to accessible areas during plant lifetime.

Adequate draining capability is assured wherever practicable by selecting tanks which have sloped bottoms and which have, or can be provided with, drain lines connected to the lowest level of the tanks. Drainage of the above listed high activity source storage tanks is via remotely operated valves or by valves which are located remotely from the tank cubicle in lower radiation areas. (For location of valves with respect to shielded areas, refer to Subsection 12.3.1.8.)

Flushing of radwaste tanks is accomplished by washing down the tank interiors with demineralized water and/or cleaning agents. Where practicable, provisions are made to remove crud sedimentation by remote mechanical means with hoses.

Where practicable, flushing of radwaste tank interior is accomplished by an installed sparger (where justified) or by providing a recirculation line for the pump servicing the tank to the bottom of the tank so that a spraying effect can be utilized to get settled deposits in suspension, so that they may be pumped or drained out of the tank. For manual flushing, adequate capability is provided in the form of water connections located near the tank cubicles.

Flushing is required when major maintenance and/or removal of the tank is necessary and also when necessary to reduce radiation levels in adjacent areas due to sources within the tank. Flushed water is directed to tanks having sufficient capacity and shielding necessary to contain and shield the flushed water.

When practicable, the above applies to other high activity source items such as pumps. Where adequate draining and flushing capability is not practicable, shielding is designed to account for worst-case radioactive crud buildup.

12.3.1.4 Floor and Sink Drains

Adequate floor drainage is provided for each room or cubicle housing components which contain, or may contain, radioactive liquids. Floors are properly sloped to the floor drain to facilitate floor drainage and prevent water puddles.

All floor drains which are considered to be radioactive are directed to appropriate liquid radwaste storage tanks. Sumps are used as intermediate collection points. Such sumps and tanks are appropriately shielded or appropriately located within radiation areas. Shielding of radwaste drain piping is discussed in Subsection 12.3.1.6.

To the extent practicable, greater potential radiation area floor drains are segregated from lesser potential radiation area floor drains to protect against backflow of radioactive liquids into lower potential radiation areas, if drainage is blocked or if a large spill occurs. Air circulation through the floor drain system is prevented by the use of water-filled seals (loop seals) or by sealing individual floor drains. The use of such seals also prevents backflow of radioactive gases into the room from the floor drain system.

Sink drains which are expected to contain radioactive fluids are reviewed for appropriate shielding and routing requirements.

Loop seals are present on sink drain lines which may handle radioactive fluids.

All floor drains in the auxiliary, containment, fuel handling, and radwaste/service buildings, except for those areas listed below, are considered to be radioactive and shall discharge to either the auxiliary building floor drain tanks or the chemical drain tank through various sump pumps. Exceptions to this requirement are:

a. diesel-generator oil storage tank rooms,

b. auxiliary feedwater tunnel,

c. main steam/steam generator feedwater tunnel,

d. tendon tunnel,

e. tendon tunnel access area,

f. diesel-generator rooms,

g. cable spreading rooms,

h. switchgear rooms,

i. office areas in service building,

j. storage rooms in service building,

k. auxiliary electrical equipment room,

l. battery rooms,

m. auxiliary building HVAC equipment area (elevation 451 feet), and

n. essential service water pump.

12.3.1.4.1 Design of Drain System

a. Equipment drains in the turbine building discharge to the two turbine building equipment drain sumps, one per unit, from which they are piped to the turbine building equipment drain tank. The drains are then treated and recycled to the condensate storage tanks.

b. Equipment drains in the auxiliary, containment, and fuel handling buildings discharge to the two auxiliary building equipment drain collection tanks. Pumps are provided to pump the drains to the auxiliary building equipment drain tanks.

c. Floor drains that are expected to handle chemical waste solutions from potentially radioactive areas are kept separate from other floor drains and are routed to the chemical drain tank, unless otherwise specified.

d. Leak detection sumps are provided for various areas in the auxiliary building that contain safety-related equipment required for long-term operation.

e. A storm drain system, complete with oil separators, is provided to remove all roof and storm drainage.

f. Borated equipment drains are recycled to the recycle holdup tanks.

g. High radiation area floor drains are routed separately from low radiation area floor drains to prevent backflow of high contamination into low radiation areas.

h. The top elevation of floor drains are set below nominal elevations of the floor area to be drained.

i. Floors are sloped to the drain to facilitate floor drainage and prevent water puddles.

j. Slotted cover plates are used to prevent solids from entering floor drain sumps. These cover plates are removable to provide full access to the sump.

k. The arrangement of drains from cubicles containing radioactive equipment is such that air from a zone of high airborne radioactivity potential does not circulate through the drain system to normally accessible areas. The prevention of air circulation is done through the use of loop seals.

l. Drain piping of equipment and systems which carry caustics or acids is the same material as the equipment or system they are draining.

m. Drain lines are positively sloped 1/8-inch per foot to assure complete drainage of piping.

n. Drain piping is of welded construction and is welded in a manner to avoid crevices (except where embedded in concrete), which might collect radioactive solids. All potentially high radioactive drain piping from the equipment to the loop seal is welded using a consumable insert.

o. Equipment drains which interconnect pieces of equipment are designed so as not to inadvertently transfer fluid from one piece of equipment to another.

p. Shielding of radwaste drain piping is provided as necessary. Radwaste drain piping not specifically shielded is routed so that is is not exposed to normally high access areas and general access routes. Vertical runs of radwaste drain piping not specifically shielded is run against walls and sufficiently isolated so as to facilitate compensatory shielding, if required.

q. All floor drain piping to the sumps (unless otherwise noted) is carbon steel unles required to be otherwise by design due to flow of corrosive liquids.

r. Primary sample drains are routed to the chemical drain tank and from these processed in the radwaste evaporators.

12.3.1.5 Venting of Equipment

Where practicable, all radioactive or potentially radioactive equipment (such as filters, demineralizers, and radwaste tanks) is vented to a filtered vent header to minimize the possibility of airborne radioactivity in occupied areas or equipment cubicles due to equipment venting.

Radwaste sumps (i.e., sumps designed to handle drains from radio-acitve service equipment or from floor areas of potentially radioactive components) are normally either vented to a high radiation area, such as to within the cubicle the sump is located, if it is high radiation cubicle, or to a filtered vent header. Venting of radwaste sumps is important to control the concentrations of radioactive contaminants normally released to the air from potentially contaminated water held in the sumps. Subsection 12.3.1.5.1 lists the sumps with venting. For sumps which are in shielded cubicles and which vent to the cubicle, cubicle ventilation rates are such as to assure adequate control over expected airborne concentrations of radioiodine. If venting to other areas is required, the sump covers have air inleakage and have no special provisions for sealing since the sump can maintain a slightly negative pressure with respect to the area in which the sump is located. A small amount of air inleakage to the sump is desirable to maintain air flow through the vent line.

12.3.1.5.1 Sumps Requiring Venting

Venting is provided for the following sumps:

a. auxiliary building equipment drain collection sumps,

b. fuel handling building floor drain sumps,

c. fuel handling building decontamination sump,

d. drum storage area sump, and

e. radwaste drumming station sump.

Venting of these sumps minimizes the possibliity of potential airborne radioactivity in the sump areas. Venting is via a small vent line connected to the sump cover plates. This line is routed to a filtered vent header. Slightly negative pressure is maintained in the vent line with respect to the area in which the sump is located.

12.3.1.6 Routing and Shielding of Lines and Ventilation Ducts

12.3.1.6.1 Routing and Shielding of Lines

All potentially radioactive process lines are evaluated to determine proper routing and shielding requirements, based on minimizing radiation exposures to station operating and maintenance personnel.

Radioactive process piping is routed in shielding pipe tunnels, trenches, or chases, or in areas where the radiation field due to the pipe is consistent with the radiation zone for that area.

To aid in preventing crud buildup in process piping, sharp bends, dead ends, and other obvious crud traps are minimized. In general, socket welds and welds employing backing rings are avoided to the extent practicable; these welds contribute to radioactive crud accumulation which results in increased radiation fields near the weld. Where practicable, welds employing consumable inserts are used instead of socket welds or welds using backing rings because the consumable insert weld makes the inside-of-pipe surface smoother and minimizes crevices which may trip crud at the weld. Socket welds and welds employing backing rings are used, however, if the weld is to be embedded in concrete (such as in concrete floor slabs); for these cases, radiation fields due to radioactive crud accumulation are attenuated by the concrete around the weld.

Shielding of radwaste drain piping (including floor and sink drain piping) is provided as necessary. Radwaste drain piping not specifically shielded is routed so that it is not exposed to normally occupied areas and general access routes. Vertical runs of radwaste drain piping not specifically shielded are run against walls and sufficiently isolated so as to facilitate compensatory shielding, if required.

To the extent practicable, radioactive or potentially radioactive sample lines used for grab samples are routed so that grab samples can be taken in low radiation areas.

Radioactive lines are process system piping, drain lines, sample lines, and other lines which normally do, or may contain, radioactive fluids. Special attention is given to the routing and shielding of radioactive lines.

The following guidelines are followed for routing and shielding of radioactive lines:

a. Routing of radioactive lines in low radiation zones is avoided to the extent practicable.

b. Lines that require shielding are routed in shielded pipe tunnels or in radiation areas to the extent practicable.

c. Penetrations through shielded pipe tunnels are not made by lines which do not, themselves, run through the pipe tunnels.

d. Lines that carry radwaste demineralizer resins, filter backwash, filter/demineralizer sludges, or other particulates have large radius bends and are continuously sloped. On radwaste demineralizer resin lines, welded piping is used but the use of socket welds or welds employing backing rings is avoided to the extent practicable; also, the use of loop seals on these lines is avoided to the extent practicable.

e. Slightly radioactive lines are routed in a manner which minimizes radiation exposure to plant operating and maintenance personnel. Slightly radioactive lines in low radiation zones are, to the extent practicable, routed at a minimum elevation above the finished floor of 10 feet 0 inch, or as high above the floor as is practicable. To the extent practicable, slightly radioactive lines are not routed near normally travelled passageways, nor near galleries or other elevated work areas.

f. For field routing of 2-inch and under nonseismic radioactive piping, the guidelines listed below are followed.

1. Piping is installed at as high an elevation as is practicable but, in no case, below 10 feet 0 inch from the finished floor level.

2. Piping is routed as close as possible to existing walls or structures to take advantage of their shielding effect.

3. Radioactive piping is not routed near groups of nonradioactive piping thereby not limiting accessibility to nonradioactive system components.

4. Radioactive piping is not routed near an area radiation monitor thereby causing abnormally high radiation readings which are nonrepresentative of the general area in which the radiation monitor is located.

5. To aid in preventing radioactive crud buildup in the piping, sharp bends, dead ends, and other obvious crud traps are avoided to the extent practicable. The use of socket welds or welds employing backing rings on the piping is avoided to the extent practicable.

12.3.1.6.2 Routing and Shielding of Ventilation Ducts

HVAC duct routing are reviewed to assure that air flow is from areas of lower potential radiation contamination to areas of higher potential radiation contamination.

Ventilation duct penetrations of shield walls, floors, and ceilings are evaluated to determine if parapet and labyrinthine shielding around the ducts is necessary. Penetrations in shield walls for HVAC ducts is discussed further in Subsection 12.3.2.3.

12.3.1.7 Waste Filters and Demineralizers

The waste filters and demineralizers which accumulate radioactivity and which, if unshielded, could cause the area design dose rate to be exceeded, are located, to the extent practicable, in separately shielded cubicles. Shielding is provided between such adjacent filters and demineralizers to minimize personnel exposure during removal or maintenance operations.

A radiation detector probe access hole is provided in all filter and demineralizer removable shield hatches so that radiation levels of the contained equipment may be measured without removing the shield hatches. The probe access hole is shown in Figure 12.3-4.

The waste filters are designed where practicable to permit removal by a remote handling device. Draining and flushing of radwaste filters is discussed in Subsection 12.3.1.3.

Waste filters also includes HVAC filters which may accumulate airborne radioactive materials. These filters are located in areas of the station where access is controlled. Shielding is provided as necessary around HVAC filters (e.g., charcoal filters) to ensure that resultant dose rates from the filter areas are less than the design dose rates for the areas, and to minimize radiation exposure to maintenance personnel during filter removal or maintenance.

HVAC filters are designed for easy removal and sized to allow proper disposal as per Regulatory Guide 1.52, "Design, Testing and Mainenance Criteria for ESF Atmosphere Cleanup System Air Filtration and Adsorption Units of LWR's," Revision 2.

For charcoal air filters, charcoal filtration capacities are such as to assure that radioiodine loadings meet criteria for ESF atmospheric cleanup system air filtration and adsorption units.

12.3.1.8 Valves and Instruments

Where practicable, valves are located and shielded from adjacent radiation sources so that they can be operated or serviced without causing excessive exposure to operating or maintenance personnel.

Shielded valve aisles are provided where necessary to allow greater accessibility to frequently operated or maintained valves. The valves are installed in the valve aisle shielded from the equipment they serve. The valves and associated piping are shielded from the valve operating area (where the valve handwheels are generally installed), located outside of the valve aisle.

12.3.1.8.1 Valves

a. To extent practicable, all valves servicing radioactive or potentially radioactive equipment are located in shielded valve aisles, apart from the (adjacent) equipment being serviced. Walk-in valve aisles are used where practicable (see Figure 12.3-3). Locating valves in pipe tunnels cannot be avoided entirely, however.

b. All radioactive or potentially radioactive manually operated valves (and associated piping) are shielded from the valve operating area, to the extent practicable. Where practicable, use is made of remote manual valve operators (valve extensions or reach rods) connected to the manual operated handwheels or geared handwheels and passing through the shielding to allow valve operation in the valve operating area (see Figure 12.3-3). This protects valve operating personnel from radiation due to radioactivity in the valves and associated fluid piping in the valve aisle.

c. Radioactive pipe runs to and from valves located in valve aisles are minimized to reduce the amount of radioactive material in valve aisles. This is done by maximizing the amount of radioactive runs behind shielding (e.g., running as much as of the radioactive pipe behind the shield wall which separates the valve aisle from the [adjacent] equipment compartment of the component which the valve services).

d. To the extent practicable, all motor-operated valves and pneumatic operated valves (air-operated valves) which are in radioactive or potentially radioactive service are located in areas which are shielded from the (adjacent) component or item of equipment which the valves service. Locating these valves--which are typically higher maintenance items than manual operated valves--in shielded areas minimizes potential personnel radiation exposures due to other nearby radiation sources during valve maintenance and inservice inspection.

e. Valves servicing radioactive or potentially radioactive equipment are installed and positioned with respect to other valves so that (1) service or maintenance time is minimized, and (2) compensatory sheilding (e.g., lead blankets) is used, where practicable, to protect workers from adjacent radioactive valves and piping.

f. For valve maintenance, provision is made for draining or flushing the valve and associated connecting lines of radioactive fluids so that radiation exposures are minimized.

12.3.1.8.2 Instruments

a. Output devices such as instrument readouts, pressure switches, electrical bistable devices, electric converters, control devices, etc., are installed and located in such a manner as to minimize plant personnel exposure to radiation.

b. Instrumentation displays and controls are installed in the lowest practicable radiation zone. (Use of transducers is maximized in high radiation areas.) Instrument readouts are located and positioned in areas (e.g., at valve operating stations) which will result in the lowest personnel exposures, if consistent with other requirements such as instrument accuracy and precision.

c. Instrument readouts are designed, located, and positioned to minimize the time and exposure required to take a reading. The following is considered in the location and positioning of the instrument readout devices to assure ALAP exposures.

   1. Locate in readily accessible areas.

   2. Position at convenient elevation for observation and application of parallax corrective devices.

   3. Face readout toward direction convenient for reading.

   4. Provide easily readable numbers and easily observable pointers and needles.

   5. Preclude or minimize application of scale multipliers on readout.

   6. Locate to take advantage of amount of lighting available.

d. Location of instruments and instrument readouts considers the possibility of local hot spots due to streaming radiation or from the accumulation of radioactivity in lines, ducts, filters, and equipment.

e. Wherever practicable, radiation monitoring equipment with remote readout is located in areas to which personnel normally have access.

Figure 12.3-3 shows a typical walk-in valve aisle arrangement for Byron/Braidwood.

12.3.1.9 Contamination Control and Decontamination

In addition to the safety design features discussed above, the following safety design features specifically relating to decontamination and contamination control are incorporated into the radiation protection design of the station.

a. Curbs

Where practicable and where failure of radioactive storage tanks, vessels, or associated piping is postulated, either the floor of the cubicle is situated at an elevation lower than the entrance to the cubicle, or curb walls are provided to restrict radioactive material to the cubicle.

Curbs are provided for equipment decontamination pads to restrict washdown water to the pad and avoid contamination of adjacent areas.

b. Protective Surface Coatings

Wherever these exists a potential for leakage or spillage of radioactive material onto concrete surfaces (e.g., shield walls, floors, or ceilings), such surfaces are coated with a nonporous coating to enhance decontamination.

The following guidelines and criteria are used for the application of coating systems to potentially contaminated concrete surfaces in the station to enable them to be effectively decontaminated.

The function of the protective coating system is to facilitate decontamination of surfaces by providing a clean, smooth, and hard finish that is minimally free of cracks, is nonabsorbent, and is water-repellent. Surface contaminants can then be removed by means of washing, sweeping, scrubbing, or wiping in one or more applications.

a. The coating systems are capable of performing their surface protective functions throughout the 40-year plant lifetime (including reasonable maintenance and touch-up activities) and under the variable radiation source and environmental conditions anticipated for the plant.

b. The coating systems applied to floors, curbs, dado, and wainscot are capable of maintaining their integrity in protecting these surfaces under conditions of water immersion. The coating systems used on floors, curbs, and dado is therefore solvent-based. The wainscot can be either solvent or water-based.

c. To enable the coating systems to perform their intended function, a surface preparation system appropriate to the surface as well as to each coating system, is first applied. The surface preparation system includes surface cleaning, the filling of holes and the application of primer coating.

d. The coating systems used on floors and ramps are capable of maintaining their integrity in protecting these surfaces under the traffic patterns (people, lift trucks, etc.) anticipated in the various areas. The thickest of the field coating systems should be specified for such areas that involve continuous use to avoid deteriorating and thereby compromising the coating.

Protective coating systems are applied to concrete surfaces on the following basis:

a. Where no other requirements are necessitated, all walls are coated to 1 foot-0 inch dado height to protect this lowest section during sweeping and washing of the floor.

b. Walls that require only partial height coverage are coated to one of several standard wainscot heights (usually 5 feet-0 inch or 8 feet-0 inch). General examples include the walls of potentially radioactive heat exchangers, and certain access area locations.

c. Cubicles containing radioactive equipment that reach above the highest wainscot level are coated to full height and in most cases, the ceiling. The coating of rooms utilizing monorail or crane systems for handling radioactive materials are based on the elevated height of the materials.

d. Cubicles containing radioactive processing equipment such as pumps or pressurized pipe with valving are coated to full height, where necessary. Potentially radioactive contaminated water from the room or area on the floor above, through penetrations in the ceiling.

e. Walls are coated to full height if the potential exists for leakage of radioactive contaminated water from the room or area on the floor above, through penetrations in the ceiling.

f. Cubicles, rooms, and areas that require complete wall coverage have their ceiling fully coated as well. This includes the underside of removable shield hatches and plugs as well as fixed ceilings.

g. Pipe tunnels that are accessible and contain radioactive pipes are fully coated.

Areas that require partial wall coverage (although complete wall coverage may be dictated by equipment size) include the following:

a. areas around sampling stations or panels receiving radioactive process streams for monitoring;

b. areas through which heavy traffic patterns are expected; and

c. clothing change areas, personnel monitoring points, and counting room.

12.3.1.9.1 Equipment Decontamination Facilities

Equipment decontamination facilities are provided in the station as required for the decontamination of contaminated equipment, tools, etc. The design of these facilities includes adequate shielding, and ventilation and filtration of the room air.

A separate area, the auxiliary machine shop and equipment decontamination facility is provided on elevation 426 feet 0 inch in the auxiliary building for cleaning, repairing, and decontaminating tools and small pieces of equipment. Decontamination and repair is done under radiation protection personnel supervision. The room is equipped with shelves, tables, hooded sinks, welding equipment, a lathe, a saw, a drill press, and tanks. For larger pieces of equipment, cleaning and decontamination takes place in the spent fuel shipping cask decontamination pit, in the fuel handling building.

12.3.1.9.2 Personnel Decontamination Facilities

A personnel decontamination facility is supplied on elevation 426 feet 0 inch in the auxiliary building to provide for prompt decontamination of plant personnel, if the need should arise.

12.3.1.9.3 Station Decontamination

Radiation decontamination of the station is currently expected to be required at least once during the life of the station. The radiation protection safety design features discussed above assure less complicated station radiation decontamination when it is required.

12.3.1.10 Traffic Patterns and Access Control Points

Traffic patterns are established to maintain occupational radiation exposures ALARA. Anticipated traffic patterns have been used to determine design dose rates in the various areas, and thus have affected the determination of radiation zones.

The majority of normal personnel traffic occurs between the service building and the auxiliary building. The remainder of the traffic occurs in operating areas (where panels and motor-control centers are located), hallways, elevators, and stairwells.

Access control points (i.e., check points for personnel) are flexible and are determined on a day-to-day basis, depending on contamination levels and maintenance activities.

12.3.1.11 Radiation Zones

Five main radiation zones have been defined as a means of classifying the occupancy restrictions on various areas within the plant boundary. The design criteria for each zone are described in the subsections which follow and are tabulated in Table 12.3-1. The radiation zones assigned to the areas of the plant, and upon which the shielding has been designed, are shown in the radiation zone maps in Figures 12.3-25 through 12.3-44.

Zone I-A

Zone I-A has no restriction on occupancy. A I-A area would represent, for example, plant site where radiation due to occupancy on a 40 hr/week, 50 week/yr basis, will not exceed the whole body dose of 0.5 rem/yr, as specified in paragraph 20.105 of 10 CFR 20. The environs around the plant such as the pump house, electrical switchyards, and turbine hall, are examples of a Zone I-A area.

It is expected that nonplant personnel or vistors to the site will receive considerably less than 0.5 rem/yr because of the relatively small time interval during which they are on the site.

Zones I-B, I-C, and I-D

Zones I-B, I-C, and I-D are radiation areas which individuals can occupy on a 40 hr/week, 50 week/yr basis, and not exceed the allowable whole body dose of 1.25 rems per calender quarter. The design dose rates are from 0.5 to 2 mrem/hr in these zones. The area will be posted and will remain accessible. Corridors in the auxiliary building and areas outside radioactive enclosures where personnel can walk freely are included in this zone.

Zone II-A

Zone II-A is a radiation area that plant personnel can occupy periodically. This zone has a design dose rate of 4 mrem/hr. The radiation level in a Zone II-A area will be posted, but the area will remain accessible to the plant personnel.

Zone II-B, II-C, and II-D

Zones II-B, II-C, and II-D are radiation areas which will be posted with "Caution-Radiation Area" signs. The radiation levels are from greater than 4 mR/hr to 100 mR/hr. Occupancy is limited. The time a worker with a permit can stay in this room is determined by four factors:

a. the actual radiation level in the room;

b. the nature of the radioactivity (airborne, gamma, etc.);

c. the past radiation history of the worker; and

d. nature of the required job.

The "nature of the required job" means that the necessity of the job being done to ensure the safe operation of the station will be considered when work in these radiation areas is being planned.

Auxiliary equipment which requires manual operation or inspection or maintenance during unit operation will not be located in these zones.

All equipment in areas designated as Zone I-A, I-B, I-C, I-D, or II-A will not contain radioactive materials, or if it does, the activity will be such that the dose rate outside the equipment is consistent with the design dose rate in the area. Such equipment could include fluid system, monitor tanks, and monitor pumps.

Zone III

Zone III is a "high radiation area" (10 CFR 20.203) which will be secured by locked doors or other suitable means. Radiation in this area is in excess of 100 mR/hr and occupancy periods are very limited.

This is a restricted area and entry into the area is prevented by a locked door, or entry will energize a conspicuous visible and/or audible alarm in such a manner that the individual entering, and the control room, are made aware of the entry. Entry is permissible only with the knowledge of the control room (shift operating engineer or a designated alternate). A Zone III area will be monitored prior to occupancy to determine the permissable time limit.

Zone IV

Zone IV has no restriction on occupancy. Zone IV covers the lowlevel counting room and personnel dosimeter storage area where a low dose rate is desirable. The dose rate in this zone will be less than or equal to 0.01 mrem/hr above background.

Zone V

Zone V is the main control room area. Zone V normal dose rate will be less than or equal to 0.2 mR/hr during normal operations. During an accident the integrated whole body dose will not exceed 5 rem.

12.3.1.12 Laboratory Complex

The station laboratory complex is located in a controlled access area on the mezzanine floor of the auxiliary building. The facilities located in this complex are: a high level laboratory, a low level laboratory, a counting room, a chemical storage room, a radiation chemistry management room, a hot instrument room, a personnel decontamination room, a supply room, a radiation office, and supervisor offices. This complex will serve as a center for the health physics and radiochemistry activities at the station.

12.3.1.12.1 High Level Laboratory

The high level laboratory is designed to provide for the safe and efficient processing and analysis of radioactive and potentially radioactive samples. Such samples may be expected for such systems as the: primary coolant loop, chemical and volume control, fuel handling and storage, steam generator blowdown, and radwaste.

The major facilities provided in this laboratory are: fume hoods (with HEPA filtered exhausts), sinks (with drains routed to the liquid radwaste system), sufficient workbench space to allow frequently used equipment to be left in place, sufficient built-in storage space to assure a safe, uncluttered work environment, computer grade regulated electrical circuits, and a close tolerance HVAC system (temperature and humidity) to assure optimal performance of sensitive laboratory equipment.

To minimize the accumulation and spread of surface contamination; floor coatings, surface coatings, workbench surfaces, fume hood interiors, and sink and drain pipe materials are chosen to minimize the adherance and ease the removal of contamination. To minimize the spread of airborne radioactivity, fume hoods are provided for the storage and processing of volatile radioactive samples, and the high level laboratory is kept at a negative pressure with respect to all adjacent areas. All air exhaust from this laboratory is filtered prior to its release to the environment via the station vent stack.

12.3.1.12.2 Low Level Laboratory

The low level laboratory is located adjacent to the high level laboratory on the mezzanine floor of the auxiliary building. It is designed to provide a radiation and contamination free environment for the chemical preparation and analysis of nonradioactive samples (i.e., those samples which could not pose a radiological danger to the laboratory workers). The major equipment provided in the low level laboratory includes: fume hoods, sinks, workbenches, and storage facilities.

12.3.1.12.3 Counting Room

The counting room is located near the high and the low level laboratories on the mezzanine floor of the auxiliary building. This room is provided with computer grade regulated electric circuits and nonfluorescent lighting to assure the optimal performance of the counting equipment. The desired radiation level in the counting room should be below background (0.1 mrem/hr). To assure that the counting room will not be affected by any in-plant airborne radioactivity the room is maintained at a positive pressure with respect to all surrounding areas and is ventilated with fresh filtered and conditioned air. The room HVAC is designed to maintain the temperature and humidity tolerances required by the detectors and their associated electronics and computer equipment. The use of thick concrete walls for shielding the counting room was precluded due to considerations of natural radiation emanating from the concrete itself.

The original equipment to be provided in the counting room includes:

a. gamma-ray spectrometer subsystem,

b. multichannel analyzer subsystem,

c. data analysis subsystem,

d. standard alpha, beta counting subsystem,

e. low-background alpha, beta counting subsystem,

f. automatic sample changer (for d and e), and

g. liquid scintillation counting system.

Localized radiation shielding will be provided for the counting equipment as is needed.

12.3.1.12.4 Chemistry Storage

A chemistry storage room is located between the low level chemistry room and the counting room on the mezzanine floor of the auxiliary building. It provides storage space for the radiochemistry supplies used in the laboratory complex.

12.3.1.12.5 Survey Instrument Storage Room

The survey instrument storage room is designed to provide a location where radiation proctection instrumentation can be stored, serviced, and decontaminated when necessary. This room and its facilities are designed to minimize the accumulation and spread of airborne and surface contamination.

12.3.1.12.6 Decontamination Room

The decontamination room associated with the laboratory complex is designed to facilitate the decontamination of station personnel.

12.3.1.12.7 Supply Room

The supply room in the laboratory complex is designed to provide for the storage of health physics related supplies.

12.3.1.12.8 Office Space

The radiation chemical management office, the radiation office, and the supervisor offices in the laboratory complex are provided to assure adequate, local office space for the laboratory complex workers.

12.3.1.13 Laundry Facility

The station laundry facility is located on the mezzanine floor of the auxiliary building. It is designed to receive, decontaminate, store, and distribute the radiation protection apparel used in-plant. The major equipment provided in this facility includes: a 25- and a 50-pound washer, two 50-pound dryers, a contaminated clothes hamper (where incoming contaminated apparel will be dropped off), a sorting table (with local ventilation), sinks, a folding and monitoring table, and clean clothing storage racks. The floor and surface coatings and the equipment in the laundry have been chosen to minimize the buildup of and ease the removal of surface contamination. The laundry is kept at a negative pressure with respect to all surrounding areas, to minimize the spread of airborne contamination.

The laundry facility also includes a mask facility. The mask area includes space and equipment for collecting, cleaning, inspecting, and storing masks.

12.3.2 Shielding

The design of the station shielding is based on the design dose rates and the established design criteria. Using the sources given in Section 12.2 and the shielding design criteria, the shielding design is determined.

12.3.2.1 General Shielding Design Criteria

Every component that handles radioactive fluids may require shielding; the thickness of which is based on the operational cycle of the component, the design dose rate, and the shielding material.

12.3.2.1.1 Regulatory Requirements

The shielding design dose rates for Byron/Braidwood meet 10 CFR 20 and 10 CFR 50, which are concerned with allowable radiation to individuals in restricted and unrestricted areas. The only shielding required to be safety-related is the control room and the primary containment shielding; this shielding satisfies the requirements stated in Criterion 19 of 10 CFR 50, Appendix A, and 10 CFR 20.

12.3.2.1.2 Shielding Requirements

Radiation protection of personnel, equipment, and materials is largely dependent upon the adequacy of the design of the station shielding system. Radiation shielding has the passive protection function of radiation attenuation and consists of material placed between radiation sources and personnel and/or equipment and materials needing protection from radiation.

The shielding system is designed and constructed to assure that the station can be operated and maintained such that the resultant radiation level and doses are within the limitations of applicable regulations and are as low as is reasonably achievable (ALARA). Specific design dose rate limits recommended to achieve this objective are discussed in Subsection 12.3.1 and listed in Table 12.3-2.

Shielding must be capable of performing its protective function throughout the plant lifetime and under the variable source and environmental conditions associated with all normal, anticipated abnormal operational, and design-basis accident conditions identified in the safety analysis reports and as noted below.

a. Normal Operating Conditions

   For the purposes of shielding design, normal station operating conditions are considered to include conditions generally known as anticipated abnormal operational occurrences. Two modes of normal station operation are:

1. normal power operation of the reactor, including anticipated operational occurrences, and

2. normal shutdown of the reactor.

Shielding is designed to provide the required protective function under such conditions.

b. Accident Conditions

Station shielding provides protection to plant operating personnel and the general public under postulated design-basis accident conditions as defined in the Chapter 15.0.

1. Control Room Habitability

The main control room and associated areas is shielded such that, after a postulated design-basis accident (LOCA), the whole body dose in the control room for the duration of the accident will not exceed 5 rem or its equivalent to any part of the body, including ingress and egress, as per requirements 10 CFR 50, Appendix A, Criterion 19. Subsection 6.4.2.5 describes control room shielding.

The radiation shielding protecting the main control room (and associated areas) is designed based on the anticipated radiation environment resulting from the postulated LOCA. Figure 6.4-2 shows an isometric view of the main control room shielding.

2. Direct Offsite Doses

All sources in the plant are adequately shielded to assure that radiation levels at the restricted area boundary are in compliance with 10 CFR 20 limits. Adequate station shielding is provided to limit site boundary doses, due to direct and scattered radiation from contained sources within the plant, to as low as practicable limits during normal operation in conformation with 10 CFR 20 and to within the limits specified in 10 CFR 100 during accident conditions.

3. Seismic and Safety Classification

Structural walls of the station are designed, as required, to meet Seismic Category I requirements. Walls which are shielding walls may be designed Seismic Category I, depending upon the particular design requirements other than radiation protection requirements (e.g., structural integrity, load bearing capacity, etc.) that the walls must meet.

The primary shield, the shield walls for the main control room, and the shield walls for the spent fuel pool are examples of shield walls which are designed Seismic Category I.

c. Protection of Equipment

Appropriate shielding is provided, where needed:

1. to limit radiation heating of build structural concrete,

2. to reduce neutron activation of equipment, and

3. to limit radiation to equipment and materials.

Protection from neutrons and from neutron-induced gamma rays is important around neutron sources such as the nuclear reactor core. The primary shield around the reactor vessel and the neutron shield plugs at the reactor vessel nozzles and examples of station shielding designed to protect personnel and equipment against neutron radiation and neutron-induced gamma rays.

d. Additional Requirements

In addition to the radiation protection functions discussed above, the shielding system have other functional requirements. These depend, however, generally upon the location of the shield and the access requirements to equipment or areas beyond the shield. Thus, access to an area may be through the shield itself; e.g., through removable shield walls. Removable shield walls, portable shields, and compensatory shielding are discussed in Subsection 12.3.2.1.6.

12.3.2.1.3 Design Requirements

The station shielding system must be capable of performing its protective functions throughout the plant lifetime and under the variable source and environmental conditions which are anticipated and/or postulated for the plant.

The radiation attenuating materials which comprise the station shielding system are selected to assure no significant loss in radiation attenuation characteristics for at least 40 years of plant operation.

12.3.2.1.4 General Description and Design Parameters

The shielding system includes all concrete walls and associated radiation attenuating materials (e.g., lead, steel, and water) which are used to protect the public, plant personnel, equipment, and materials from radiation emitted from radioactive sources contained or generated within the plant. The radiation exposure of individuals, equipment, and materials is a function of the following basic parameters, which are given due consideration in the shielding design:

a. source strength (type, intensity, energy);

b. number of sources, source geometry, and self-absorption factors;

c. shielding material, geometery, and mass between source(s) and receptor;

d. distance between source(s) and receptor;

e. time that receptor is exposed; and

f. allowed dose rate or dose.

Where radioactive crud buildup sources are known, the source strength parameter is appropriately adjusted and the shielding designed to accommodate the effects of crud buildup for at least 10 years of reactor operation. Where radioactive crud buildup sources are not known, but expected, the shielding design reflects appropriate conservatism to accommodate the expected effects of crud buildup for at least 10 years of reactor operation, and/or protective measures are used, where practicable, e.g., those discussed in Subsection 12.3.1.

12.3.2.1.5 Shielding Materials and Construction Methods

Bulk shielding structures such as cubicle shielding walls, floors, and ceilings are mainly designed of ordinary concrete, either of (solid) block or poured-in-place construction. Where space limitations are encountered, a special high density concrete (e.g., Hematite concrete) is employed to assure adequate radiation protection. Concrete is a mixture of materials, the exact proportions of which may differ from application to application. Concrete for radiation shielding is classified as oridinary or high density according to the unit weight of the aggregate. The design of concrete mixtures and forms, the construction of concrete radiation shielding structures, and the quality assurance provisions needed to verify that the desired quality of construction has been achieved is in accordance with accepted design criteria for concrete radiation shields.

Poured-in-place concrete construction is normally used for shielding structures which are load-bearing structural walls.

Concrete block walls are provided where necessary to accommodate equipment installation, removal, and construction. Concrete block wall installation is controlled to assure as-built radiation attenuation characteristics similar to those expected from equivalent poured concrete.

In the case of the primary shield around the reactor vessel, nuclear heating is not severe enough to warrant special designs (e.g., water cooling coils) for cooling the primary shield.

A special hinged door design is used at the reactor vessel nozzle inspection openings. These doors are designed to allow pressure relief in the event of a reactor coolant pipe break. The shield consists of special neutron shielding material, Heat Resistant Cement 277, supplied by Reactor Experiments Inc.

Where a potential of leakage or spillage of radioactive material exists, effective features are provided in the design of the shielding to prevent the spread of contamination by seepage through walls. As discussed in Subsection 12.3.1.9, wall surfaces are coated with a nonporous coating to permit effective decontamination.

12.3.2.1.6 Removable Shield Walls, Portable Shielding, and Compensatory Shielding

Shielding is designed to be removable, where required, to provide personnel access for inspection, servicing, maintenance, or replacement of plant equipment.

Removable shield panels are provided in shield walls, floors, or ceilings as necessary where frequent access for maintenance or removal of equipment is required and if radiation levels in the area can cause excessive exposure. Such shielding is designed to minimize exposure to operating and maintenance personnel.

Compensatory, portable, or temporary shielding is considered in station design only as required where other more permanent shielding is not practicable. Where compensatory shielding is necessary, provisions are made to accommodate such shielding in terms of space, structural loading, clearances, and equipment accessibility.

The station shielding system uses three types of removable shield walls: stacked unmortared block, shield hatches and plugs, and shield doors. The primary functions of a removable wall are equipment installation, inspection, maintenance, and removal.

The following are guidelines for the design of removable shield walls. The term major requires the removal of a removable shield wall in addition to repairing and maintaining equipment.

12.3.2.1.6.1 Stacked (Unmortared) Block

Removable stacked block walls that are provided to accommodate removal of equipment are constructed such that the top of the removable unmortared block sections are offset and provided with a lintel arrangement. The blocks are held in place by special metal frames to resist lateral pressure and seismic loads. Use of stacked unmortared block avoids unnecessary exposure associated with disassembly or mortared blocks.

Removable stacked block shield walls are used in the shield design when a room contains equipment that seldom requires replacement or major maintenance. Seldom is defined in the section as once a year. The type of shielded equipment which fits into this category are heat exchangers, pumps, and radwaste tanks.

12.3.2.1.6.2 Removable Shield Hatches and Plugs

Removable shield hatches (or removable floor slabs) and plugs are used in the shield design when a room contains equipment which often requires replacement or maintenance. Often is defined in this section to mean more frequent than once a year.

In addition to all equipment that falls into "the often category," shield hatches or plugs are used, whenever practicable, for access to equipment and piping which have, or are in radiation areas that have, a dose rate greater than 3 R/hr.

The use of removable shield hatches or plugs minimizes the maintenance exposure to station personnel; shield hatch and plug design and construction shall be in accordance with ANSI 101.6-1972. |

A radiation detector probe access hole is provided in all filter and demineralizer removable shield hatches so that radiation levels of the contained equipment may be measured without removing the shield hatches. This is provided by boring a vertical stepped hole in the top of the shield hatch for insertion of a radiation detector. The arrangement is pictured in Figure 12.3-4.

The types of equipment that require removable shield hatches are demineralizers, filters, and pumps and motors, which are radioactive or are in radioactive areas. Removable shield plugs are also used for shielding around the reactor nozzle inspection openings. |

12.3.2.1.6.3 Shield Doors

Shield doors are used when access requirements, maintenance requirements, or design consideration make it undesirable to adequately employ the removable shield walls mentioned previously. Shield doors can also be used with labyrinthine entrances where the dose rate at the entrance due to scattered radiation is greater than the design dose rate.

12.3.2.1.7 Inspection (Inservice) and Maintenance Requirements

Shielding is designed to permit access for required inspections, testing, and maintenance of plant systems and components which require these functions.

During construction, shield walls are visually inspected for cracks and separations that might compromise the shield. There are initial preoperational radiation surveys taken as well as periodic routine radiation surveys during power operation. These surveys serve as a check on the radiation buildup within auxiliary equipment and the adequacy of shielding design. Installed radiation monitoring systems survey continuously the radiation condition at certain areas of the plant and also serve as a check on the adequacy of shield wall design and construction.

As discussed in Subsection 12.3.1, biological protection of personnel during anticipated inspection and maintenance activities are considered in shielding design in the effort to maintain exposures ALARA.

12.3.2.1.8 Shield Thicknesses

Shield thicknesses are designed to reduce the average area dose rate to or below the assigned area dose rate level for worst-case conditions of normal plant operation or, where applicable, for accident conditions. Worst-case conditions include source terms appropriate to maximum power level and 1% failed fuel fraction as discussed in Section 11.1.

Shielding thickness are designed with consideration given to all sources in the area including localized hot spots or penetrations. Design parameters are listed in Subsection 12.3.2.1.4. Byron/Braidwood's shielding design is pictured in Figures 12.3-5 through 12.3-24. Computer codes used in shielding design account for energy spectra and source strengths for each nuclide (including daughter products), material cross sections or attenuation coefficients for each material or element comprising the shield, dose buildup factors, and other relevent parameters.