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A DESIGN STUDY
FOR
FAST FLUX TEST FACILITY
SECONDARY GAMMA SHIELD

ATOMICS INTERNATIONAL

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SECONDARY GAMMA SHIELD**

MASTER

By

**J. V. FACHA
J. G. ROBERTS**

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ABSTRACT

Fuel handling and radioactive maintenance modes which involve occupancy of the reactor hot cell by the operating personnel utilize a secondary gamma shield over the reactor. This study defines the requirements for and establishes the feasibility of such a shield for the FFTF reactor. Alternate rotating and stationary design concepts are presented and evaluated.

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1.0 SUMMARY AND CONCLUSIONS

The primary function of the secondary gamma shield is to provide a gamma barrier between the FFTF reactor and the operating personnel for a nonremote refueling concept. The shield becomes the interface between the reactor and the fuel handling equipment and must allow access for maintenance of reactor components such as the reactor nozzles and closed loop piping.

This study defined the requirements for, and established the feasibility of, a secondary gamma shield which would provide the functions noted above. Design study layouts were prepared to show possible variations of the shield design within two basic categories: rotating and stationary (see Figure 1). The layouts also show many of the design features, with alternates, that could be used in the design of the shield.

Access to the reactor nozzles, for fuel handling and maintenance or replacement of guide tubes, is provided through one or more ports in the rotating gamma shields. The port(s) can be positioned over any reactor nozzle by appropriate rotation of the entire shield and an eccentrically positioned turret plug. The stationary shields have an access port over each reactor nozzle. Radiation streaming through the port is prevented, and the atmosphere below the shield is kept sealed, by a floor valve. The valve is placed over the access port, or in the case of some of the rotating concepts, is built into the shield.

A major variation in the designs of the stationary shields is in the location of the shielding relative to the nozzles. Designs with the shielding completely above the reactor nozzles, or built around the nozzles, are shown. With the latter, a floor plate is required to enclose the nozzle region atmosphere.

The basic advantage of a rotating secondary gamma shield is that it provides unlimited adjustment in positioning the floor valve over a reactor nozzle. The penalties are the increased complexity and cost, and the maintenance associated with the support and drive equipment and with the moving seals.

Rotation of a 25- to 30-ft diameter shield weighing approximately 250 tons is definitely within the current state of the art. Existing polar bridge cranes, tracking antennas, railroad turntables and naval gun turrets involve rotation of equivalent masses with requirements for positioning accuracy and speed that are comparable.

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Figure 1. Secondary Gamma Shield Concepts

The multiple-plug rotating shield (Concept III) provides for adjustment of the floor valve position in the circumferential direction only and therefore does not give the full benefit of shield rotation. The split rotating shield (Concept I) provides only a reduction in the weight that must be lifted to remove or open the shield for hot cell type access to the nozzle gallery. The difference in lift weight does not justify the increased complexity in the structure and the difficult seal problem at the split plane. Therefore, the single-plug, double, rotating shield (Concept II) is the best candidate for a rotating secondary gamma shield. The basic advantages of a stationary secondary gamma shield are: (1) elimination of support bearings or roller-and-track features; moving seals improves reliability; (2) the reactor nozzles can be close to the reactor working face, thereby reducing the reach requirement of the nozzle preparation equipment and the fuel handling machine; this is applicable only to stationary concepts in which the shielding is built in around the nozzles and (3) the closed loop piping is routed through a gallery separate from the driver fuel and open loop nozzles, thereby isolating the contamination from any leakage of closed loop coolant.

The disadvantage of the stationary shield is that adjustment of the floor valve position relative to the nozzle is possible only at the expense of reduced structural capability of the shield or floor plate, or increased nozzle lattice spacing.

In stationary Concept I, a difference in temperature across the shield or between the shield and the reactor vessel cover will cause the reactor nozzles to induce large reactions in the vessel cover. This could require accurate and highly reliable temperature control in this area to prevent overstressing the nozzles or the reactor vessel cover. Also, this concept requires that the entire shield weight be on the reactor vessel cover.

Stationary Concept II provides a lighter load on the reactor vessel, approximately 8 tons, and provides the best accessibility to the instrumentation disconnects and reactor nozzles. Stationary Concept III provides many of the same advantages as the rotating secondary gamma shield concepts. Therefore, the stationary Concepts II and III should remain as shield candidates for further study.

In the contact fuel handling concept, the fuel handling system and the secondary gamma shield are closely related. Their interrelationships will have a major influence on the time required for refueling one of the key considerations in the FFTF design; therefore, the development of these two systems must be closely coordinated.

2.0 INTRODUCTION

2.1 OBJECTIVE

The objective of this study is to determine the feasibility of the concepts and to develop candidate designs of a secondary gamma shield for the FFTF reactor, see Figure 2.

2.2 PURPOSE

One of the alternate reactor refueling modes involves operation of fuel handling equipment by personnel working within the reactor hot cell. This is practicable only if gamma shielding can be provided to permit the operators to work on the reactor loading face and the floor area surrounding the reactor; therefore it is necessary to develop one or more shield concepts for achieving this.

2.3 SECONDARY GAMMA SHIELD FUNCTION

The secondary gamma shield must be designed to provide a component subsystem that supports the FFTF reactor and the fuel handling and radioactive maintenance systems. The basic functions of the secondary gamma shield subsystems are to provide:

- 1) Shielding sufficient to limit the gamma dose rate to a safe working level (The dose rate is to be maintained at the reactor floor during reactor operation and during core component handling or transfer by the fuel handling system.), and
- 2) Backup containment of reactor cover gas and containment of closed loop cross piping cover gas.

The secondary gamma shield becomes an interfacing component between reactor and the radioactive handling equipment. Conceptual design studies in the area of fuel handling and maintenance of the radioactive equipment, such as the closed loops and associated piping, have shown that the gamma shield design has an important influence on the sequence used and the time required for fuel handling. These have also shown the design to have a major influence on the capabilities that can be provided to inspect, repair, or replace closed loop piping and other components under the shield.

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Figure 2. FFTF Basic Concept

2.4 SUBSYSTEM SUMMARY DESCRIPTION

The secondary gamma shield design concepts developed in this study are based on the split, conical-core arrangement. The split, conical-core concept incorporates a reactor vessel cover with nozzles for insertion and removal of core components-and-experiments by use of the reactor refueling system.

The secondary gamma shield is located directly over the reactor vessel cover and nozzle area. The shield contains ports, in line with the reactor nozzles, which provide controlled access to the core components and experiments. The nozzle area includes space for instrumentation lines, reactor cover coolant piping, secondary gamma shield cooling equipment, and closed loop primary cross piping.

The space between the secondary gamma shield and the reactor vessel cover contains an inert atmosphere to prevent oxidation of residual sodium (in event of coolant leakage) and to control radioactive contamination. A cooling system is required to control temperatures of the shield.

2.5 TECHNICAL APPROACH

The tasks required to accomplish the objective of this study were defined as follows.

- 1) Review the technical documents and drawings applicable to a secondary gamma shield for FFTF and study other reactor systems which have a top cover shield such as the EBR-II, Fermi, and AI SGR's and FBR concepts.
- 2) Determine interfacing requirements of associated components and systems.
- 3) Establish the secondary gamma shield requirements based on functional requirements supplied by PNL.
- 4) Identify and evaluate conceptual arrangements that meet the design requirements.

3.0 STUDY RESULTS

3.1 FFTF TECHNICAL DOCUMENT REVIEW

The specific FFTF technical documents (see bibliography) applicable to a secondary gamma shield and interfacing or related systems or components are significant to this report in that they define the information in effect at the time this study was performed. The FFTF design is in the study phase; therefore, much of this information is tentative and subject to change.

Many aspects of the plant design, and operating modes and criteria are not completely defined; and for study purposes, a number of assumptions were required. Some typical examples follow.

- 1) To determine shielding thickness requirements, it was assumed that transfer of a fuel element through the gamma shield would be the limiting case. Using the then current reference fuel element design, a minimum cooling period (8 hr) was assumed and a shielding analysis was made. A major change in the fuel element design would require recalculation of the shield thickness. In addition, there are other radiation sources below the shield such as radioactive sodium and possible fission products in the closed loop piping.
- 2) The designs of the components in the gallery under the secondary gamma shield and their maintenance requirements are not fully established. In the study, it was assumed that as much maintenance as possible will be performed by working remotely through the shield and, wherever possible, the components such as piping joints and electrical connectors will be designed with mechanical disconnects that can be operated remotely. Ports for insertion of manipulators and viewing devices were therefore included in the design studies.
- 3) In the study it was assumed that there might be occasions when contact maintenance of equipment under the shield would be possible. Manways for personnel access were therefore included in the design study. The actual feasibility of contact maintenance, due to the undefined extent of the hazards of radiation and radioactive contamination, toxic atmosphere, sodium fire, etc., remains to be established.

TABLE 1
REACTOR GAMMA SHIELD DESIGNS AND REFERENCE DOCUMENTS

Shield	Documents	Gamma Shield Design Features					
		Support	Rotation Method	Indexing	Primary Shield Materials	FHM Shielding	Seals
EBR-11 Double Rotating Shield Plugs	ANL-5719 (Addendum) Hazard Summary Report - Jan. 1, 1964	Roller bearings	Electric motors	Automatic	Steel and concrete	Undefined	Bi-Sn freeze
ENRICO FERMI Single Rotating Top Plug	Hazards Summary Report, Section I, Reactor and Plant Design, Volume I	Ball bearings	Electric motors	Automatic	Steel and graphite	Lead, steel and depleted uranium	Elastomer
SRE Stationary Top Plug	AI Dwg 9693-70005	Solid step	Raised and rotated by crane	Visual	Steel, limo- nite, and concrete	Lead and steel	Bi-Sn freeze
HNPf Top Shield Stationary for Fuel Handling, Plugs Removed for Maintenance	AI Dwgs 7518-071301 through 7518-071330	Casters	Hydraulic	Visual	Steel, limo- nite, and concrete	Lead and steel	Bi-Sn freeze
DOUNREAY Inner and Outer Shield Plugs	Information Sheet Date - Jan. 1959 IAEA - Power R. Pages 185-190 and 301-306	Roller bearings	Electric motors	Undefined	Borated graphite mild steel, aluminum foil, and concrete	Undefined	Sodium
AI FBR Double Rotating Shield	AI-66-TDR-227 500 Mwe Fast Breeder Reactor Plant Description	Ball Bearings	Electric motor	Automatic	Steel, serpen- tine, and iron shot	Lead and steel	Undefined

Generally, a change in an information item on which this study is based, or an incorrect assumption, will not invalidate the results. For example; if it is later determined that 20 in. of equivalent lead shielding is required, instead of the 15 in. established in this study, all of the secondary gamma shield concepts developed would still be feasible.

3.2 STUDY OF OTHER REACTORS WITH TOP COVER SHIELDS

Table 1 shows the principal design features of the top shields of a number of existing sodium-cooled reactors and reactor concepts which include top cover shields.

Except for SRE and HNPF, all of the reactor designs require rotation and indexing of the shield for fuel transfer. On SRE and HNPF the fuel elements are individually suspended from removable small diameter plugs within the large top shields and shield rotation is required only for replacement of moderator elements or for other infrequent maintenance.

The FFTF secondary gamma shield is unique in that all of the reactors listed have only one shield (designated a primary shield) which performs the total shielding function, other than that provided by reactor coolant above the core, and the shields are part of the reactor atmosphere containment.

The significant variation in each of the design features tabulated indicates that the selection is highly dependent on the specific application. For FFTF design, therefore, this portion of this study can only indicate what has been done by others. Selection of specific design features must be based on study and evaluation of the various possibilities for applicability to the FFTF.

3.3 SUBSYSTEM REQUIREMENTS

- 1) The secondary gamma shield is a gamma barrier between the radioactive reactor components and the operating personnel. It shall provide gamma shielding in accordance with the following tentative conditions and requirements.*

*This list of tentative requirements was mutually agreed to by PNL and AI at the meeting in Canoga Park on May 11, 1967.

- a) One hundred mr/hr maximum at 3 ft above the top surface of the shield and 6 mr/hr maximum at the reactor floor area near the perimeter of the shield while the reactor is at full power. This is for coolant activity only and does not include contributions due to radiation from closed loop cross piping caused by ruptured fuel assemblies or fission products in the primary coolant (see Shielding Requirement e" below).
 - b) Six mr/hr at the surface of the shield while the reactor is shut down and coolant is circulating in the closed loop cross piping or with the cross piping drained. Exceptions are at areas of localized streaming through mating surfaces and structural members where weight limitations or undue design restraints are encountered. The design philosophy shall be to limit dose rate to 200 mr/hr at these local areas.
 - c) One hundred mr/hr at the surface of the shield during transfer of a fuel assembly from the reactor to the fuel handling machine. Exceptions are at areas of localized streaming through mating surfaces and structural members where weight limitations or undue design restraints are encountered. The design philosophy shall be to limit the dose rate to 200 mr/hr at these local areas.
 - d) One hundred mr/hr at the top surface of the floor valve when a shield plug and hanger tube are removed and a stuck and/or ruptured fuel element remains in the reactor tube.
 - e) Two hundred mr/hr due to radiation from the closed loop cross piping in the event of a ruptured fuel assembly which releases fission products into the closed loop coolant. Since this is an accident condition, if operation is to be continued, temporary localized shielding can be placed on the top surface of the secondary gamma shield to meet this requirement.
- 2) Access to the reactor nozzles must be provided through the secondary gamma shield. This includes access to valves or plugs that are supported on or are integral with the secondary gamma shield. The secondary gamma shield must also allow access for preparation for maintenance and replacement of cross piping and spool pieces while maintaining

an inert atmosphere in the nozzle region. The secondary gamma shield design must be versatile enough to permit all routine activities such as charge and discharge of fuel assemblies and experiments without removal of the shield; i.e., removal of the shield should be considered unusual and required for major maintenance or major experiments only.

- 3) The secondary gamma shield, with floor valve, will provide the target for positioning the fuel handling machine over each of the reactor nozzles. The design of the secondary gamma shield must include an indexing system for centering the shield floor valve over a designated open or closed loop nozzle. The fuel handling machine will then be positioned by the floor valve.

If the shield is movable, or has movable segments, bearings, or rollers-and-trackways, methods of driving-and-indexing must be considered in the design.

- 4) The secondary gamma shield shall be removable from the face of the reactor nozzle region in one piece or in sections. This is required for removal and replacement of cross piping and spool pieces. This operation will be performed remotely by use of hot cell equipment. Storage areas, removal fixtures, stands, and any other equipment required when the shield is not in its normal position shall be considered.
- 5) A gas tight seal is required for all joints, sliding and stationary, in the secondary gamma shield. Ease of replacement and methods for periodic or continuous leak check must be considered for each seal. Under normal operating conditions, the contained atmosphere will be an inert gas. The seals must prevent the spread of any contamination in this atmosphere to the reactor floor and surrounding areas.
- 6) The secondary gamma shield must provide internal blast and missile protection (presently unspecified). Incorporation of shield holddown devices shall be considered.
- 7) The secondary gamma shield must be capable of supporting applied loads such as the weights of floor valves, the FHM valve and skirt, maintenance equipment, and personnel. For conceptual design purposes, a load of

50,000 lb, applied at any location on the shield surface, shall be assumed. This is based on estimated weights of a floor valve plus the FHM valve and skirt.

- 8) The design of the shield should include cooling to prevent high temperature deterioration or excessive thermal stress in the shield. The temperature of the working face of the shield should not exceed that which will allow normal access for personnel (about 135°F). This would imply the need for temperature monitoring of the shield and shield coolant. Shield coolant leak detection and flow measurement must be considered.
- 9) The secondary gamma shield design shall provide for routing of electrical and gas lines to the reactor nozzle areas. These are required for fuel element and test loop instrumentation and for operation of floor valves, auxiliary tool casks, and maintenance equipment. It is desirable that this be accomplished in a manner that leaves the working face of the shield clear of obstructions.

4.0 ANALYSIS

4.1 SHIELDING ANALYSIS

The shielding analysis, performed as part of this study, was only that required to establish an approximate thickness of the secondary gamma shield for conceptual design. This analysis, see appendix, shows that the shield thickness required is 15.9 in. This 15.9 in. includes 13.9 in. of poured lead plus a 1-in. steel structural facing sheet at the top and bottom surfaces of the shield. The equivalent thicknesses for other shielding media such as lead shot or solid steel can be estimated by using tenth-thickness or density ratios with sufficient accuracy for conceptual design.

A comprehensive shielding analysis to verify complete conformance with the shielding requirements of Section 3.3, can only be performed after the shield design and the radiation source levels are defined in greater detail.

4.2 SECONDARY GAMMA SHIELD CONCEPTS

As the design study of secondary gamma shields for the FFTF progressed, two specific shield types evolved.

- 1) A rotating secondary gamma shield positioned above the reactor nozzle and pipe gallery. The rotating shield is a carryover from the FFTF skewed core concept. It provides gamma shielding over space required for closed loop cross piping at the periphery of the nozzle region. This is required if any of the outer open loop or driver fuel positions are converted to closed loops. It also provides a gallery for maintenance and nozzle region cleanup.
- 2) A stationary secondary gamma shield either positioned above the reactor nozzle and pipe gallery, or with gamma shielding provided as an integral part of the nozzles and reactor vessel cover. The stationary gamma shield was specifically derived for the split conical core concept.

The split conical core concept allows shielding to be placed around the nozzles and spool pieces because there are no closed loops in the driver fuel or open loop region.

*The amount of shielding required to lower the dose rate by a factor of ten.

4.3 ROTATING SECONDARY GAMMA SHIELD CONCEPTS

Three design study layouts of rotating secondary gamma shields (AI Dwg. No. SK-N68181063 through SK-N68181067) are included in this report. These three basic concepts are:

- 1) Split, rotatable, secondary-gamma shield,
- 2) Double, rotating, secondary-gamma shield, and
- 3) Multiple-plug, single-valve, rotating, secondary-gamma shield.

These layouts provide different approaches to accomplishing the requirements. (Many of the detail design features such as methods for rotation and drive, sealing, and methods for controlling the shield and gallery temperature can be interchanged among the concepts). Items that are typical of the rotating secondary gamma shield follow.

- 1) The shield structure is above the nozzle spool pieces, and a seal sleeve is required to adapt a floor valve to the reactor nozzle spool piece.
- 2) The shielding materials are common; i. e., steel, lead and/or depleted uranium.
- 3) The seals are conventional and can be engineered for the application. The types considered are elastomer O-rings, quad rings, and inflatable ring seals, bismuth-tin molten freeze seals and metallic mechanical seals.
- 4) The methods for providing rotation to the secondary gamma shield are: a large segmented roller or ball bearing, large wheels similar to those on a polar gantry, or flat roller wheels with outboard guide supports.

The shield can be driven through a ring gear attached to the circumference, or by powering the roller wheels, if this type of mounting is used.

5.0 ROTARY SECONDARY GAMMA SHIELD, CONCEPT I (SPLIT REMOVABLE) – SK-N68181063 GENERAL DESCRIPTION

The core- and nozzle-lattice arrangement assumed in developing this concept is similar to that of the PNL Split Core Reactor Arrangement I, SK-3-12766, and the PNL Core Concept III SK-3-12767. This concept followed the original ground rule that all nozzles, open and closed loops, driver fuel, and experiments must have the capability of being converted into a closed loop assembly. The secondary gamma shield must, therefore, have clearance completely around the nozzles for closed loop cross piping. Also, all spool pieces have instrumentation leads that disconnect at the nozzle and at the periphery of the gallery. For this concept, the control rod drives are shown with the complete assembly under the secondary gamma shield.

This rotating shield has two eccentrically located inner rotating plugs with integral floor valves. By appropriate orientations of the main shield and one of the inner plugs, a floor valve can be aligned over any reactor position.

The body of the shield is split in an off center plane passing between the two inner rotating plugs, and the larger segment is removable. The methods proposed for removal of the section are use of: (1) a lifting dolly arrangement by which the shield section is lifted vertically and then moved horizontally, or (2) a clamshell arrangement by which the shield section is hoisted into a vertical position with the in-cell hoist.

Only the larger section need be removable because the remaining section of the shield can be rotated on its bearing and thereby uncover any area of the gallery. The removable section weighs approximately 120 tons; this is about 60% of the total shield weight. A single inner rotating plug arrangement is also possible with the split rotating shield, Concept II. With the single inner plug, the split plane is further off-center and the weight of the removable section is increased to approximately 135 tons.

Ports for installation of manipulators, viewing devices, etc., can be provided for remote maintenance of equipment for working through the shield. Manways can also be provided to allow contact maintenance with the shield in place when radiation levels under the shield permit.

5.1 PRINCIPLES OF OPERATION

For alignment of a floor valve to a prescribed nozzle, the inner plug and large shield are rotated to the required position and centered by using visual or automatic methods. Of importance in the double rotating concept, is the ability to align with any nozzle even though thermal distortions may have changed the exact position of the nozzle. When the valves are aligned, they provide a target for the auxiliary equipment or fuel handling machine.

The shield rotates on a ball bearing assembly approximately 24 ft in diameter and is actuated by an electrical drive system with a spur gear that drives a segmented bull gear mounted on the periphery of the rotating shield. This type of drive mechanism can be designed into the reactor system so that it would be readily accessible for maintenance. However, the ball bearing assembly, as shown, would require complete removal of the secondary gamma shield for maintenance or replacement.

The secondary gamma shield has a removable section to provide access for major maintenance. This section comprises approximately 60% of the shield area and, when it is removed, provides access to one-half of the nozzle region and the row of closed loops. This section is removed by either a rollaway method or by tilting the section up to the hot cell wall. For the rollaway concept, the shield section is unbolted from the main assembly and a U-shaped trolley is rolled into position. Jack pads are attached to jacks on the trolley and all necessary preparations are made in the hot cell prior to evacuation of personnel. All subsequent operations are performed remotely from outside of the hot cell. The shield section is raised by actuating the jacks, and the trolley is rolled away from the nozzle region by either a drive system on the trolley or a cable system operated by the overhead hot cell crane. The removable section weighs approximately 120 tons. The nozzle region is now available for hot cell maintenance and replacement operations. The tilt up method is similar except a wall mounted structure would tilt the removable shield section into a vertical position for access to the nozzles.

The remaining section of the shielding is rotated to provide access to any area in the nozzle region. This assembly must be indexed to the original position for replacement of the removable section.

Since the secondary gamma shield is located over the top of the control rod drives, there is approximately 5 ft of space over the nozzles and additional space at the periphery of the nozzles. With the large amount of space under the shield, auxiliary maintenance and cleaning equipment can be positioned on the shield floor valve and travel through the valve into the gallery. Viewing and lighting equipment can also be designed to operate through the existing valves or through special parts.

If the reactor has been shut down for an extended period of time such that contact maintenance is feasible, personnel access to the pipe gallery and nozzles could be possible through manways that can be designed into the shield.

5.2 SHIELDING MATERIALS

The shielding materials are 1-1/2 in. of stainless steel on top and bottom, and 13.25 in. of solid lead poured or assembled into the egg crate structure. The shielding under the valves is depleted uranium. Depleted uranium is used to meet the shielding requirement where reduced thickness is required.

5.3 STRUCTURE ANALYSIS

This concept was not analyzed for structural stability because of the complexity at the shield split line. An analysis would be similar to the study done for Concept II (Dwg SK-N68181064) except for the structural requirements between the rotating plugs and the split line.

5.4 SEALS

The seals used for maintaining an inert atmosphere under the rotating secondary gamma shield in each concept are in general similar. In this split concept however, the seal is between the removable section and the main body. This seal would be irregular in shape. It should have double seals with a buffer zone between them for evacuation during seal check. During reactor operation, the buffer zone must be pressurized slightly higher than the internal inert atmosphere under the shield. This can be monitored continuously to verify seal effectiveness.

More sliding seals must be installed and maintained for this shield than for the other rotating secondary gamma shields. These seals would probably be of

the inflatable type with full internal pressure applied during static conditions and a light pressure applied during seal sliding.

The floor valves have seals similar to the type used on the Fermi fuel handling system. These also have double seals with leak check capabilities.

5.5 SHIELD COOLING

The method shown for maintaining this secondary gamma shield at an acceptable temperature is by insulation of the closed loop cross piping and circulation of gallery atmosphere through cooling radiators located within the gallery or at an external location.

5.6 CONCEPT EVALUATION

The following are advantages and disadvantages of this concept.

5.6.1 Advantages

- 1) All spool pieces and cross piping are accessible to hot cell manipulators and overhead hoists with a portion of the secondary gamma shield removed.
- 2) The large roller bearing remains a complete assembly with the shield section removed.
- 3) The section of secondary gamma shield remaining on the large bearing can be rotated to any position for complete access to the nozzle region.
- 4) Floor valves may be removed for maintenance by plugging the port in the small rotating shield.
- 5) The shield transfer dolly may be disassembled and stored when not in use.
- 6) If hot cell floor space is limited, the removable section of shield may be tilted up on the wall as shown in Zone 11, Dwg. SK-N68181063.
- 7) The floor valve can be positioned and aligned with any spool piece position even though the nozzle may have been mislocated during fabrication or moved because of thermal distortion.

- 8) All indexing of the secondary gamma shield valve to the reactor spool pieces utilizes direct viewing devices.

The direct viewing devices can be used by operating personnel standing on the secondary gamma shield, or remotely by use of T.V.

5.6.2 Disadvantages

- 1) The split in the secondary gamma shield makes the structural design difficult.
- 2) The complete secondary gamma shield must be removed for maintenance of the large bearing, or the large bearing must be designed so it can be removed in sections.
- 3) Removal of one split section of the shield creates an uneven load on the bearing.
- 4) Maintainable seals must be provided between the basic shield and the removable section.
- 5) This concept requires a long reach from the floor valve to the nozzles.
- 6) In practically all reactor component or experiment transfers, only one nozzle can be serviced at a time. The seal sleeve between the floor valve and nozzle piece must be removed to allow rotation of the secondary gamma shield.

DISADVANTAGES

- 1 THE SPLIT IN THE SECONDARY GAMMA SHIELD MAKES THE STRUCTURAL DESIGN MORE DIFFICULT
- 2 DUE TO THE DIAMETERS REQUIRED FOR EACH SMALL ROTATING PLUG THE DIMENSION BETWEEN THEM IS LIMITED. THIS MAY NECESSITATE THE USE OF ONE SMALL ROTATING PLUG ONLY AS SHOWN IN ZONE II.
- 3 MAINTAINABLE SEALS MUST BE PROVIDED BETWEEN THE BASIC SHIELD AND THE REMOVABLE SECTION.
- 4 REMOVAL OF ONE SPLIT SECTION OF SHIELD CREATES AN UNEVEN LOAD ON THE BEARING TRUCK.
- 5 THE COMPLETE SECONDARY GAMMA SHIELD MUST BE REMOVED FOR MAINTENANCE OF THE LARGE BEARING OR THE LARGE BEARING MUST BE REMOVABLE IN SECTIONS.

ADVANTAGES

- 1 ALL SPOOL PIECES AND CROSS PIPING ARE ACCESSABLE TO HOT CELL MANIPULATORS AND OVERHEAD HOISTS WITH A MINIMUM OF THE SECONDARY GAMMA SHIELD REMOVED
- 2 THE LARGE ROLLER BEARING REMAINS A COMPLETE ASSEMBLY WITH THE SHIELD SECTION REMOVED
- 3 THE SECTION OF SECONDARY GAMMA SHIELD REMAINING ON THE LARGE BEARING CAN BE ROTATED TO ANY 360° POSITION FOR ACCESSABILITY TO THE NOZZLE REGION.
- 4 FLOOR VALVES MAY BE MAINTAINED BY PLUGGING THE PORT IN SMALL ROTATING SHIELD AND LIFTING THE VALVE AS A UNIT FOR REPAIR OR REPLACEMENT.
- 5 SHIELD TRANSFER DOLLY MAY BE DISASSEMBLED AND STORED BETWEEN USAGE.
- 6 IF HOT CELL FLOOR SPACE IS LIMITED THE REMOVABLE SECTION OF SHIELD MAY BE TILTED UP ON THE WALL AS SHOWN IN ZONE II.

NOTES

1. STATIC SEALS WILL BE SILICONE O-RING OR QUAD RING SEALS WITH MAXIMUM TEMPERATURE OF 480°F.
2. ROTATING SEALS MAY BE INFLATABLE TUBES, O OR QUAD RINGS ON SMALL DIAMETERS OR CHEVRON PACKING TYPE SEALS. THE LARGE DIAMETER SEAL IS A BISMUTH-TIN MOLTEN AND FREEZE SEAL. SEE A1 DWG SK-N68181064 FOR CONCEPT.
3. SHIELD COMPONENTS WILL BE SECURED TO MEET REQUIREMENTS FOR NOZZLE BLAST AND MISSILE CONTAINMENT.
4. SEE A1 DWG SK-N68181064 FOR METHODS OF COOLING THE SECONDARY GAMMA SHIELD.
5. ACCESS TO THE SPOOL PIECE ASSEMBLIES IS PROVIDED BY FLOOR VALVES ON THE INNER ROTATING PLUGS.
6. ACCESS TO THE CROSS PIPING & NOZZLE SPOOL PIECES IS PROVIDED THRU THE FLOOR VALVES AND AUXILIARY PLUGS. MANIPULATORS AND VIEWING EQUIPMENT IS USED FOR CONNECTING & DISCONNECTING FITTINGS. THE EQUIPMENT REQUIRED WILL BE INSTALLED USING AUXILIARY CRANES AND WILL MAINTAIN AN INERT ATMOSPHERE UNDER THE SHIELD.
7. A BORE SIGHT OR COLLIMATING DEVICE WILL BE USED TO CENTER THE FLOOR VALVE OVER THE NOZZLE FOR FUEL TRANSFER.
8. THE CORE & NOZZLE LATTICE USED IN THIS CONCEPT IS SIMILAR TO PNL SPLIT CORE REACTOR ARRANGEMENT I, SK-3-12766 AND PNL SPLIT CORE CONCEPT III, SK-3-12767.
9. SECONDARY GAMMA SHIELD HOLD DOWN MECHANISMS ARE NOT SHOWN ON THIS CONCEPT. THESE CAN BE SHOWN AFTER DBA REQUIREMENTS ARE DEFINED.
10. WITH CONTROL ROD JACKS AS SHOWN, AN ADDITIONAL LENGTH IS REQUIRED FOR VALVE TO SPOOL PIECE SEAL SLEEVE. THIS ALSO ADDS AN ADDITIONAL REQUIREMENT TO THE LENGTH OF THE FUEL HANDLING MACHINE SNOCKEL.
11. SINGLE OR DOUBLE INTERNAL ROTATING PLUG ARRANGEMENT AND SHIELD REMOVAL METHODS ARE INTERCHANGEABLE.

SEQUENCE OF OPERATION (SHIELD REMOVAL)

1. ALL FITTINGS FOR SPOOL PIECE REPLACEMENT & MAINTENANCE IN THE NOZZLE REGION ARE TO BE PREPARED FOR HOT CELL WORK.
2. SECONDARY GAMMA SHIELD IS ROTATED TO AN INDEXED POSITION FOR ALIGNMENT WITH THE SHIELD REMOVAL DOLLY.
3. PICKUP BRACKETS ARE PLACED ON AND SECURED TO THE SHIELD.
4. DOLLY IS PLACED ON THE RAILS (IF IT HAS BEEN IN A STORED LOCATION) AND ROLLED INTO POSITION.
5. ALL INTERCONNECTING LINES (ELECTRICAL, AIR & GAS) BETWEEN THE SHIELD SECTIONS ARE DISCONNECTED.
6. BOLTS OR OTHER CLAMPING MEDIA (ON THE SHIELD SECTION TO BE REMOVED) ARE RELEASED.
7. HOT CELL IS PREPARED & EQUIPMENT TO BE USED IS GIVEN OPERATIONAL CHECK. PERSONNEL ARE EVACUATED FROM THE CELL.
8. FROM A REMOTE CONTROL STATION, THE DOLLY JACKS RAISE THE SHIELD AND THE DOLLY MOVES THE SHIELD SECTION OUT OF POSITION, THUS ALLOWING HOT CELL MANIPULATORS TO WORK IN THE NOZZLE REGION.
9. THE PROCEDURE IS REVERSED FOR RELOCATING AND SECURING THE SECONDARY GAMMA SHIELD, AFTER HOT CELL OPERATIONS ARE COMPLETED.

CONCEPT

THIS CONCEPT INCORPORATES THE USE OF TWO ROTATING PLUGS (WITH VALVES) IN A ROTATING SECONDARY GAMMA SHIELD. FOR ACCESS TO THE NOZZLE REGION UNDER THE SECONDARY GAMMA SHIELD, A SECTION (APPROXIMATELY 60% OF THE SHIELD) IS RAISED BY JACKS MOUNTED ON A DOLLY. THE DOLLY CARRIES THE SHIELD TO AN AREA ADJACENT TO THE NOZZLE REGION. THE SHIELDING WILL BE LEAD & STEEL WITH DEPLETED URANIUM USED WHERE THICKNESS IS REDUCED.

ALTERNATE CONCEPT OF THE SPLIT SECONDARY GAMMA SHIELD (ZONE 10) USES A FLOOR MOUNTED TRUNNION & FIXTURE TO TILT UP THE SHIELD SECTION (CLAM SHELL).

ANOTHER ALTERNATE (NOT SHOWN) IS A STRAIGHT PICK UP OF THE SECONDARY GAMMA SHIELD SECTION USING THE HOT CELL CRANE-HOIST.

NAA-SR-MEMO-12586 Page 31 Sheet 1 of 3

DESIGN STUDY NO.1

ATOMIC INTERNATIONAL A DIVISION OF NORTH AMERICAN AVIATION, INC. 8700 DESOTO AVENUE, CANOGA PARK, CALIF.	
SECONDARY GAMMA SHIELD SPLIT-REMOVABLE CONCEPT	
DRAWN BY: <i>[Signature]</i> CHECKED BY: <i>[Signature]</i> APPROVED BY: <i>[Signature]</i>	DATE: <i>10/1/63</i> SCALE: <i>1/4" = 1'-0"</i> SHEET NO. <i>31</i> OF <i>31</i>

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REVISIONS			
SYM	ZONE	DESCRIPTION	DATE APPROVED

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THIS DRAWING PROVIDES 3 ALTERNATIVE
BEARING TYPE CONCEPTS FOR ROTATION
OF SECONDARY GAMMA SHIELD

NAA-SR-MEMO-12586 Page 33 Sheet 1 of 3

DESIGN STUDY NO.4

SECONDARY SHIELD BRG-TYPE DRIVE #1
SEGMENTED GEAR RING

0 1 2 3 4 5 6 7 8
SCALE (INCHES)

ATOMICS INTERNATIONAL			
A DIVISION OF NORTH AMERICAN AVIATION, INC. 5900 DESOTO AVENUE, CANOGA PARK, CALIF.			
ROTATING SECONDARY GAMMA SHIELD BEARING & DRIVE CONCEPTS			
DRAWN	M. MYERS	1/2	DWG. J
CHECKED	J. J. JONES	1/2	SIZE
ENGINEER	D. H. JONES	1/2	SCALE
APPROVED		1/2	SHEET NO. 33

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6.0 ROTATING SECONDARY GAMMA SHIELD CONCEPT II, DOUBLE ROTATING PLUG (SK-N68181064)

This concept employs the use of a double rotating plug with one floor valve in the inner plug. This valve provides access to all reactor nozzles by double rotation of the top shield and the eccentric inner plug. Manipulators and viewing devices are operated through the shield to prepare spool pieces and cross piping for maintenance or replacement. An inner ring with an internal plug is raised and removed from the nozzle region to provide access for major maintenance of the nozzles and cross piping. This design study was based upon a reactor concept which included the need and ability to provide closed loops at the periphery of the nozzle region and maintainable instrumentation leads at each nozzle.

6.1 PRINCIPLES OF OPERATION

The secondary gamma shield spans the nozzle area and the pipe gallery. An outer ring assembly with rollers and drive assembly provides rotation of the entire shield. This drive assembly is similar to that of a polar gantry. The outer ring is designed for a large-diameter (approximately 25-ft) plug. The plug rests on a shoulder at the inside diameter of the ring. Off center and inside of the 25-ft plug is a 10-ft diameter rotating plug. This plug has an integral floor valve for access to the reactor nozzles. The floor valve can be positioned over any nozzle by rotation of the large shield and the inner plug. Final alignment is verified using viewing devices or electronic alignment equipment. Auxiliary casks and auxiliary equipment⁽¹⁾ are positioned on the floor valve to prepare the nozzle spool piece for the fuel handling machine. Minor maintenance and preparation for major maintenance of components under the secondary gamma shield are performed through the shield. Visual equipment (boroscope or TV) is inserted through the shield as shown on SK-N68181064, Sheet 3. Manipulators are inserted in a similar manner using auxiliary equipment. The gallery has lights that are either inserted through the shield or are permanently attached to the wall of the gallery.

6.2 MATERIALS

The shield materials are stainless steel plate for the exterior and cross member (egg-crate) structure, with lead shot and depleted uranium as the basic

gamma shielding. To meet the shielding requirement of 15 in. of lead equivalent, 21 in. of lead shot and 3 in. of steel are assumed. This was derived by using 1 in. of steel as the equivalent to 0.66 in. of solid lead and lead shot with a 60% packing fraction. Lead shot was chosen for the 24-in. thick shield (established by structural considerations) so that all voids will be filled; i.e., if 13-in. of solid lead were used there would be a void at the top or bottom of the shield. Depleted uranium is used for shielding under the floor valves and other areas where the thickness is reduced.

The shield structure would be fabricated and transferred to the reactor site and the depleted uranium and lead shot added during or after shield installation. The shielding thicknesses used were derived from the shielding analysis performed as part of this study, see appendix.

6.3 STRUCTURAL ANALYSIS

The structural integrity of this concept was analyzed for stability and load carrying capabilities. Two cases were studied, (1) an applied load of 50,000 lb, a condition that would exist if the weight of the fuel handling machine, valve, and drip pan assembly or a shielded auxiliary tool cask were placed on the shield, (2) an applied load of approximately 300,00 lb, a condition that would exist if the complete fuel handling machine was set upon the top of the shield.

The shield is a slightly curved composite plate, 24 ft in diameter and 24 inches in depth. The interior rotating plug is eccentrically located and has a 10-ft diameter. The composite plate is made of 1-1/2-in. stainless steel top-and-bottom plates and an 18-in. square grid of 1-in. thick webs. The cells of this structure are filled with a 21-in. depth of lead shot. The concentrated load acts at the rim of the 10-ft plug. Due to the rotation of the 10-ft plug, this load does not have a fixed location.

The structure is complex and a rigorous stress analysis was not necessary to establish the concept feasibility. Therefore, the eccentricities of the 10-ft plug and the concentrated load were neglected for an approximate flexural analysis. The contribution of the web plate to the flexural rigidity of the entire plate was also neglected. Results of this approximate analysis are:

Case I: Concentrated load $P = 50,000$ lb,
Uniform load = $1,074$ lb/ft² (shield weight),
Max. bending stress at the edge of plug, near the center of the
plate = $13,134$ psi,
Max. shearing stress with concentrated load at outer edge of
the plug = $4,767$ psi, and
Max. deflection at the center = 0.0041 in.

Case II: Concentrated load = $250,000$ lb,
Uniform load = $1,074$ lb/ft² (shield weight),
Max. bending = $19,140$ psi,
Max. shearing stress = $14,683$ psi, and
Max. deflection at the center = 0.087 in.

According to the "ASME Boiler and Pressure Vessel Code Section III, Nuclear Vessels," the maximum allowable bending stress and shearing stress are $30,000$ and $15,000$ psi respectively, for SA240-304 steel plate. The calculated stresses in both cases are well below these limits.

6.4 SEALS

Bismuth-tin molten freeze seals, elastomer O-rings, and inflatable seals can be used. The large diameter seal is shown on Dwg. SK-N68181064, Sheet 3 as a bismuth-tin molten freeze seal with the trough located at the inside stationary wall of the pipe gallery and the tang assembly mounted on the rotating shield. The molten-freeze seal has been used on various reactors as shown in Table I. The EBR II had some difficulty in maintaining the seal during reactor operation. For this case, the seal was secured by freezing at the top and maintaining the bismuth-tin molten at the bottom.⁽²⁾ Difficulties were also experienced at the SRE. It was concluded that the tinning process on the steel trough and tang is very important. A similar seal was installed on the Fermi reactor but has never been used because the backup elastomer seals have met the sealing requirements.

The molten seal, as shown in this concept, has the disadvantage of poor accessibility. In the event of heater failure, additional heat would be required and would have to be applied from under the shield before the secondary gamma shield could be rotated. Also, replacement of heater elements or components would be difficult.

Additional seals for this concept include static seals for the large inner plug and the gate valves and inflatable rotating seals for the 10-ft diameter internal rotating plug. The large plug and the valves have double stationary seals with leak check and backup pressure capabilities. These seals could be either (or combinations of) O-rings, quad rings, or inflatable types (as shown on Dwg. SK-N68181064).

6.5 SECONDARY GAMMA SHIELD COMPONENTS

This concept incorporates the use of large roller wheels as the means of rotation. Such an approach is typical for large polar cranes and for rotating bases on boom cranes. Overhead polar cranes of similar concept have been used at the Fermi Reactor and the Piqua Nuclear Power Facility. The polar crane at the Enrico Fermi Atomic Power Plant can be positioned within a thirty-second of an inch for any trolley position. These polar cranes are designed for remote operation.

Sheet 2, SK-N68181064, shows a conceptual design of the floor valve and the inner plug. The valve is similar to the floor valve used with the Fermi Reactor (Ref. AI Dwg. No. 7026-HM095). Double seals with leak check capability are provided. The inner plug can be lowered onto the outer plug shoulder during bearing and inflatable seal maintenance. The gallery pressure may be retained with the inflatable seals during plug bearing maintenance or removal. Additionally, the inflatable seals may be removed without removing the plug bearing.

The rotary turntable bearing has gear teeth (No. 3 pitch) on the external ring. It has approximately 528 gear teeth and has a 167.5-in. pitch diameter. The dynamic capacity of the bearing in thrust is 900,000 lb.

6.6 SHIELD COOLING

Cooling coils (containing nitrogen or non-hydrogenous liquid coolant) are used for cooling the shield and the inert gas under the shield. The gallery

atmosphere is circulated through cooling radiators located within the gallery or at an external location. These methods are presented for consideration but final selection requires thermal analysis and further study.

6.7 GALLERY MAINTENANCE

Closed loop cross piping, instrumentation leads, and shield components in the gallery can be maintained by manipulators inserted through the top shield. See Sheet 3 of 3, Dwg. SK-N68181064. Removable plugs in the gamma shield are replaced by use of manipulators and viewing equipment. Reactor personnel operate the manipulators while standing on the shield. Pipe joints and electrical disconnects can be parted or secured by use of the manipulators for major maintenance. Cleaning or minor maintenance operations can also be performed. TV or boroscope devices can be located to set up cross pattern viewing.

The manipulators and viewing devices provide methods of preparing the pipe gallery for maintenance with the secondary gamma shield in place. For closed loop cross piping and nozzle replacement, the secondary gamma shield must be completely removed. The concept for removal and replacement of the secondary gamma shield incorporates the use of a gantry structure within the reactor hot cell. This gantry structure is assembled on the fuel handling machine gantry tracks when required. Linear actuators (100 ton jacks) all driven by a common drive system, provide the lifting force.

After the secondary gamma shield and the reactor components have been prepared for maintenance or replacement, the gantry is positioned over the shield and the linear actuators are attached to pads on the shield. With all necessary preparations taken for the removal of the secondary gamma shield, personnel are evacuated from the hot cell. The shield is then raised and rolled out of position. All maintenance work is accomplished remotely using the hot cell manipulators and cranes.

Long term shutdown may make contact maintenance under the secondary gamma shield possible. Access manways through the shield can be provided. Due to their infrequent removal, the manway plugs could be secured and sealed by welding.

6.8 CONCEPT EVALUATION

Following is a list of advantages and disadvantages of the double rotating concept.

6.8.1 Advantages

- 1) One inner rotating plug, with floor valve, is capable of providing access to all spool pieces for fuel transfer.
- 2) The floor valve can be positioned and aligned with any spool piece position even though the nozzle may have been mislocated during fabrication or moved because of thermal stresses.
- 3) Access is provided to the closed loop cross piping and instrumentation by use of manipulators and viewing devices that operate through the secondary gamma shield.
- 4) Floor valves may be removed for maintenance by plugging the port in the small rotating shield.
- 5) The shield transfer dolly may be disassembled and stored when not in use.
- 6) The manipulators can be used to clean the pipe gallery.
- 7) All indexing of the secondary gamma shield valve, to the reactor spool pieces, utilizes direct viewing devices. The devices can be used by operating personnel standing on the secondary gamma shield or remotely by use of TV.
- 8) Additional small diameter ports can be provided in the shield for test monitoring. These ports would be located at specific core positions.

6.8.2 Disadvantages

- 1) One complete fuel transfer operation or cycle must be completed at any one nozzle before the shield can be moved to a new position because only one valve can be used.
- 2) A large diameter section (approximately 24 ft in diameter and weighing approximately 200 tons) must be removed from the top face of the reactor for replacement of the spool pieces and closed loop cross piping. Also,

floor space for storage must be provided in the hot cell during gallery component maintenance or replacement.

- 3) The control drives must be located under the shield. Maintenance or replacement must be performed through the floor valve and requires inert atmosphere tooling casks. This will be very time consuming, cannot be performed concurrent with fuel handling, and will tend to increase reactor down time. Another drawback to location of the drives under the shield is that their height must be limited to that of the nozzles or the gamma shield must be raised, increasing the reach requirement of the fuel handling system.

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NOTES:

- 1 THE CONCEPTUAL VALVE SHOWN IS SIMILAR TO THE FLOOR VALVE USED WITH THE FERMI REACTOR (REF AT DWG # 7026-HM095)
- 2 ALL SEALS ARE DOUBLE WITH A PURGE OR EVACUATION CHAMBER BETWEEN FOR PRESSURIZING OR LEAK CHECKING
- 3 ROTATING PLUG CAN BE LOWERED TO REST ON GAMMA SHIELD SHOULDERS DURING BEARING AND INFLATABLE SEAL MAINTENANCE
- 4 GALLERY SEAL PRESSURE CAN BE RETAINED WITH INFLATABLE SEALS DURING TURRET BEARING MAINTENANCE OR REMOVAL
- 5 INFLATABLE SEALS MAY BE REMOVED WITHOUT REMOVING TURRET BEARING

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 CARLSBAD, CALIF. 92008
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 SK- N68181064

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 ENGINEER BY: J. J. JONES
 APPROVED BY: J. J. JONES
 DATE: 1/22/64
 SHEET NO. 2 OF 3
 NAA-SR-MEMO-12586
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OSTI ID: 000021950

7.0 ROTATING SECONDARY GAMMA SHIELD CONCEPT III, MULTIPLE-PLUG, SINGLE-VALVE (SK-N68181065)

This concept incorporates multiple ports in a rotating secondary gamma shield. The shield covers the nozzle region and pipe gallery as did the concepts discussed previously. For access to a reactor nozzle, an independent floor valve is placed over the appropriate port, the shield plug is removed, and the port and valve are aligned with the nozzle by rotation of the shield. A seal sleeve inserted between the floor valve and the nozzle isolates the gallery atmosphere from that of the nozzle, floor valve, and equipment connected to the floor valve.

The core arrangement shown in the drawing for this concept is Split Core Concept III (PNL Dwg. No. SK-3-12767).

7.1 PRINCIPLES OF OPERATION

The large top shield is rotated to a position in which a predetermined secondary gamma shield port is aligned with the desired reactor nozzle. A plug cover plate is removed from the shield and the floor valve adaptor plate is positioned on the secondary gamma shield by use of the overhead hoist. The floor valve is then placed on the adaptor plate and the seals are checked for leak tightness. An auxiliary tool cask is used to remove the gamma shield plug and to install an adaptor seal sleeve between the floor valve and the reactor spool piece. The auxiliary equipment, previously mentioned, is also used to prepare the reactor spool piece and fuel assembly components for fuel transfer.

Because of space limitations and the diameter (15-in.) of the multiple plugs, an eccentric rotatable plug is required for reactor center positions. This rotatable plug is required for reactor center positions. This rotatable plug, with eccentric port, is perpendicular to the center row of closed loops. For repositioning, it must be picked up, by use of the hot cell overhead hoist, and rotated to an indexed position. The plug is raised a short distance (less than one inch) and rotated manually without losing the inert gas seal. This rotatable plug accommodates all of the closed loop positions and 4 of the driver fuel positions. Instrument feedthrough ports for the 3 center closed loops can be built into the rotatable plug.

7.2 SHIELDING MATERIALS

The shielding materials selected for this concept are 1-1/2 in. of stainless steel plate on top and bottom, 13 in. of solid lead in the exterior shielding ring, and 18 in. of lead shot in the multiple plug center section. The floor valve and adaptor plate are not built into the shield; therefore, this concept does not require the use of depleted uranium. The 13 in. of solid lead in the external shield rings is located at the bottom so that the space above can be used for electrical leads, gas lines, and hoist pickup blocks.

7.3 STRUCTURAL ANALYSIS

No structural analysis was performed for this specific concept. From the structural standpoint, the concept is similar to those discussed previously and it can be assumed that the required loads can be accommodated.

7.4 SEALS

All sliding or stationary seals can have provisions for leak checking by use of double seals with an evacuation chamber or buffer zone between them.

This concept has the advantage that all seals, except the large rotating seal, are stationary and circular. These seals are located so they can be elastomer O-rings or quad rings.

The large rotating seal is a bismuth-tin molten freeze seal with a backup inflatable seal as shown on Dwg. SK-N68181066. The molten freeze seal arrangement shown with this concept is more realistic than that previously discussed because the seal is on the outside of the shield and would be accessible for maintenance and heater replacement. Also, localized heat could be applied if required. The backup inflatable seal would be fully pressurized during reactor operation and maintained at a light pressure during secondary gamma shield rotation. For this concept, the molten-freeze seal trough rotates and the heater tank remains stationary.

7.5 SECONDARY GAMMA SHIELD COMPONENTS

The secondary gamma shield is rotated by driving a support wheel. Alternate arrangements are shown on AI Dwg. SK-N68181065. For concept purposes, one side of the design layout shows rollers mounted on the floor and the

track mounted on the rotating secondary gamma shield. The other side on AI Dwg. SK-N68181066 shows the rollers and drive system attached to the secondary gamma shield and the track on the floor.

If 220 tons is used as the estimated total weight of the secondary gamma shield, roller assemblies would provide adequate support. The wheels are flat and ride on a hardened track. The shield is retained on center by guide rollers on the outer race of the roller track.

Thirteen plugs, 15 in. in diameter, are located at specific radial distances from the center of the shield. They are shown to be 15 in. in diameter to provide the capability of handling closed loops located at any core location. As defined in later core arrangements, closed loops would be in a center row only, and all but the center plug could be reduced in diameter. When the shield is positioned as shown on Dwg. SK-N68181065, or when rotated 180°, all of the 13 plugs are aligned over a reactor nozzle. In almost all other positions only one plug aligns over a reactor nozzle.

All 15-in. diameter plugs have a cover plate. This cover plate is flush with the top surface of the secondary gamma shield. When this plate is removed, a seal area and locating surface is provided for a floor valve adaptor plate.

The sequence in preparing for a fuel transfer is:

- 1) The shield is rotated until a part is positioned over the desired reactor nozzle,
- 2) The plug cover plate is removed,
- 3) A floor valve adaptor plate is positioned on the secondary gamma shield (overhead hoist used),
- 4) The floor valve (14,000 lb) is positioned on the valve adaptor plate,
- 5) All seals are checked for leak tightness,
- 6) An auxiliary tool cask is used to remove the shield plug and install the seal sleeve, and
- 7) An auxiliary tool cask is used to prepare the spool piece for fuel transfer.

7.6 SHIELD COOLING

The proposed method of maintaining this secondary gamma shield at an acceptable temperature is by circulation of gallery atmosphere through cooling radiators located within the gallery or at an external location. The closed loop cross piping should be insulated. Cooling coils could be built into the shield as shown in Concept II.

7.7 GALLERY MAINTENANCE

Three basic approaches can be used for maintenance or replacement of components within the gallery.

1) Hot cell approach

The large central plug and one or both of the ring elements of the shield, each weighing approximately 65 tons, can be removed by the 100-ton hot cell crane to allow use of the hot cell facilities.

2) Through-the shield approach

Manipulators and special tools can be operated through one or more of the 13 ports in the center segment, or through ports provided in the outer ring segments of the gamma shield.

3) Contact approach

Manways in the outer ring segments of the gamma shield provide for personnel access to the gallery for contact maintenance when the reactor shutdown period is long enough to reduce the radiation level in the gallery to acceptable levels.

7.8 CONCEPT EVALUATION

The following is a list of advantages and disadvantages of the rotating secondary gamma shield multiple plug-single valve concept.

7.8.1 Advantages

- 1) The floor valves are not required during reactor operation and can be serviced in a maintenance area during this time.
- 2) The hot cell crane hoist can be utilized for removing the secondary gamma shield. This alleviates the need for a large gantry structure for shield transfer.

- 3) With the secondary gamma shield in position for reactor operation, special equipment or instrumentation can project through special ports in the secondary gamma shield into the open loops.
- 4) Viewing and manipulating equipment can be placed through the secondary gamma shield as shown on AI Dwg. SK-N68181064, Sheet 3.
- 5) Except for the large diameter seal between the shield and foundation, all seals are static.
- 6) Portions of the shield can be removed for maintenance in the gallery by using hot cell facilities.

7.8.2 Disadvantages

- 1) In practically all reactor component or experiment transfers, only one nozzle can be serviced at a time. The seal sleeve between the floor valve and nozzle spool piece must be removed to allow rotation of the secondary gamma shield.
- 2) The floor valve must be transferred from nozzle to nozzle by use of the hot cell crane hoist or other special equipment. Since the transfer of the floor valve requires the use of the hot cell hoist, systematic cycling may be delayed if waiting periods are required because the hoist is in use.
- 3) Electrical and gas lines leading to the floor valve must lay on the secondary gamma shield during fuel system transfer operations. These lines will probably require an armored protective covering.
- 4) A difference in thermal expansion between the secondary gamma shield and the reactor vessel may occur during both reactor operation and reactor down time. The resulting misalignment between the secondary gamma shield ports and the reactor spool pieces will require a flexible and adjustable spool piece seal sleeve or adjustment of the floor valve position over the port.
- 5) The floor valve seals and adaptor plate seals must be broken, resealed, and checked with each valve transfer.

ALTERNATE ADAPTATION TO THE ROLLER SHOWN IN ZONE 3A IS ROLLERS MOUNTED FROM THE FLOOR AND A TRACK MOUNTED ON THE ROTATING SECONDARY GAMMA SHIELD.

TROUGH FOR ELECTRICAL & GAS LINES

21"

15" LEAD

15" ON CENTER
EGG CRATE CONSTRUCTION

SEAL CHECK (TYP)

SEAL SLEEVE (TO PROVIDE SEAL BETWEEN FLOOR VALVE AND REACTOR SPOOL PIECE)

15 PLATE (TYP)

1 EGG CRATE STIFFENERS
PLUG COVER PLATE

15 MAX DIA PLUG

15 LEAD SHOT

SEE DISADVANTAGES #11

FLOOR VALVE

ADAPTER PLATE WITH REST PADS

VIEW B

THIS VIEW SHOWS FLOOR VALVE MOUNTED ON THE SECONDARY GAMMA SHIELD

SEQUENCE FOR INSTALLING VALVE

1. PLUG COVER PLATE IS REMOVED
2. FLOOR VALVE ADAPTER PLATE IS POSITIONED ON THE SECONDARY GAMMA SHIELD (OVERHEAD HOIST USED)
3. FLOOR VALVE (14000 LBS) IS POSITIONED ON VALVE ADAPTER PLATE
4. SEALS ARE CHECKED FOR LEAK TIGHTNESS
5. AUXILIARY TOOL CASK IS USED TO REMOVE SHIELD PLUG AND INSTALL SEAL SLEEVE
6. AUXILIARY TOOL CASK IS ALSO USED TO PREPARE THE SPOOL PIECE FOR FUEL TRANSFER

SEE A1 DWG NO. SK-N68181066 FOR FULL SIZE CONCEPT

SECTION AA

ADVANTAGES

- 1 THE FLOOR VALVES ARE AVAILABLE FOR MAINTENANCE DURING REACTOR OPERATION
- 2 THE HOT CELL HOIST CAN BE UTILIZED FOR REMOVING THE SECONDARY GAMMA SHIELD THIS ALLEVIATES THE NEED FOR A LARGE GANTRY TYPE STRUCTURE FOR SHIELD TRANSFER
- 3 WITH THE SECONDARY GAMMA SHIELD IN POSITION FOR REACTOR OPERATION, SPECIAL EQUIPMENT CAN PROJECT THRU SPECIFIED PORTS (SEE DISADVANTAGES, # 6.)
- 4 VIEWING AND MANIPULATING EQUIPMENT CAN BE PLACED THROUGH THE SECONDARY GAMMA SHIELD AS SHOWN ON A1 DWG SK-N68181066.
- 5 WITH THE LARGE DIAMETER MOLTEN FREEZE SEAL OUTSIDE OF THE SECONDARY GAMMA SHIELD, THE HEATERS AND SEAL TROUGH ARE ACCESSIBLE FOR MAINTENANCE
- 6 DIFFERENCE IN THERMAL EXPANSION BETWEEN THE SECONDARY GAMMA SHIELD AND THE REACTOR FLOOR CAN BE ABSORBED WITH THE FLAT ROLLERS AND MOLTEN-FREEZE SEAL.
- 7 EXCEPT FOR THE LARGE DIAMETER SEAL (SHOWN AS MOLTEN-FREEZE SEAL) ALL SEALS ARE STATIC TYPE.

ADVANTAGES CONTINUED ON ZONE BC

DISADVANTAGES

- 1 ONLY ONE NOZZLE CAN BE SERVICED AT A TIME
- 2 THE FLOOR VALVE MUST BE TRANSFERRED BY USE OF AN OVERHEAD HOIST FOR EACH NOZZLE LOCATION
- 3 ELECTRICAL AND GAS LINES, LEADING TO THE FLOOR VALVE, MUST LAY ON THE SECONDARY GAMMA SHIELD DURING FUEL TRANSFER OPERATIONS THESE LINES WILL REQUIRE AN ARMORED PROTECTIVE COVER.
- 4 CORE POSITION DENOTED #1 (ZONE 3B) DOES NOT HAVE THE FLOOR VALVE PERPENDICULAR TO THE REACTOR NOZZLE. THE FHM AND REACTOR TUBE CAN BE ALIGNED BUT THE FHM SKIRT AND SPOOL PIECE SEAL SLEEVE MUST BE FLEXIBLE FOR SEALING TO THE VALVE. THE FHM SKIRT MUST TILT APPROX. .060 IN 58 INCHES (THE DIA OF THE SKIRT)
- 5 THE TRANSFER OF THE FLOOR VALVE REQUIRES THE USE OF THE HOT CELL HOIST IF THIS HOIST IS IN USE A WAITING PERIOD MAY BE REQUIRED.
- 6 ALIGNMENT OF THE SECONDARY GAMMA SHIELD PORTS TO THE REACTOR SPOOL PIECES WILL REQUIRE BUILT IN ADJUSTMENT OF THE VALVE TO SPOOL PIECE SEAL SLEEVE
- 7 THE FLOOR VALVE SEALS AND ADAPTER PLATE SEALS MUST BE BROKEN, RESEALED AND CHECKED WITH EACH VALVE TRANSFER.

NOTES

- 1 THE CORE ARRANGEMENT SHOWN IN THIS CONCEPT IS TAKEN FROM PNL SPLIT CORE CONCEPT III, DWG NO SK-3-12767
- 2 ALL SLIDING OR STATIONARY SEALS WILL HAVE PROVISIONS FOR LEAK CHECK IN ALL PRACTICAL CASES THIS WILL BE A DOUBLE SEAL WITH EVACUATION CHAMBER BETWEEN THEM.
- 3 SEE A1 DWG SK-N68181066 FOR METHODS OF COOLING THE SECONDARY GAMMA SHIELD AND THE CROSS PIPING REGION
- 4 FOR THIS CONCEPT, LINES AND HOSES, REQUIRED FOR AUXILIARY TOOL CASKS AND EQUIPMENT, ARE DRAPED OVER THE SECONDARY GAMMA SHIELD
- 5 THE FLOOR VALVE WILL PROVIDE A TARGET FOR AND WILL MATE WITH THE FHM ALL MATING SEALS WILL BE CHECKED AFTER BEING SECURED
- 6 SPIDER (NOT SHOWN) WOULD BE ADAPTED TO THE SECONDARY GAMMA SHIELD FOR PICKING UP THE SECTIONS OF SHIELD FOR HOT CELL MAINTENANCE.
- 7 THIS LAYOUT ASSUMES THAT THE HEIGHT OF THE CONTROL ROD DRIVES DOES NOT EXCEED THAT OF REACTOR NOZZLES

CONCEPT

THIS CONCEPT INCORPORATES MULTIPLE PLUGS IN A ROTATING SECONDARY GAMMA SHIELD. A FLOOR VALVE IS POSITIONED ON THE SHIELD AND A PLUG IS REMOVED USING AN AUXILIARY TOOL CASK. THIS PROVIDES ACCESS TO THE NOZZLE SPOOL PIECE. FOR ACCESS TO THE CLOSED LOOP CROSS PIPING AND INSTRUMENTATION LINES, THE SHIELD IS REMOVED IN CIRCULAR SECTIONS OF EQUAL WEIGHTS (APPROX. 25 TON) BY USE OF THE HOT CELL HOIST.

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DESIGN STUDY NO.3

ATOMIC INTERNATIONAL	
8900 DESOTO AVENUE, CANOGA PARK, CALIF	
SECONDARY GAMMA SHIELD	
MULTIPLE PLUG-SINGLE VALVE CONCEPT	
DRAWN	SK-N68181065
CHECKED	SK-N68181065
ENGINEER	SK-N68181065
APPROVED	SK-N68181065

ADVANTAGES (CONT.) SEE ZONE 1C

8. IT MAY BE POSSIBLE TO DO THE MAINTENANCE REQUIRED BY REMOVING ONE OR TWO RINGS OF THE SECONDARY GAMMA SHIELD. THAT IS IF THE POOL PIECE OF AN OPEN LOOP OR DRIVER FUEL HAD TO BE REPLACED IT WOULD BE NECESSARY TO REMOVE THE CENTER PLUG ONLY.

ALL 15" DIA PLUGS HAVE A BOLTED COVER PLATE. THIS COVER PLATE IS SEMI-FLUSH WITH THE TOP SURFACE OF THE SECONDARY GAMMA SHIELD. WHEN THIS PLATE IS REMOVED A SEAL AND LOCATING SURFACE IS PROVIDED FOR A FLOOR VALVE ADAPTER PLATE.

FLATS ARE MACHINED ON TOP SURFACE OF THE SECONDARY GAMMA SHIELD TO ACCOMMODATE THE FLOOR VALVE ADAPTER PLATE. ALTHOUGH NOT SHOWN, THIS IS TYP FOR ALL FLOOR VALVE POSITIONS.

OVER-SIZED ECCENTRIC PLUG. THIS ENLARGED PLUG WITH ECCENTRIC PORT IS PERPENDICULAR TO THE CENTER ROW OF CLOSED LOOPS. FOR POSITIONING, THE LARGE PLUG MUST BE PICKED UP, USING THE HOT CELL OVERHEAD HOIST, AND ROTATED TO AN INDEXED POSITION. THE PLUG IS RAISED A SHORT DISTANCE (2") AND ROTATED WITHOUT LOSING THE INERT SEAL.

NOTE: THIS ECCENTRIC PLUG ALSO ACCOMMODATES CORE POSITION IDENTIFIED AS NO 1.

LEAD OUT PORTS FOR CLOSED LOOP INSTRUMENTATION (FOR 3 CENTER LOOPS ONLY) (FOR USE ROTATE PLUG 180° FROM POSITION SHOWN)

14'0" DIA INNER SHIELD WITH MULTIPLE PLUGS ~ 65 TONS
20'0" DIA INTERMEDIATE SHIELD RING ~ 65 TONS
25'0" DIA OUTER SHIELD RING ~ 65 TONS

MANWAY PLUGS FOR CONTACT MAINTENANCE

SHIELD PLUG FOR MANIPULATOR (SEE A1 DWG SK-N68181064 SHTS 1 & 3 FOR CONCEPT)

ROLLER BRACKET 8 PLCS. OR AS REQ'D.

4 3 2 1

REVISIONS			
SYM	ZONE	DESCRIPTION	DATE

TYSON TAPER ROLLER BRG
775 SERIES S (3 750 I D X 7 1250 O D X 18750 W)

THIS DRAWING PROVIDES A WHEEL
DRIVE CONCEPT FOR
ROTATION OF SECONDARY GAMMA SHIELD

BOSTON # 140A18 SPROCKET

BOSTON # 140 (1 1/2 PITCH) LINK CHAIN

TORRINGTON 20NBF 2040 GUIDE ROLLER

SCALE (INCHES)

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DESIGN STUDY NO 3

ATOMICS INTERNATIONAL A DIVISION OF NORTH AMERICAN AVIATION INC 8800 REDDIE AVENUE CARROLL PARK, CALIF.	
SECONDARY GAMMA SHIELD WHEEL & SPROCKET ROTATION & DRIVE CONCEPT	
DRAWN BY: J. W. HERS CHECKED BY: J. W. HERS ENGINEER BY: J. W. HERS APPROVED BY: J. W. HERS	DATE: 2-27-62 SIZE: 1/2 SCALE: 1/1 SHEET NO. 1 OF 1
SK-N68181066	

4 3 2 1

C
B
A
SK-N68181066

1

2

3

4

8.0 STATIONARY SECONDARY GAMMA SHIELD CONCEPTS

Seven design study layouts of stationary secondary gamma shields are included in this report. These concepts show basic methods for providing gamma shielding to closed loop cross piping and the reactor nozzles during reactor operation and to operating personnel during fuel transfer.

The design study of stationary secondary gamma shields has developed two basic arrangements.

- 1) The shielding material is located (in different ways) in and around the reactor nozzle and spool pieces. This means the shielding material is located directly above the reactor vessel top cover. Directly above the reactor nozzles is a steel floor plate of some thickness. This thickness is dependent upon the load carrying requirements and how the floor plate is supported. If the floor plate can be supported from the vessel cover, the thickness can be much less than if it must span the entire gallery with no intermediate support.
- 2) All the shielding material is above the nozzles. This is similar to the rotating secondary gamma shield except the shield is fixed. The weight of the secondary gamma shield and fuel transfer system equipment must be supported at the periphery of the reactor cavity.

The layouts of the stationary secondary gamma shield provide different approaches for accomplishing the requirements. Many of the design details are not exclusive to a specific concept and can be interchanged among the concepts.

Some of the design features that are typical to all of the stationary secondary gamma shield concepts are as follows:

- 1) The shielding materials are common; i. e., steel, lead and/or depleted uranium,
- 2) All seals in the stationary concept are static, (the types that can be used are elastomer O-rings, quad rings, inflatable ring seals, and metal seals),
- 3) Floor valves are positioned on individual reactor nozzles, (this is accomplished using hot cell handling equipment or the fuel handling machine),

- 4) All concepts are based on a reactor arrangement with a single row of vertical closed loops and a separate gallery for the cross piping, and
- 5) All concepts provide a smooth working surface near floor level.

Two design concepts of stationary secondary gamma shields with shielding around the nozzles are included in this report. They are:

	<u>Applicable Drawings</u>
1) Monolithic shielding built into the nozzle region, and	SK-N68181080 SK-N68181088
2) Interlocking stacked shielding in the nozzle region.	SK-N68181083 SK-N68181084 SK-N68181085 SK-N68181086 SK-N68181087 SK-N68181089 SK-N68181090 SK-N68181092

A third concept, shown by Dwg. SK-N68181091, has all of the shielding above the nozzles.

9.0 STATIONARY SECONDARY GAMMA SHIELD CONCEPT I, MONOLITHIC SHIELDING BUILT INTO THE NOZZLE REGION, GENERAL DESCRIPTION

The core- and nozzle-lattice used in this concept is similar to that of the PNL Split Core Reactor Arrangement I, SK-3-12766 and the PNL core Concept III, SK-3-12767. This design study evolved because the approach was taken that the split conical core concept would have closed loop assemblies in one diametral row only and none in the driver fuel and open loop area. For this reason, the nozzle can be designed with shielding between and around them. The instrumentation leads for the driver fuel and open loops can be connected at the top of the nozzle covers.

The control rod drives are not shown for the stationary concepts, but it is assumed that the drives would be mounted above the floor and that these drives would be disconnected and removed from the reactor floor area for fuel handling. Instrumentation or test equipment on the reactor shield must be removed.

This concept has the secondary gamma shield as an integral part of the nozzle and reactor vessel cover assembly. The basic gamma shield is a lead filled assembly supported on the reactor vessel cover flange. The nozzles and instrumentation are above the gamma shield and a steel floor plate encloses the gallery atmosphere and serves as the fuel handling system interface.

The closed loop pipe gallery is horizontal and parallel with the cross piping. The pipe gallery is shielded by shield blocks that are removable for cross piping maintenance.

9.1 PRINCIPLES OF OPERATION

Floor valves are supported and positioned on the top of the floor plate. The floor valve is sealed to the reactor nozzle by a seal sleeve similar to that shown for the rotating concepts.

Maintenance of all closed loops would be accomplished by removing the closed loop shield blocks and use of the hot cell equipment. Maintenance of the driver fuel and open loop experiments can be accomplished through the ports in the floor plate or through removable access panels at the periphery of the shield.

9.2 SHIELDING MATERIALS

The shielding materials for this concept would be solid lead in a stainless steel container. The shield is made in one assembly with nozzle pieces welded into the assembly. For installation, the secondary gamma shield is placed on the reactor vessel cover, seal welds to the reactor tubes are made from the inside of the nozzles, and a final weld is made to the vessel cover at the periphery of the shield.

The shield block over the cross piping is solid lead sheathed in stainless steel. These shield blocks provide the necessary 15 in. of lead equivalent required when experiments are being withdrawn from the closed loops.

In the event of a stuck element during the fuel transfer, additional shielding (lead blocks) can be laid on the reactor floor plate. This may require spacer blocks between the floor plate and the secondary gamma shield to prevent excessive deflection of the floor plate.

9.3 STRUCTURE ANALYSIS

Structural analysis was made on a floor plate for a stationary gamma shield.

For the study, a semicircular plate with holes in the central portion was assumed. The hole parameters used were 8.5-in. diameter and 9.25-in. triangular pitch, as shown on Dwg. SK-N68181094. The plate was considered to be simply supported at all edges. The problem was to determine the thickness of the plate required to carry four, 12,500-lb concentrated loads located near the diametral edge of the plate.

For simplicity, the semicircular plate was considered to be completely perforated and the concentrated loads were transformed into an equivalent uniformly distributed load. These are conservative simplifications. The results summarized are based on assumed allowable bending and shearing stresses of 22,000 and 11,000 psi, respectively.

9.4 SUMMARY

Given: 50,000-lb load applied at 4 separated points as shown on the drawing,

Minimum calculated required thickness = $h = 11$ in., and

Recommended thickness = $h = 12$ in.

ATOMIC INTERNATIONAL
 2100
 09974
 SK-NGB181088

SECTION A-A

- NOTES:
- 1 THIS CONCEPT IS BASED ON PNL SPLIT CORE CONCEPT II FUEL ARRANGEMENT (SK-3-12765)
 - 2 THIS CONCEPT IS BASED ON A COMBINED PRIMARY & SECONDARY GAMMA SHIELD SERVING AS A REACTOR COVER

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ATOMIC INTERNATIONAL
 A DIVISION OF NORTH AMERICAN AVIATION INC.
 1800 JEFFERSON AVENUE, SUITE 1000, DENVER, COLORADO 80202
 PRIMARY-SECONDARY COMBINED
 FIXED SHIELDING CONCEPT NO. V
 SK-NGB181088

OSTI ID: 1000021950

Except for the possibility of welding and bending stresses created during its installation, the secondary gamma shield does not impose additional loads on the vessel cover. In this concept, the load is primarily supported on the vessel cover flange.

9.5 SEALS

The seals required are the floor-plate, plug seals and the cross-piping gallery, shield-plug seals. All seals are static and can be leak checked.

After removal of the instrument lead, a seal sleeve is inserted between the floor valve and the reactor nozzle to isolate that nozzle from the surrounding atmosphere under the floor plate. The seals for the reactor nozzles and floor valves are similar to those of previous concepts discussed.

9.6 SECONDARY GAMMA SHIELD COMPONENTS

With the stationary gamma shield built into the nozzle-vessel cover assembly, the only other major components are the pipe gallery shield blocks and the floor plate. The floor valve is a separate item which is positioned at different core positions as required.

Removable access panels are located near the periphery of the floor plate. This provides access to the instrumentation leads or other components under the shield.

9.7 SHIELD COOLING

The method for maintaining this secondary gamma shield at an acceptable temperature is by insulating the closed-loop cross piping and by circulation of gallery atmosphere through cooling radiators located within the gallery or at an external location.

9.8 GALLERY MAINTENANCE

For major maintenance in the closed loop gallery, the shield blocks are removed and work is performed remotely by using the hot cell equipment. However, for maintenance in the driver fuel or open loop region, personnel can work through the floor plate or the floor plate can be removed, unless there has been a sodium spill or major contamination of the area.

9.9 CONCEPT EVALUATION

The following are advantages and disadvantages of the stationary secondary gamma shield with monolithic shielding built into the nozzle region.

9.9.1 Advantages

- 1) The distance between the floor plate top surface and the nozzle is minimized.
- 2) The weight of the floor plate plugs is relatively small.
- 3) Closed loop instrumentation leads can be routed through the shield.
- 4) There are no sliding seals required.
- 5) The total weight of the shield is minimized.
- 6) Good access for maintenance of nozzles and cross piping is provided.
- 7) The floor valves are not required during reactor operation and can be serviced in a maintenance area during this time.

9.9.2 Disadvantages

- 1) Fabrication of the assembly can be difficult.
- 2) The reactor vessel cover flange must support the weight of the secondary gamma shield.
- 3) The floor plate would probably require support spacers to reduce deflection from the weight of the fuel handling system components.
- 4) A difference in thermal expansion between the floor plate and the reactor vessel may occur during both reactor operation and reactor down time. The resulting misalignment between the floor plate ports and the reactor spool pieces will require a flexible and adjustable spool piece seal sleeve or adjustment of the floor valve position over the port.
- 5) The floor valve seals and adaptor plate seals must be broken, resealed, and checked with each valve transfer.

9.10 ALTERNATE DESIGN CONCEPT STUDY IA

A concept similar to the stationary shielded vessel cover, just discussed, is shown in Dwg. SK-N68181088. For this concept, the gamma shielding is an

C

B

A

67

integral part of the vessel cover. The basic idea is that except for the closed loops and cross piping, there is no need for secondary gamma shielding. If sufficient reactor shielding is provided in a single top shield and additional gamma shielding is required for the cross piping only, the fabrication and installation problems would be greatly reduced.

Although the concept drawing shows a floor plate approximately 4-in. thick, it is conceivable that this floor plate can be nothing more than a protective covering for the instrumentation leads during reactor operation. Then, during reactor shutdown, the control rod drives are removed, the floor plate taken off, and the instrumentation leads disconnected and removed. The floor valve can then be installed directly onto the reactor nozzle for fuel transfer. This would require deletion of the requirement for an inert atmosphere in the nozzle region during fuel transfer.

10.0 STATIONARY SECONDARY GAMMA SHIELD, CONCEPT II INTERLOCKING STACKED SHIELDING IN THE NOZZLE REGION (SK-N68181084 THROUGH SK-N68181087), GENERAL DESCRIPTION

These design concepts are based on the PNL split core, Concept IV fuel arrangement (SK-3-12765). The basis for these concepts was that the massive outer portion of the secondary gamma shield can be supported outside of the reactor vessel cover and the shielding in the nozzle region can be supported on the reactor vessel cover.

Once again, driver fuel and open loop nozzles can be designed to accept shielding between and around them because no closed loops are in this region. The control rod drives are not shown but it is assumed that the drives would be mounted above the floor level and that these drives would be disconnected and removed from the reactor floor area during reactor shutdown for fuel transfer operations.

The general concept in this design is the use of collar blocks around the nozzles for gamma shielding as shown on Dwg. SK-N68181090. These blocks are staggered to prevent radiation streaming. Each nozzle supports a stack of blocks that are independent of the blocks on the adjacent nozzles. This arrangement thereby allows unrestrained expansion and contraction of the distance between nozzles. The blocks are supported on shoulders provided on the nozzles.

The closed loop pipe gallery, shown in more detail on Dwg. SK-N68181089, is a sealed stainless steel chamber and has thermal expansion joints around the closed loop nozzles. The cross piping is insulated and the gallery walls are cooled. The closed loop pipe gallery is shielded by rectangular shield blocks with floor plugs for access to the closed loops. The vertical walls of the pipe gallery support the weight of the gallery shield blocks and provide partial support for the floor plate.

10.1 PRINCIPLES OF OPERATION

For this type of secondary shield, the floor valve is mounted on the floor plate, the instrumentation leads are disconnected, and a seal sleeve is inserted

and secured between the floor valve and the reactor nozzle. Auxiliary casks and equipment are used to prepare the reactor nozzle for core component or experiment transfer. The fuel handling machine operates through the floor valve and does the necessary transferring of core components and experiments.

When fuel is being drawn into the fuel handling machine, radiation in the nozzle region is limited by the shielding around the nozzles. When the fuel is just above the nozzles, the floor plate and the floor valve provide the shielding.

10.2 SHIELDING MATERIALS

The shielding materials are conceptually shown as stainless steel clad lead assemblies that form a ring around the nozzle region and either steel or depleted uranium collar blocks around the nozzles.

Steel would be easier to machine to the varied configurations required but would require a thickness twice that of the depleted uranium. The depleted uranium would require plating or cladding to prevent corrosion. The principle advantage to the use of uranium is the shorter distance required between the reactor vessel and the floor plate.

10.3 STRUCTURAL ANALYSIS

The structural analysis performed on the floor plate of the previous concepts is applicable to this concept (see Section 9.3).

Preliminary calculations show that the weight of the shielding in the nozzle region, which is attached to the nozzles and thereby carried by the reactor vessel top cover, is approximately 15,000 lb. The weight of the floor plate, the closed loop gallery shielding, and the shield ring surrounding the nozzle region are supported from the foundation structure surrounding the reactor.

10.4 SEALS

Seals are required for the floor plate plug seals and the cross piping gallery shield plugs. All seals are static and can be leak checked. After removal of the instrument lead, a seal sleeve is inserted between the floor valve and the reactor nozzle to isolate that nozzle from the surrounding atmosphere under the floor plate.

10.5 SHIELD COOLING

Inert gas will be circulated over the reactor vessel cover and under the floor plate in the driver fuel and open loop region. The closed loop pipe galleries can be cooled by circulation of cooled inert gas through the gallery and/or cooling of the gallery walls by using honeycomb paneling or cooling coils as shown on Dwg. SK-N68181089. Thermocouples can be used to monitor the temperatures.

10.6 GALLERY MAINTENANCE

For major maintenance in the closed loop gallery, the shield blocks are removed and work is performed remotely by using the hot cell equipment; however, for maintenance in the driver fuel or open loop region, personnel can work through the floor plate or the floor plate can be removed, unless there has been a sodium spill or major contamination of the area.

10.7 CONCEPT EVALUATION

The following are a list of the advantages and disadvantages of the stationary secondary gamma shield with interlocking stacked shielding in the nozzle region.

10.7.1 Advantages

- 1) The instrumentation disconnect points are accessible without the need of shielded handling equipment.
- 2) The shielding requirements of the floor plate are minimized.
- 3) The amount of cover gas required in the nozzle region is minimized.
- 4) The reach of the fuel handling machine snorkel is minimized.
- 5) The length of the nozzles is reduced which in turn reduces the height of the fuel handling machine.
- 6) There are no sliding seals required.

10.7.2 Disadvantages

- 1) Alignment between the access holes in the floor plate and the nozzles may be difficult to maintain because of differential thermal expansion between the reactor cover and the floor plate.
- 2) The weight of the nozzle region shielding is carried by the reactor nozzles into the vessel top cover.
- 3) A large amount of machining will be required on the shielding collars for the nozzle region.

SECONDARY GAMMA SHIELD CONCEPT
USING SPLIT CORE CONCEPT III (SK-3-12767)

ATOMICS INTERNATIONAL A DIVISION OF NORTH AMERICAN AVIATION, INC. 2000 BAYVIEW AVENUE, SAN JOSE, CALIF. 95131	
CODE IDENT NO. 09974	FRAME
SK-N68181084	REV SHEET

- NOTES:
- THIS CONCEPT IS BASED ON PNL SPLIT CORE CONCEPT III FUEL ARRANGEMENT (SK-3-12767) AND PROVIDES 10' DEPLETED URANIUM, 15 1/4" LEAD OR 27" STEEL SHIELDING ABOVE PRIMARY SHIELD

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0 1 2 3 4 5 6
SCALE (FEET)

ATOMICS INTERNATIONAL A DIVISION OF NORTH AMERICAN AVIATION, INC. 2000 BAYVIEW AVENUE, SAN JOSE, CALIF. 95131	
SECONDARY GAMMA SHIELD STATIONARY CONCEPT No. I	
DESIGNED BY M. G. E. 23	REV. DATE
CHECKED BY J. J. 22	DATE
ENGINEER J. J. 22	SCALE
APPROVED	SHEET NO. OF
SK-N68181084	1

051110 000021450

REV	DATE	DESCRIPTION	APPROVED

ADVANTAGES

1. PERMITS ACCESS TO TOP OF FUEL ELEMENTS TO DISCONNECT INSTRUMENTATION AND REMOVE COVER WITHOUT RADIATION EFFECTS
2. SHIELDING BRICKS ALLOW THERMAL EXPANSION MOVEMENT OF NOZZLES
3. TOP COVER OF MINIMUM THICKNESS TO SATISFY STRUCTURAL REQMT ONLY SINCE IT DOES NOT ACT AS SHIELDING

DISADVANTAGES

1. TOLERANCE BUILDUPS FROM STACKED BRICKS OF SHIELDING WOULD BE DIFFICULT TO HOLD
2. IRREGULAR CORE PATTERN REQUIRES FITTING OF ODD SHAPED BLOCKS TO FILL ALL VOIDS
3. WEIGHT OF SHIELDING BRICKS CLAMPED TO NOZZLES WOULD BE TRANSMITTED TO REACTOR DOME.

NOTES:

1. THIS CONCEPT IS BASED ON PAUL SPILL CORE CONCEPT II. FUEL ARRANGEMENT (SK-3-1276) PROVIDING 10" DEPLETED URANIUM, 15" LEAD OR 27" STEEL SHIELDING ABOVE PRIMARY SHIELD AND DURING REMOVAL OF FUEL FROM REACTOR TO FUEL HANDLING MACHINE
2. THIS CONCEPT REQUIRES AN ADAPTER AND A FLOOR VALVE CAPABLE OF PROVIDING A SEAL BETWEEN FUEL-HANDLING EQUIPMENT AND TOP PLATE PORT

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SECTION A-A

ATOMIC INTERNATIONAL
7100 West 12th Avenue, Suite 100
Golden, CO 80401
CODE IDENT NO. 09974 FRAME
SK-N68181085

ATOMIC INTERNATIONAL
A DIVISION OF ROSS INDUSTRIES, INC.
8800 DIXIE AVENUE, CANYON VIEW, UTAH
SECONDARY GAMMA SHIELD
STATIONARY CONCEPT NO. II
DRAWN BY: M. J. HARRIS
CHECKED BY: J. E. HARRIS
APPROVED BY: J. E. HARRIS
DATE: 10/1/79
SHEET NO. 1 OF 1
SK-N68181085

057110-000021950

ADVANTAGES

1. PERMITS ACCESS TO TOP OF REACTOR NOZZLES TO DISCONNECT INSTRUMENTATION AND REMOVE COVER OF FUEL ELEMENT WITHOUT ADDITIONAL SHIELDING
2. TOP COVER OF MINIMUM THICKNESS TO SATISFY STRUCTURAL REQ'TS ONLY SINCE IT DOES NOT ACT AS SHIELDING

DISADVANTAGES

1. TOLERANCES FOR SHIELDING BLOCKS BETWEEN FUEL ELEMENTS DUE TO THERMAL CHANGE ARE DIFFICULT TO MAINTAIN
2. IRREGULAR CORE PATTERN NECESSITATES ODD SHAPED EXTERNAL FILLER BLOCKS
3. WEIGHT OF SHIELDING BLOCKS & SPLIT COLLAR - SHIELDING BLOCKS IS TRANSMITTED TO REACTOR

NOTES:

1. THIS CONCEPT IS BASED ON PUL SPLIT CORE CONCEPT III FUEL ARRANGEMENT (SK-1-1765) PROVIDING 10' DEPLETED URANIUM, 15% LEAD OR 27" STEEL SHIELDING ABOVE PRIMARY SHIELD.

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ATOMIC INTERNATIONAL
11100 BAYVIEW AVE. CANADA PARK, CALIF. 92626
CODE IDENT NO. 09974 1 FRAME
SK-N68181086

ATOMIC INTERNATIONAL
A DIVISION OF NORTH AMERICAN ATOMICS, INC.
4000 BAYVIEW AVENUE CANADA PARK, CALIF. 92626
SECONDARY GAMMA SHIELD
STATIONARY CONCEPT NO. III
DRAWN BY D. DYER
CHECKED BY J. J. JONES
ENGINEERED BY J. J. JONES
APPROVED BY J. J. JONES
SHEET NO. 1
NAA-SR-MEMO-12586

SECTION A-A

057110:060021950

- ADVANTAGES**
1. PERMITS ACCESS TO INSTRUMENTATION & UPPER PORTION OF NOZZLE WITHOUT SHIELDED HANDLING EQUIPMENT
 2. REDUCES OVERALL HEIGHT TO SEPARATE GAMMA SHIELD REQUIREMENTS FROM TOP COVER
 3. MINIMIZES VOLUME OF GAS REQUIRED TO PRESSURIZE INTERNAL CAVITY

- DIS ADVANTAGES**
1. TRANSMITS SHIELDING LOAD THROUGH REACTOR NOZZLE TO VESSEL COVER, S
 2. SOME INTRICATE MACHINING TOLERANCES ARE REQUIRED ON GAMMA SHIELDING FILLER BLOCKS

NOTES:

1. THIS CONCEPT IS BASED ON PNL SPLIT CORE CONCEPT IV FUEL ARRANGEMENT (SK-3-126) PROVIDING 10" DEPLETED URANIUM, 15 1/2" LEAD OR 27" STEEL SHIELDING ABOVE PRIMARY SHIELDING AND DURING REMOVAL OF FUEL FROM REACTOR TO FUEL HANDLING MACHINE
2. THIS CONCEPT REQUIRES AN ADAPTER (NOT SHOWN) CONTAINING A FLOOR VALVE AND CAPABLE OF PROVIDING A SEAL BETWEEN FUEL HANDLING EQUIPMENT AND FLOOR PLATE PORT

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ATOMIC INTERNATIONAL
DIVISION OF WESTINGHOUSE ELECTRIC CORP.
PITTSBURGH, PENNSYLVANIA
CODE IDENT NO. 09374 FRAME
SK-N68181087

ATOMIC INTERNATIONAL
DIVISION OF WESTINGHOUSE ELECTRIC CORP.
PITTSBURGH, PENNSYLVANIA
SECONDARY GAMMA SHIELD
STATIONARY CONCEPT NO. IV
DRAWN BY M. MYERS
CHECKED BY J. J. JONES
ENGINEER BY J. J. JONES
APPROVED BY J. J. JONES
SK-N68181087

OSTI ID: 000001950/NAA-SR-MEMO-12586

REVISIONS			
SYM	ZONE	DESCRIPTION	DATE

NOTES

1. THIS CROSS SECTION SHOWS THE SHIELDING AS STEEL BLOCKS INTERWOVEN BETWEEN THE OPEN LOOP & DRIVER FUEL SPOOL PIECES.
2. FOR THIS CONCEPT, THE WEIGHT OF THE SHIELDING BLOCKS IS SUPPORTED ON THE REACTOR TOP VESSEL COVER.
3. SEVERAL METHODS ARE SHOWN FOR COOLING THE CLOSED LOOP PIPE CHASE.
4. INSTRUMENTATION LEADS ARE DISCONNECTED PRIOR TO INSERTING SEAL SLEEVE (BETWEEN FLOOR VALVE AND REACTOR SPOOL PIECE.) SEE SHT. SK N68181083

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CROSS SECTION OF CLOSED LOOP PIPE GALLERY & OPEN LOOP OR DRIVER FUEL

ATOMICS INTERNATIONAL <small>A DIVISION OF NORTH AMERICAN AVIATION, INC. 8800 REDDYS AVENUE, CARLSBAD, CALIF.</small>			
SECONDARY GAMMA SHIELD-CLOSED LOOP & DRIVER FUEL CROSS SECTION			
<small>DRAWN</small> <small>CHECKED</small> <small>ENGINEER</small> <small>APPROVED</small>	<small>J. G. ROBERTS</small> <small>P. J. ROBERTS</small> <small>J. G. ROBERTS</small> <small>J. G. ROBERTS</small>	<small>1/4\"/> </small>	<small>SK-N68181089</small> <small>NAA SR MEMO-12586</small> <small>85</small>

REVISIONS			
SYM	ZONE	DESCRIPTION	DATE

GAMMA SHIELDING BLOCKS
(STEEL) INTER LAID TO PREVENT
STREAMING

SPOOL PIECE

OPEN LOOP, DRIVER FUEL,
CONTROL DRIVES AND
REMOVABLE REFLECTOR
POSITIONS

FLOOR PLUG

HOLD DOWN LATCH

CLOSED LOOP
FLOOR PLUG
5 PLUGS
REMOVABLE FOR
CLOSED LOOP FUEL
HANDLING

CLOSED LOOP
SHIELD BLOCK
5 PLUGS
(OPTIONAL CONCEPT
IS ONE REMOVABLE
BLOCK THAT HAS
5 PORTS)

SECTION

SHIELD RING

NOTES
1. SEE A1 DWG SKNGB181091 FOR COMPLETE
PLAN VIEW
2. THIS VIEW SHOWS THE DRIVER FUEL AND OPEN
LOOPS ON 9 CENTERS WITH AN 8 MAX OD ON THE
NOZZLE SPOOL PIECES. THIS CONCEPT DOES
NOT PROVIDE FOR SPOOL PIECE TO NOZZLE
BOLTING FLANGES

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A DIVISION OF NORTH AMERICAN AEROSPACE INC 2500 DEXTER AVENUE - CANOGA PARK, CALIF.	
SECONDARY GAMMA SHIELD - PLAN VIEW - CONCEPTUAL	
DRAWN CHECKED ENGINEER APPROVED	J. C. ROBERTS J. C. ROBERTS J. C. ROBERTS J. C. ROBERTS
DWG SIZE SCALE	E 1/2 1/2
SK-N68181090	
NAA SR MEMO 12586 87	

11.0 STATIONARY SECONDARY GAMMA SHIELD, CONCEPT III, ALL SHIELDING ABOVE THE NOZZLES (SK-N68181091) GENERAL DESCRIPTION

This design concept, shown on Dwg SK-H68181091, incorporates a stationary secondary gamma shield that is supported at the periphery of the reactor vessel cover. The closed loops and cross piping are contained in a pipe chase or gallery independent of the open loops and driver fuel. The secondary gamma shield is a heavy stainless steel cover similar to the rotating secondary gamma shield, except this cover is penetrated by a plugged port at each core component or experiment location. Adapter plates are used to align and locate floor valves. The floor valves provide the interface between the reactor spool pieces and the auxiliary casks or fuel handling machine.

11.1 PRINCIPLES OF OPERATION

An adapter plate and floor valve is positioned on the top shield and the instrumentation is disconnected. A seal sleeve is installed between the reactor nozzle and the floor valve using an auxiliary tool cask. Auxiliary equipment operating through the floor valve and seal sleeve prepare the fuel assemblies for fuel transfer.

11.2 SHIELDING MATERIALS

The shielding material is stainless steel; because of the thickness (approximately 20 in.), laminated plates may be required.

The area outside of the nozzle region is shielded by solid lead blocks encased in stainless steel. These blocks are removable for maintenance of components outside of the nozzle region.

11.3 STRUCTURAL ANALYSIS

Structural analysis was performed to find the load carrying capacity of an 18-in. thick floor plate. For the study, a 19-ft diameter semicircular plate with holes in the center portion was assumed (Dwg SK-N68181094). The plate was considered to be simply supported at all edges and to be perforated with 8.5-in. diameter holes on a 9.25-in. triangular pitch. For simplicity of analysis, the semicircular plate was considered to be completely perforated and the concentrated loads were transformed into an equivalent uniformly distributed load.

Assuming an allowable bending stress of 22,000 psi, the floor plate will support an applied loading of 144,000 lb. This provides ample margin for the 50,000-lb weight of the floor valve and the lower skirt of the fuel handling machine.

11.4 SEALS

The seals required are those for the plugs in the ports over each nozzle and the shielding blocks over the closed loop piping gallery. All seals are static and can be leak checked. After removal of the instrument lead, a seal sleeve is inserted between the floor valve and the reactor nozzle to isolate that nozzle from the surrounding atmosphere under the shield.

11.5 SECONDARY GAMMA SHIELD COMPONENTS

The heavy steel secondary gamma shield is the major component of this concept. This is approximately 20 in. thick and 17 ft in diameter. The concept drawing shows the shield in three pieces. They are the rectangular blocks over the closed loop cross piping and the two semicircular segments over the driver fuel and open loop regions. The large segments weigh approximately 40 tons each. This is within the lifting capacity of the hot cell crane hoist.

Since the closed loops are in one line, maintenance of the cross piping can be accomplished by lifting the shield blocks out of position and storing them in the hot cell. Removal and replacement of components is accomplished by using hot cell equipment.

Removable access panels are located on the periphery of the shield. This provides access to the instrumentation leads or other components under the periphery of the shield.

11.6 SHIELD COOLING

The method for maintaining this secondary gamma shield at an acceptable temperature is by insulating the closed-loop cross piping and circulation of gallery atmosphere through cooling radiators located within the gallery or at an external location. The inside of the closed loop gallery may also use cooling methods as shown on AI Dwg SK-N68181089.

11.7 GALLERY MAINTENANCE

For major maintenance in the closed-loop gallery, the shield blocks are removed and work is performed remotely by using the hot cell equipment. However, for maintenance in the driver fuel or open loop region, personnel can work through the shield or the shield can be removed, unless there has been a sodium spill or major contamination in the gallery.

11.8 CONCEPT EVALUATION

Advantages and disadvantages of the stationary secondary gamma shield with shielding above the nozzles follow.

11.8.1 Advantages

- 1) The closed loop cross piping is contained in a single pipe chase. This provides a coolant system for the closed loop gallery that is separate from the open loop and driver fuel bay.
- 2) The secondary gamma shield may be removed in sections by using the hot cell hoist.
- 3) Cross piping shield blocks can be removed to provide access to closed loop spool pieces and cross piping.
- 4) A small diameter secondary gamma shield (as compared to the size of the rotating secondary gamma shield) is used.
- 5) The floor valves are not required during reactor operation and can be serviced in a maintenance area during this time.
- 6) The instrumentation disconnects are accessible without the need of shielded handling equipment.

11.8.2 Disadvantages

- 1) The nozzles in the reactor vessel cover will probably move because of thermal expansion. The ports in the secondary gamma shield must be oversize to accommodate the resulting misalignment between the secondary gamma shield and the reactor nozzles.
- 2) The concept requires a long reach from the floor valve for work on the reactor nozzle.

ADVANTAGES

- 1 THE CLOSED LOOP CROSS PIPING IS PROVIDED WITH A SINGLE PIPE CHASE WITH COOLANT SYSTEM SEPARATE FROM THE OPEN LOOP & DRIVER FUEL BAY.
- 2 INSTRUMENTATION LEADS ON OPEN LOOPS AND DRIVER FUEL MAY BE DISCONNECTED PRIOR TO INSERTING SEAL SLEEVE BETWEEN REACTOR SPOOL PIECE AND FLOOR VALVE.
- 3 THE SECONDARY GAMMA SHIELD MAY BE REMOVED IN SECTIONS. THE BACKUP HOT CELL HOIST IS USED TO TRANSPORT THESE SECTIONS.
- 4 ADAPTOR PLATE CAN BE USED TO FOR POSITIONING THE FLOOR VALVE.
- 5 CROSS PIPING SHIELD BLOCKS CAN BE REMOVED TO PROVIDE ACCESS TO CLOSED LOOP SPOOL PIECES AND CROSS PIPING.
- 6 THIS CONCEPT UTILIZES A SMALL DIAMETER SECONDARY GAMMA SHIELD (COMPARED TO THE SIZE OF THE ROTATING SECONDARY GAMMA SHIELD).
- 7 THE REACTOR SHIELD PROVIDES A UNIFORM AND ACCESSABLE FLOOR AREA.

DISADVANTAGES

- 1 THE NOZZLES IN THE REACTOR VESSEL COVER WILL MOVE OUTWARD BECAUSE OF THERMAL EXPANSION. THE PORTS IN THE SECONDARY GAMMA SHIELD MUST BE OVER SIZE TO ACCOMMODATE MISALIGNMENT BETWEEN THE SECONDARY GAMMA SHIELD AND THE REACTOR NOZZLES.
- 2 CLEANING THE NOZZLE SPOOL PIECE REGION MAY BE DIFFICULT BECAUSE OF POOR ACCESSIBILITY.
- 3 THE SECONDARY GAMMA SHIELD PLUGS ARE LIMITED IN SIZE BECAUSE OF THE LATTICE SPACING OF THE NOZZLES.
- 4 CLOSED LOOP CROSS PIPING HAS SPACE LIMITATIONS IN THE CLOSED LOOP SPOOL PIECE REGION.

CONCEPT

THIS CONCEPT INCORPORATES A STATIONARY SECONDARY GAMMA SHIELD SUPPORTED AT THE PERIPHERY OF THE REACTOR VESSEL COVER. THE CLOSED LOOPS & CROSS PIPING ARE CONTAINED IN A PIPE CHASE, INDEPENDENT OF THE OPEN LOOPS AND DRIVER FUEL. ADAPTOR PLATES ARE USED TO LOCATE & ALIGN FLOOR VALVES. THE FLOOR VALVES PROVIDE THE INTERFACE BETWEEN THE REACTOR SPOOL PIECES AND THE AUXILIARY CASKS & FHM.

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12.0 SAFETY PRECAUTIONS

The following hazards were considered during this design study.

12.1 FIRE

The fire hazard is minimized by maintaining an inert atmosphere over the reactor vessel cover and nozzles during reactor operation and fuel handling. The fire hazard is minimized in the hot cell complex by transporting and handling sodium-contaminated components in inert atmospheres only.

12.2 RADIATION

High radiation levels from the cross piping and closed loops present a potential radiation hazard. However, personnel radiation exposure will be reduced to acceptable levels by the design of the secondary gamma shield.

Personnel radiation exposure is minimized by providing adequate shielding, containment of contaminated equipment within shielding, and a capability to perform operations on highly radioactive equipment by remote handling techniques.

12.3 CONTAMINATION

Release of radioactive contamination is minimized by providing containment during all secondary gamma shield operations. In addition, strict procedural, administrative, and health and safety controls will be required.

12.4 PERSONNEL INJURY

All handling equipment is fully powered to eliminate operations requiring great physical exertion and minimize the possibility of personnel injury.

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13.0 REACTOR NOZZLE LATTICE SPACING

This design study included the requirement to investigate the possibility and the effect on the secondary gamma shield design of reducing reactor nozzle lattice center-to-center spacing. Drawings SK-N68181083 and SK-N68181092 show a nozzle concept developed to allow possible reduction of the nozzle lattice spacing to 9.25 in. This concept proposes the use of a threaded joint with a seal weld for the connection between the spool piece and the reactor nozzle.

With the adoption of the split conical core and deletion of the requirement for possible conversion of open loop and driver fuel channels to closed loops, the only reason for retaining the spool piece, as a component separable from the reactor nozzle, is for replacement of the sealing surfaces. If the sealing surfaces can be incorporated in a removable internal sleeve, the spool piece could be eliminated and the reactor nozzle extended.

Some increase in the lattice spacing, >9.25 in., is required on the fixed shield concepts which have the shield or a floor plate over the reactor nozzles. The 9.25-in. spacing does not provide for increasing the port diameter, to provide a clearance between the port and the seal sleeve which must be installed, between the floor valve and the nozzle. Some clearance, presently undetermined, will be required to allow adjustment of the floor valve position over the shield port to compensate for any misalignment between the shield port and the reactor nozzle.

THIS SECTION SHOWS THE INSTRUMENTATION
DISCONNECTED AND A SEAL SLEEVE IN PLACE
ON THE REACTOR NOZZLE.

NOTE
SEE A1 DWG. SK-N68181083 FOR SIMILAR REACTOR
DRIVER FUEL & OPEN LOOP CONCEPT.

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ATOMICS INTERNATIONAL A DIVISION OF NORTH AMERICAN AVIATION, INC. 8900 REDDY AVENUE, CARLSBAD, CALIF.	
SECONDARY GAMMA SHIELD - NOZZLE - OPEN LOOP - CONCEPTUAL	
DRAWN J.G. ROBERTS RJS	DWG
CHECKED J.P. ZIEGLER JAZ	SIZE
ENGINEER J.P. ZIEGLER JAZ	SCALE
APPROVED	FULL
NAA-SR-MEMO-12586 101	

SK-N68181092

-

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-

-

14.0 APPENDIX

RADIATION SHIELDING STUDY FOR FFTF

14.1 OBJECT

The purpose of this study was to estimate the thickness of lead shielding required for the fuel handling machine and for the secondary gamma shield during a fuel transfer operation.

14.2 SUMMARY

During a fuel transfer operation, about 15 in. of lead equivalent is required for the fuel handling machine cask and about 14 in. of lead equivalent is required for the secondary gamma shield. These quantities will limit the gamma dose rate at the surface of the cask and the shield to 100 mr/hr due to fission products from a 10-Mwt fuel element which has cooled 8 hr before handling.

14.3 DISCUSSION

The assumed reference fuel element for this study had operated at 10 Mwt and had cooled 8 hr before handling, Reference 3. Figure 3, taken from Reference 4, shows that for the assumed conditions, 35.3 cm (13.90 in.) of lead will lower the dose rate at a distance of 100 cm (39.37 in.) from the fuel element to 100 mr/hr. In Reference 4, credit for 1 cm of steel on either side of the lead was included. Figure 3 also shows that the tenth-thickness (i.e., the amount of shielding to lower the dose rate by a decade) is 5.3 cm (2.09 in.) for a thick lead shield in front of the FTR fuel element. From Reference 5, Figure 3.4.03(o), the tenth-thickness for iron is about 3.18 in. Therefore, 1 cm of steel is equivalent to 0.656 cm of lead. Consequently, the equivalent lead thickness for 100 mr/hr at 100 cm is $13.90 + 0.79(0.656)$ or 14.4 in.

Figure 4 shows the variation in dose rate as a function of distance from the unshielded fuel element midpoint. The data (points) come from Table III in Reference 4. The lines are drawn at a slope appropriate for an inverse-distance-squared effect. This implies that the fuel element can be taken as an isotropic point source. At distances of about 1 ft, the agreement is within 25% and improves as the distance increases.

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Figure 3. Gamma Intensity 100 cm from FTR Fuel Assembly (Line source) as a Function of Lead Shield Thickness

Figure 4. Calculated Gamma Intensity Near Irradiated FTR Element

The data from Figures 3 and 4 were combined to produce Figure 5. This shows the shield thickness required to limit the dose rate to 100 mr/hr as a function of the distance from the fuel element midpoint.

For the secondary gamma shield, 3 to 4 ft is a reasonable separation distance between the fuel element and the top outside surface of the shield. Figure 5 indicates that about 14 in. of lead (equivalent) will lower the dose rate to 100 mr/hr.

In this study, heavy reliance was placed on data from Reference 4. Since that study, a new conceptual fuel element has been devised. The new element includes a long fission gas plenum above the fuel section which may negate the conclusion reached in Figure 4 that the fuel element can be taken as a point source. Therefore, the shield thicknesses quoted here should be regarded as tentative. In addition, the dose rate during reactor operation shall not exceed 10 mr/hr. The radiation sources for this case are the radioactive sodium and possible fission products in the closed-loop piping. Whether this case is more restrictive or not remains to be ascertained.

Figure 5. Shield Thickness vs Separation Distance
FFTF - Secondary Gamma Shield and
Fuel Handling Machine Cask

REFERENCES

1. J. V. Facha and J. G. Roberts, "Auxiliary Tool Casks for Reactor Nozzle Service," NAA-SR-Memo-12377
2. L. J. Koch, W. B. Loewenstein, and H. O. Monson, "Addendum to Hazard Summary Report Experimental Breeder Reactor-II (EBR-II)," ANL-5719 Addendum (January 1, 1964)
3. H. D. Lenkersdorfer (BNWL, meeting at AI, May 11, 1967)
4. W. L. Bunch, "Shielding Calculations for Irradiated FTR Fuel," BNWL-342 (December 1966)
5. "Progress Report, Conceptual Design, Fast Flux Test Facility, Design Analysis," BNWL-CC-175, Volume 3 (August 1965)

BIBLIOGRAPHY

FFTF Reference Documents

<u>Source</u>	<u>Subject</u>
PNL SK-3-12599	Equipment Arrangement, Hot Cell Study VIII
PNL SK-3-12096	Reactor Concept XI
PNL SK-3-12105	Secondary Gamma Shield Concept XI
PNL SK-3-12545	Reactor Elevation "A-A" Concept XII
PNL SK-3-12765	PNL Split Core Concept IV
PNL SK-3-12766	Split Core Reactor Arrangement
PNL SK-3-12767	PNL Split Core Concept III
AI Dwg. No. 7026-HM095	Valve Assembly - Floor and Cask Car Top Shield
AI SK-N68181053	Reactor Position-Normal Nozzle Preparation-Auxiliary Tool Cask
AI SK-N66811044	Secondary Gamma Shield Proposal
AI SK-N68181054	Auxiliary Tool Cask Normal Nozzle Preparation
AI SK-N68181055	Shroud Tube Welding Proposal
AI SK-N68181056	Auxiliary Tool Cask, Shroud Tube Cutting (Proposal)
AI SK-N68181057	Auxiliary Tool Cask, Cut and Weld Reactor Tube (Proposal)

FFTF Reference Documents

<u>Source</u>	<u>Subject</u>
I. N. Fig. D-1 (Idaho Nuclear Report 1038)	FTR Multiple Vertical, Closed-Loop Chaseway Arrangement
I. N. Fig. C-4 (Idaho Nuclear Report 1038)	Process Piping Chaseway