**CALCINE CONVERSION FACILITY
ALTERNATIVE CONCEPTS
ENGINEERING STUDIES**

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1.0 INTRODUCTION

1.1 BACKGROUND

The Federal government will assume permanent custody of all high level radioactive waste generated by commercial nuclear fuel reprocessing plants, in accordance with Code of Federal Regulations, Title 10, Part 50, Appendix F. These wastes must be solidified within 5 years and shipped to a Federal repository within 10 years after fuel reprocessing.

Ultimate disposal concepts and ultimate disposal sites have not been selected. Their selection is not expected to be complete in time for use in the disposal of the first solidified wastes generated by the commercial fuel cycle. Therefore, the Federal government will undertake the design and construction of a Retrievable Surface Storage Facility that will store the solidified radioactive wastes until a permanent disposal facility becomes available.

The least expensive and simplest method of solidification of the wastes is to convert it to a calcine. However, calcine is partially soluble in water, and fine particles might become airborne if they should escape the confinement barriers of the storage system. The RSSF system is designed to safely store calcine; however, the technology is available for converting the calcine to a glass* form which is less dispersible to the environment. Furthermore, conversion to a glass form would eliminate the need to resolve questions about the long term stability of calcine.

If it is determined that the glass form is indeed preferred over calcine, then commercial reprocessors should add a calcine-to-glass conversion process to their plants as soon as the process and equipment have been demonstrated. A government-owned Calcine Conversion Facility (CCF) would serve to develop and demonstrate a licensed conversion process which could be transferred to industry.

* The product of the CCF process will be referred to as "glass" throughout this document. It may be either glass or ceramic and will contain calcine chemically incorporated in the solid matrix.

1.2 PURPOSE OF THE STUDY

The purpose of the engineering study reported in this document is to develop conceptual designs for two alternative facilities for the conversion of high level waste calcine to high level glass. The document describes the objectives and design bases of the two concepts. A brief physical description of the facilities and a brief review of technical and engineering considerations are also given. Capital cost estimates are provided, however comparative costs tend to be misleading because the two concepts are not truly comparable either in overall value to the nuclear fuel cycle or in their dependence on related facilities.

No recommendation of one concept in preference to the other is contained in this document and a sincere effort has been made to avoid establishment of a bias in either direction.

2.0 SUMMARY COMPARISON OF TWO CCF CONCEPTS

Engineering studies have been made of two alternative facilities for the conversion of calcine to a glass product. A basic objective of both facilities is to demonstrate calcine/glass conversion technology. This will assist the owners of commercial fuel reprocessing plants in designing and installing their own conversion facilities at a later date.

One alternative facility, referred to as the CCF/RSSF, would be located at the RSSF. The CCF/RSSF would accept calcine from the RSSF and return it as a glass product suitable for long term storage.

The other alternative facility, referred to as the CCF/FRP, would be located adjacent to a Fuel Reprocessing Plant. The CCF/FRP would accept calcine directly from the FRP. After conversion to a glass product the waste would be stored in a water basin at the FRP until decayed to an optimum activity level for shipment to the RSSF.

2.1 OBJECTIVES

The current objectives for both CCF facilities are to demonstrate the following:

- a. Calcine/glass conversion process is feasible on a production scale, and can be licensed.
- b. Product quality and uniformity can be controlled.
- c. Production operation can be conducted safely and efficiently.
- d. Production of a glass product can be accomplished without damage to man or the environment.

2.2 FUNCTIONAL REQUIREMENTS

The major functional requirements of the CCF may be summarized as follows:

- a. CCF/RSSF will receive calcine filled canisters from the RSSF. CCF/FRP will receive loose calcine direct from the FRP.
- b. CCF/RSSF will provide safe storage of canisters received during a period of up to 60 days.

- c. CCF/RSSF will remove calcine having a wide range of physical properties from canisters.
- d. Transport, blend, melt, cast and anneal the calcine and glass materials.
- e. Inspect and test the new containment canister.
- f. Transfer the glass filled canister to the PSW mold and test cell or the FRP water basin for storage.

2.3 DESIGN BASES AND PERFORMANCE CRITERIA

The bases and the performance criteria used for CCF design are summarized in this section; expanded requirements are enumerated in Section 3.1.

- o The CCF/RSSF design shall be based on receiving calcine in canisters 12.75" OD x 15' overall length containing 9.4 ft³ of calcine. The CCF/FRP will receive loose calcine directly from the FRP via a powder transfer device.
- o Normal processing rates shall be achieved with 5-year-old waste in the CCF/RSSF and 1-year-old waste in the CCF/FRP. Younger wastes may be processed in either facility on a demonstration basis with no production rate requirements.
- o The designed processing rate of the CCF/RSSF shall equal the calcine produced by an 8 MTU per day FRP. The CCF/FRP shall be designed to process the calcine from a 5 MTU per day FRP.
- o The handling and process equipment shall be designed to initially handle 12.75" OD x 15' long canisters. The structure shall be designed to handle canisters from 6" OD to 24" OD x 15' long after modification of process and handling equipment.
- o
- o The facilities shall be licensed in accordance with the appropriate Federal Regulations. All safety and environmental requirements shall be met.
- o The CCF/RSSF shall be adjacent to the RSSF and use the RSSF receiving facilities. The CCF and RSSF shall share utilities and services where it is practical and safe to do so.

- The CCF/FRP shall be adjacent to an FRP and use the waste canister storage facilities provided by the FRP. The CCF and FRP shall share utilities and services where practical.
- The product of the CCF shall be a glass material sealed in a metallic canister suitable for packaging for storage in the RSSF.

2.4 CCF/RSSF DESCRIPTION

2.4.1 Facility Description

In the present study the CCF/RSSF is a facility to be built adjacent to the RSSF receiving facility. If both facilities were designed and constructed simultaneously they could be totally integrated in a single structure. However there is a strong possibility that their construction schedules will not match; therefore, it is necessary to consider them as separate facilities that share the same site and use common services wherever practical.

The RSSF and the CCF/RSSF will be connected by a water canal between the structures to permit transfer of canisters of waste between facilities. Some common facilities are to be shared.

The conversion is performed in a series of concrete shielded process cells. Equipment and processes within the cells are controlled from an adjacent operating gallery. Shielding windows within the cell walls permit process observation. Manipulators are provided for minor adjustments and maintenance. Major material handling is performed by in-cell cranes and all process operations are controlled remotely from the operating gallery.

2.4.2 Process Description

The calcine is received in sealed canisters that are opened and emptied into a blender in the decanning cell. In the blender the calcine is mixed with glass forming materials, "frit". The mixture is then returned to the original canister, which has been placed in an electric furnace where the temperature is raised to the molten mixture temperature (about 1,000 °C). To avoid thermal shocks and resultant cracking of

the glass product, the canister of glass is cooled at a controlled rate. If the used canisters are judged unfit for reuse or more are required due to increased volume of the glass over the calcine, new canisters are introduced as required.

The canisters of glass are sealed by welding, checked for leakage, and decontaminated prior to return to the RSSF via the water canal.

2.4.3 Technology

The basic technology for the manufacture of glass from a variety of components is well understood and is in use in the commercial glass industry. Battelle Northwest Laboratory is currently adapting this technology to the conversion of radioactive calcine to glass.

2.4.4 Safety Considerations

The addition of a glass conversion process to the waste storage cycle introduces new steps and new risks. The new risks are those occasioned by the high temperatures required to melt the glass and the potential for contamination spread when the waste canisters are opened and the loose calcine is handled. These processing risks are controllable by proper facility design.

2.5 CCF/FRP FACILITY DESCRIPTION

2.5.1 Facility Description

The CCF/FRP will be built adjacent to an existing fuel reprocessing plant and will receive loose calcine directly from the FRP. This structure may contain the calciner and the waste storage basin which are totally the responsibility of the FRP.

The CCF/FRP will share facilities and services with the FRP wherever practical.

The conversion is performed in a series of concrete shielded process cells similar to those of the CCF/RSSF. However, fewer cells are required because the decanning and canister reuse operations have been deleted, and the CCF effluents will be routed to the FRP.

2.5.2 Process Description

The conversion process at the CCF/FRP will be identical to that of the CCF/RSSF. The CCF/FRP will also use the same equipment except that the younger waste of the CCF/FRP will require the removal of about six times as much decay heat from comparable quantities of solidified waste.

2.5.3 Technology

The CCF/FRP will use the same technology as the CCF/RSSF.

2.5.4 Safety Considerations

The conversion process for the CCF/FRP and the CCF/RSSF will introduce the same risks during the conversion operation; however, the consequences will be greater with the CCF/FRP because of the younger waste. The additional risk is compensated for by the fact that the waste will be reduced to a glass form at about 1 year of age compared to 5 years age for the CCF/RSSF. This 4 years' difference covers a period of highest radioactivity and decreased dispersibility during this period reduces the overall risk.

2.6 COSTS

Cost estimates have been developed based on the design described in this document. The estimated total project costs, including contingency and escalation, are \$80 million for the CCF/RSSF and \$60 million for the CCF/FRP.

5.2.1.1.1-1

SUMMARY COMPARISON OF TWO CCF CONCEPTS

	CCF/RSSF	CCF/FRP
Program Objectives	<ul style="list-style-type: none"> ● Demonstrate feasibility of production scale conversion ● Demonstrate safe process, quality product, no environmental damage. ● Provide technological bases for licensing future CCF's ● Minimize calcine backlog accumulation 	<ul style="list-style-type: none"> ● Same
Design Bases	<ul style="list-style-type: none"> ● Receive calcine canisters from RSSF. ● Routinely convert 5-year old waste. ● Capacity matches 8 MTU/day FRP ● CCF provides underwater storage ● CCF provides own effluent treatment ● Overpacks routinely required ● Reference canister size 12.75" OD x 15' long. ● Reference site Hanford reservation 	<ul style="list-style-type: none"> ● Receive loose calcine from FRP. ● Routinely convert 1-year old waste. ● Capacity matches 5 MTU/day FRP ● FRP provides underwater storage ● Host FRP provides CCF effluent treatment ● Overpacks seldom required ● Same ● Reference site AGNS Barnwell FRP
Cells	● 4 plus transfer	● 3 plus transfer
Schedule	● Hot startup Jan. 1933	● Same
Cost	● \$76,000,000	● \$56,000,000

3.0 PRINCIPAL DESIGN BASES

This section provides the principal design bases in the detail appropriate to the present design study effort. Subsequent sections provide a description of the two facilities. Certain of the design bases apply equally to both of the CCF concepts while others apply to only one concept or are different for the two concepts. The conditions are reflected in the following "design bases".

3.1 FORM OF RECEIVED WASTE

The waste to be converted by the CCF will be a stable, dry, solid, high level radioactive calcine as described in 10 CFR 50, Appendix F.

The waste will arrive at the CCF/RSSF sealed in stainless steel canisters nominally 12.75 inches outside diameter by 15 feet long; however, the size may vary from 6 to 24 inches in diameter and lengths from 10 to 15 feet.

Waste will be received at the CCF/FRP as a loose calcine material as discharged from the FRP calciner.

3.2 INCOMING LAG STORAGE

The CCF/RSSF shall have a water storage basin capable of storing 160 canisters to permit segregation of receipts from several FRPs, and provide lag storage for incoming canisters of calcine during CCF shutdowns.

3.3 AGE OF RECEIVED WASTE

The CCF/RSSF shall be designed to routinely process waste as young as five years out of the reactor. The facility shall also be capable of processing limited quantities of waste as young as three years under special conditions.

The CCF/FRP shall be designed to routinely process waste as young as one year out of the reactor. It shall also be capable of processing limited quantities of waste as young as six months out of the reactor.

The operation of either facility must also result in data that can be extrapolated to design a CCF that can process waste as young as six months out of the reactor as a routine, fullscale operation. The basis for the difference in the age of waste for routine processing is discussed in Section 5.2.

3.4 CONVERSION RATES

The CCF/RSSF shall be designed to convert the calcine generated by the reprocessing of 8 tonnes of uranium fuel per day (2,400 tonnes per year). The CCF/FRP shall be designed to convert the calcine generated by the reprocessing of 5 tonnes of uranium fuel per day (1,500 tonnes per year).

3.5 DISPOSITION OF CONVERTED WASTE

Sealed canisters of glass waste from the CCF/RSSF shall be transferred immediately to the RSSF where they will be sealed in casks for long term storage. Sealed canisters of glass waste from the CCF/FRP shall be placed in the FRP waste storage basin for additional radioactive decay prior to shipment to the RSSF.

3.6 TEMPERATURE RATE LIMITS FOR CALCINE

The decay heat from the calcine must be removed continuously to prevent overheating of the calcine and processing equipment prior to entering the melter. However, the time and temperature rise limits are still to be determined.

3.7 TEMPERATURE RATE LIMITS FOR GLASS WASTE FORMS

Temperatures of waste in process must reach the molten temperature during processing. After the annealing step is complete, the maximum rate of temperature change shall not be permitted to exceed 25 °C (45 °F) per hour.

3.8 PRODUCT AND CANISTER CRITERIA

Criteria for the glass product, glass canister, and calcine canister are in the process of being developed.

3.9 STRUCTURE AND SYSTEM DESIGN CLASSIFICATION

Structures and systems shall be classified as to their importance to the safety and operability of the CCF. The following classifications shall be used in establishing design requirements and quality assurance levels of effort:

Class I - Those structures and systems whose failure could cause the release of excessive amounts of radioactivity, or that are essential to safe shutdown.

Class II - Those structures and systems important to the operation of the CCF but not essential to safe shutdown.

Class III - Those structures and systems whose failure will not result in release of excessive amounts of radioactivity and whose operation is not essential to the CCF.

3.10 USE OF PROVEN TECHNOLOGY

The CCF is a near-term facility and must use existing technology, or technology that can be extended to meet CCF requirements with a high degree of confidence.

3.11 CONFINEMENT OF RADIOACTIVE MATERIALS

The CCF shall be designed for safe confinement, under all credible conditions, of all radioactive waste received at the facility.

3.11.1 Normal Operating Conditions

Under normal operating conditions, the release rate of radioactive material to the environs shall not exceed 10 percent of the amounts permitted in 10 CFR 20 for individuals and population groups in uncontrolled areas. The anticipated temporary malfunction of equipment or systems which require repair or replacement are considered to be "normal".

3.11.2 Abnormal Operating Conditions

Abnormal operating conditions might result from equipment failures, operating errors, or unplanned process variations that might occur sometime during the plant operating life.

Under abnormal operating conditions, the release rate of radioactive material to the environs shall not exceed the amounts permitted in 10 CFR 20 for individuals and population groups in uncontrolled areas.

3.11.3 Design Basis Conditions

Under design basis (maximum credible) accident conditions or natural phenomena, exposure to the general public as a result of the escape of radioactive material shall not exceed 2.5 rem, which is 10 percent of the exposure reference values stated in 10 CFR 100, paragraph 100.11.

Design basis accident and natural phenomena are highly improbable events which are not expected to occur during the plant operating life; however, design features which further reduce the probability and possible magnitude of waste confinement loss resulting from these events are justified by their potential consequences and shall be included. The design basis natural phenomena shall be determined for the CCF site as described in 10 CFR 100 and Design Guide 1.76.

3.11.4 Contamination Control

To the extent practicable, the facility will be operated "contamination free" outside of the cells. The design shall accommodate this philosophy by providing: (1) surfaces which can be easily decontaminated; (2) a decontamination system; and (3) isolation of high risk processes from those processes that are inherently less apt to release contamination to work areas.

3.12 MULTIPLE CONFINEMENT BARRIERS

At least two barriers shall be provided on any possible escape routes between stored or in-process waste and the environment.

Where either calcine or glass waste is in a sealed canister, the canister may be treated as one of the barriers. The second barrier may be an overpack, transport cask, cell or a series of components made up of water, heat exchangers, filters, and piping.

Where the canister does not form a confinement barrier, equivalent confinement functions shall be provided by the use of additional process enclosures such as storage bins and a process off-gas system.

3.13 RADIATION PROTECTION

Shielding shall be provided to protect plant personnel from all sources of radiation to assure their radiation exposure is within the requirements of 10 CFR 20. Interlocks and automatic detection alarms shall be used to prevent personnel from entering high radiation zones and to warn them of high radiation levels.

3.14 RECOVERY FROM EMERGENCY CONDITIONS

A number of abnormal events can be expected to occur during the lifetime of the CCF and there is a probability that

accidents will occur. In addition to showing, by safety analysis, that such events will not cause undue risk to the health and safety of the public or plant personnel, it must be shown that the facility can be returned to normal after any abnormal event or design basis accident.

The probability of the simultaneous occurrence of two design basis events is not considered credible and need not be covered by the CCF design. However, assuming the occurrence of a single design basis event, it shall be practical to place the CCF in a condition to withstand a second design basis event within 30 days after the first event. The second event may be a repeat of the first event or any of the other design basis events.

3.15 EMERGENCY PLANNING

Emergency planning requirements, including space for storage of emergency equipment, shall be considered during design to assure (1) that the facility features provide for ease of evacuation and other emergency requirements and are coordinated with the overall plant complex emergency plan, and (2) compliance with 10 CFR 20.

3.16 COMPLIANCE WITH REGULATIONS, CODES AND STANDARDS

The CCF will be a licensed facility complying with federal, state and local regulations. The design and the manufactured and structural components of the installation shall comply with applicable national codes and standards. Exceptions shall be noted and the basis for the criteria used documented.

Following is a tabulation of the regulations, codes and standards considered applicable to the CCF. Compliance with additional criteria referenced therein is required as applicable.

3.16.1 Code of Federal Regulations

- Title 10, Part 20, "Standards for Protection Against Radiation"
- Title 10, Part 30, "Rules of General Applicability to Licensing Byproduct Material"
- Title 10, Part 40, "Licensing of Source Material"
- Title 10, Part 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection"

- Title 10, Part 70, "Special Nuclear Material"
- Title 10, Part 71, "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions"
- Title 10, Part 73, "Physical Protection of Plants and Materials"

3.16.2 State and Local Regulations

Applicable state and local regulations and ordinances shall be determined for each site. Compliance is required if these are more restrictive than Federal regulations.

3.16.3 Codes and Standards

The Atomic Energy Commission "Regulatory Guides" shall be used to implement the requirements in the referenced Parts of the Code of Federal Regulations. National codes and standards are referenced in the Regulatory Guides and compliance is required.

The design and fabrication requirements specified in the following sections of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) shall be used as applicable:

- Section II, "Material Specifications"
- Section III, "Nuclear Power Plant Components"
- Section V, "Nondestructive Examination"
- Section VIII, "Pressure Vessels" (Division 1)
- Section IX, "Welding Qualifications"

An ASME "N" stamp is not required for any components.

4.0 CONCEPT DESCRIPTIONS

Both of the alternative CCF designs are described in this section. General features shared by both CCF designs are discussed in 4.1. Specific functional design requirements and concept descriptions pertinent to the individual CCF concepts are then discussed in following subsections.

4.1 GENERAL FEATURES COMMON TO BOTH CCF CONCEPTS

4.1.1 Receiving Facilities

Neither CCF concept requires receiving facilities for rail or truck shipments of calcine in shielded shipping casks. In the case of the CCF/FRP, calcine comes to the CCF via pipeline from the host plant. In the case of the CCF/RSSF, the RSSF provides the receiving facilities and transports calcine canisters to the CCF via a water canal, as illustrated in Drawings 7238-100-AR-1 (Plans) and 7238-100-AR-2 (Sections).

4.1.2 Water Basin Storage

Water basin storage facilities are required for both concepts, but for different reasons.

- The CCF/FRP requires water basin storage facilities for canisters of glass in order to remove decay heat until the canisters' heat output is low enough to permit economical shipping to the RSSF. This storage basin will be provided by the host FRP.
- The CCF/RSSF requires water basin lag storage facilities for incoming calcine canisters from the RSSF, to permit segregation of calcine from the various reprocessors until enough calcine has accumulated for an economical batch run of each type of calcine. Lag storage is also needed during short shutdowns of the RSSF. This storage basin will be provided in the CCF/RSSF design, and must be large enough to store 160 canisters of calcine.

In both cases, regardless of how the water basin storage facilities are provided, they must meet the following functional requirements.

- Maintain the waste in a safe condition at all times, including the duration and aftermath of all credible naturally occurring events. Class I construction is required.

- Provide a safe heat sink which will allow adequate time to recover from loss of mechanical water circulation and heat removal.
- Provide containment within the system for radioactive material which might escape from the canisters, and also provide for the subsequent removal of such material in order to return the system to a safe and tolerable level of contamination and radiation.
- Provide radiation shielding sufficient to reduce occupational exposure of operating personnel to as low as practicable levels.
- Maintain water quality to prevent corrosion of the stainless steel canisters.
- Prevent the accidental lowering of the basin water level more than 12 inches.

4.1.3 Utilities

In general the two concepts require the same type of utilities but capacities may vary. Both will be self-sufficient, except for some instances where the host facility may be able to supply a portion of the needs. Functionally, the requirements for both concepts are the same and the design of each utility system must satisfy all operating and safety demands under normal and accident conditions. Those utility systems or portions of systems which serve or support a Class I function will be enclosed in Class I structures.

The following utilities will be supplied per Drawings 7238-100-PR-3 and 7238-100-PF-3.

- Water system for fire protection, demineralized water, potable water, soft water, cooling water, and emergency cooling water;
- Electrical system providing incoming utility power, emergency diesel-generated power, and emergency non-interruptible battery and inverter power;
- Compressed air system providing for both building and instrument uses as separate systems, and for process requirements;
- Building heat;

- Fire protection, detection, annunciation, and quenching;
- Sanitary system;
- Fuel oil for diesel and other use;
- Aqueous makeup.

4.1.4 Support Facilities

Both of the CCF concepts require the same general support facilities, but they vary somewhat in detail.

4.1.4.1 Waste Treatment Facilities. All liquid and gaseous effluents from the process equipment, decontamination activities, and operations must be treated to reduce their radioactive constituents to levels permitted in Section 3.10. The CCF/FRP will utilize the effluent cleanup system of the host plant to accomplish this functional requirement, while the CCF/RSSF will provide its own cleanup system.

Solid wastes generated by both facilities will be suitably packaged for storage at an approved site.

4.1.4.2 Ventilation. The ventilation system for all contaminated and potentially contaminated areas of the buildings shall be of the once-through type. Conditioned air will flow from the clean areas through the progressively higher contamination areas; the final exhaust air is passed through sufficient stages of HEPA filtration to reduce the concentration of radioactive particulates to levels permitted in Section 3.0. Monitors which both record and annunciate alarms shall be installed in the exhaust stack, upstream of the first stage of HEPA filtration, and at other selected locations.

The ventilation system shall be of Class I construction and be safely operable by the emergency power from the diesel generators. The systems are shown in Drawings 7238-100-HVR-4, 7238-100-HVR-5, 7238-100-HVF-4, 7238-100-HVF-5, and 7238-100-L-7.

4.1.4.3 Radiological Protection and Instrumentation System. All variables important to safety will be monitored over their minimum-maximum ranges, recorded, and annunciated in the control room when alarm set points are exceeded. The control room will have communications equipment which can spread alarms and direct corrective action.

Specific functional requirements are:

- Detect radiation and airborne particulate radioactive material in all areas occupied by people, display the readings as dose rate or counts per minute as appropriate, and alarm when levels exceed pre-set limits.
- Detect radioactive material on the surfaces of objects and people.
- Detect radioactive material in all CCF effluents, and alarm this condition.
- Detect and alarm other conditions which affect safety, such as exhaust air system failure, instrument air system failure, low voltage, failure of the emergency power system, full liquid waste tanks, open air lock doors, fire, unauthorized intrusion, etc.

4.1.4.4 Maintenance and Administration. Both CCF's will be self-sufficient, regarding facilities and manpower, in performing their own routine maintenance and immediate administration. It is not intended, however, that the CCF's be equipped to perform major shop work, develop and mock up large equipment items, repair and calibrate intricate instrumentation systems, or stock large quantities of supplies and spare parts. For these types of services, and also for major administrative support, the CCF's will both depend upon the Operations Contractor at the site upon which they are located.

4.2 CCF/RSSF CONCEPT

4.2.1 Functional Design Bases

The specific functional design bases are given in Section 3.0.

4.2.2 Facility and Equipment Arrangement

The CCF/RSSF is a separate, self-sufficient facility located adjacent to the RSSF. A covered water canal will connect the CCF/RSSF and the RSSF. The CCF/RSSF building is a combination of reinforced concrete and insulated metal construction, and contains the hot cells for the conversion equipment and necessary support facilities. The building is shown in plan and section in Drawings 7238-100-AR-1 and 7238-100-AR-2.

The reference site is the Hanford reservation.

Because of the nature and quantity of the radioactive material being handled and processed, all structures concerned with these activities are of Class I construction, as are those support systems which are vital to the protection of workers, the environment, and the general public.

4.2.3 Operational Description

After receipt at the RSSF, calcine canisters are unloaded from the shipping cask into an RSSF cell, visually examined, and a smear is taken. If acceptable for further transport and receipt at the CCF, the canisters are cooled, placed into a water canal and moved to the CCF. The canisters may either be temporarily stored in the lag storage pool or transferred directly into the decanning and conversion cell.

In the decanning and conversion cell the canister is opened and a valved adaptor is installed in place of the removed lid. The canister is then inverted and connected to the crusher. Mild vibration is applied to empty the contents into the crusher. After agglomerates have been crushed, the calcine is transferred to a blender. There it is blended with glass-making frit in the proper proportions.

The previously emptied canister is transferred into the incanister glass-making furnace and connected to the blender. Blend is fed into the canister. As melting proceeds more blend is added until the canister is filled to the correct level with glass.

The molten glass is slowly cooled, to reduce cracking, until it is cool enough for air transfer. The canister is disconnected from the blender, the final lid mechanically installed, and the canister transferred to the product quality assurance cell. Because of the slow cooling step, six furnaces are provided to assure an average production rate of 2 canisters per day.

The closure weld is made and leak tested. The canister is then cooled to the point where water decontamination will not significantly thermally shock the canister or the glass, and the canister surface is decontaminated to levels acceptable to the RSSF. The canister of glass is then placed in the transfer canal and transported back to the RSSF where it is processed for storage.

More detailed descriptions of the important operating steps follow.

4.2.3.1 Receiving. Canisters of calcine are received at the RSSF from the fuel reprocessing plants. Following inspection for physical integrity and smearable surface contamination, the canisters are cooled to a point approved for water immersion.

4.2.3.2 Transfer. The cooled canisters are transferred to the CCF/RSSF via a covered water canal which is provided with a suitable conveying system. The concrete canal is lined with stainless steel, and is the same depth as the lag storage pool with which it connects. Water quality and contamination level are maintained by the same equipment which performs these functions for the lag storage pool.

At the opposite end of the storage pool the conveyor continues through a short length of canal, terminating underneath the decanning and conversion cell, where the in-cell crane can pick up the canister.

4.2.3.3 Storage. If a canister is to be stored instead of going directly into the process, the conveyor will stop in the lag storage pool. The overhead crane servicing the pool will then remove the canister and place it into a selected storage position. The concrete pool is lined with stainless steel to reduce leakage and permit monitoring for leaks. This lining also aids in preserving water purity. An ion exchange system is provided to remove radioactive material from the water and to maintain the purity of the water. The pool contains storage racks for canisters, which are so designed that any selected canister can easily be retrieved by the overhead crane and placed on the conveyor.

4.2.3.4 Decanning. Upon receipt in the decanning-conversion cell, the canister is placed in the decanner. This equipment is designed to cut out the seal weld at the top of the canister and remove the lid. It will also be able to cut off the entire top of the canister if necessary.

When the lid has been removed, an adaptor lid is installed which contains a large valve. The canister is then turned upside down and the adaptor engaged with the crusher.

4.2.3.5 Crushing. The valve is opened, and the calcine flows into the crusher with the aid of mild vibration of the canister.

In case some of the calcine has agglomerated into lumps or clinkers, a crusher is required to reduce all calcine particles to allow transport and adequate mixing with glass formers.

4.2.3.6 Blending. The calcine is fed into blenders where it is mixed with the appropriate quantity and type of glass-making frit.

4.2.3.7 Melting. A distribution system feeds blend to any of six furnace-coolers into which are placed empty, used calcine canisters with lid adaptors to connect to the distribution pipes. Blend is fed into a canister, and as the bottom portion melts more blend is added until the level of molten glass reaches the desired height. The melt is then furnace cooled slowly until the glass is at equilibrium temperature.

4.2.3.8 Welding. The canister of glass is then removed to the product quality assurance cell where a new lid is welded in place. At least initially, the canister will then be overpacked in a new canister.

A selected few of the old, used calcine canisters will be destructively examined at some appropriate hot lab facility in order to determine whether or not they could be approved as primary containment for glass. If used canisters can be approved, then the expensive step of overpacking could be eliminated.

The final closure weld will be helium leak-checked.

4.2.3.9 Decontamination. Two methods of canister decontamination will be provided; high pressure water sprays and ultrasonic cleaning baths. These methods will be repeated, if necessary, until smear survey shows the canister to be clean enough to be transferred to the RSSF.

4.2.4 Maintenance and Repair

All of the in-cell equipment will be designed for remote maintenance and repair and also for remote replacement. Selected spares will be kept in stock.

When maintenance and repair work cannot be successfully performed in place, the equipment item will be disconnected, decontaminated as much as possible, and transferred to the maintenance cell with the canyon crane. If it cannot be successfully repaired there, it will be removed into a shielded burial box and loaded onto a truck in the truck airlock. Replacement equipment will follow the reverse path into the process cell.

All other maintenance and repair work, including what is required for manipulators, will be done by contact. Manipulator work will be done in a special shop which is partitioned into a warm and cold area.

4.2.5 Sample Analysis

At various stages in the process, samples of blend and product are taken as control and QA measures. These samples are pneumatically transferred to the analytical cell where they are examined. Some samples will be stored as archive samples.

4.3 CCF/FRP CONCEPT

The CCF/FRP is very similar to the CCF/RSSF in that both facilities will be designed to convert calcine to glass to make it more satisfactory for long-term storage in the RSSF. Both facilities will consist of a series of remote process cells containing equipment to melt the frit/calcine mixture and seal it in high quality canisters.

The following sections will describe the significant details of the CCF/FRP

4.3.1 Functional Design Bases

Specific functional design bases are given in Section 3.0.

4.3.2 Facility and Equipment Arrangement

The CCF/FRP is housed in a reinforced concrete structure adjacent to the FRP and is shown on Drawings 7238-100-AF-1 and 7238-100-AF-2. Two processing cells are provided, one for blending and melting the frit/calcine and the other for sealing the canisters and performing QA operations. These cells are supplemented by an analytical cell and a hot maintenance cell. The cells are arranged in a single line and are covered by a shielded canyon equipped with a crane that can move equipment from cell to cell for maintenance purposes after removal of cell cover blocks.

The operating gallery is on the front of the line of cells. It is equipped with viewing windows to observe cell operations and with master-slave manipulators to aid maintenance. Each cell has an in-cell bridge crane to handle canisters of glass and assist with maintenance operations.

A service gallery abutts the back of the cells and is used for bringing services to and from the cell spaces. No viewing windows are provided between the cells and the service gallery.

A drain system and ventilation ducts are in the space below the cells.

Spaces for personnel, utilities, control rooms, etc., are provided at appropriate locations outboard of the service and operating galleries.

4.3.3 Operational Description

The calcine is received as a continuous stream from a calciner located in the FRP. The calcine is mixed with a predetermined amount of glass frit in a rotating blender. The blend is periodically sampled and analyzed before being dumped into a new stainless steel canister in a melter/cooler unit. At about 1,000 °C the blend will melt and slump in the canister making it necessary to add more blend to fill the canister. After one or two supplemental fillings, the canister will be 80-90 percent full of glass and will be ready for the cooling phase of the cycle. Cooling will be at a controlled rate to avoid temperature shocks to the glass monolith. After the glass is properly cooled, the cover is welded to the canister and the assembly is tested to be sure it meets the process standards.

The decay heat of a representative canister of glass 1 foot in diameter by 15 feet high is about 50 kilowatts, which will reheat the canister of glass at about 3 °C per minute if no heat is removed. This makes it necessary to keep the canisters of glass in cooled stations except for brief periods in air during transfer from station-to-station. When all processing operations are completed the canisters of waste are placed in a water basin for a period of several years until the decay heat reduces to 5-13 kw per canister and the canister of waste can be shipped to the RSSF for long-term storage.

Canisters used for product glass from the CCF/FRP are new and of very high quality. They enter the calcine conversion cell from the canyon area via shielded air locks and are moved by an in-cell crane to one of the melters.

After being filled with the waste/frit mixture, which is then melted and solidified, the canister of glass is moved by the in-cell crane to the decontamination station or directly to

the intercell transfer system. This system moves the canister of glass through an air lock in the cell wall to the QA cell where it is picked up by an in-cell crane and placed in the canister welding mechanism.

The QA cell crane moves the canister from station-to-station in the QA cell and finally places it in an arm of the water storage basin that extends into the QA cell. From this point the canister of glass is transported under water in canals that connect to the water storage basins.

4.3.4 Maintenance and Repair

The environment within the process cells will be highly radioactive from materials inside the equipment or firmly attached to surfaces making it impractical to clean the cells for personnel entry. Maintenance of equipment within cells will be performed in the following manners.

- All possible cell auxiliary or control equipment will be installed outside the cells to permit contact maintenance.
- Items of low contamination level may be located in service gallery niches or small compartments which can be decontaminated and opened for contact maintenance.
- Minor maintenance and adjustment of in-cell equipment will be performed by master-slave manipulators and in-cell bridge cranes. Tools and replacement parts for such maintenance will enter and leave via pass-through openings or through canister passageways.
- Maintenance jobs beyond the capability of the in-cell equipment will require the use of the remote canyon crane after removal of cell cover blocks. Extensive decontamination of cell interiors will be required before removal of cover blocks. The maintenance operations to be performed in this category will normally consist of remote removal and replacement of large components without attempting to make immediate repair of components.
- Failed equipment remotely removed from process cells will be transported by canyon crane to the maintenance cell for further decontamination prior to repair or disposal.

4.3.5 Waste Disposal

The operation of the conversion equipment and its auxiliaries will release small amounts of calcine to the cells. This

calcine must be collected and stored. The interactions of this collection and storage system with other parts of the CCF and the FRP is quite complex and only the bare essentials are covered below.

4.3.5.1 Solid Waste Materials. Occasional leakage or spills of waste in process are expected to occur. Such material will be retrieved and returned to the process wherever possible by use of vacuum cleaners, etc. Materials not returned directly to the process may become airborne or may fall to the cell floor. Waste which stays airborne for a few minutes will be picked up by cell exhaust filters; waste which falls to the floor (or settles on equipment) may be removed by vacuum cleaning or by water flushing during occasional cell decontamination efforts.

Contaminated filters will join items of failed cell process equipment and tools for packaging and disposal with FRP solid wastes.

4.3.5.2 Liquid Waste Effluents. Water that has been used for flushing, or has become contaminated by any means, will be collected in a cell drainage system and sent to the FRP for treatment by evaporation and/or ion exchange.

4.3.5.3 Gaseous Effluents. The melting process will release radioactive gaseous materials due to the high temperatures reached in the melting process. This system, as well as other process equipment and piping containing loose calcine, will be treated as a process off-gas system operated under a slight negative pressure to make sure all leakage is inward. The discharge from the process off-gas system will be returned to the FRP for treatment in the FRP off-gas system.

4.3.5.4 Cell Exhaust Air. Air will be circulated through the process cells to provide cooling and to maintain airflow in the proper direction. Such air will pick up loose contamination which must be removed before release to the environs. This is accomplished by multiple HEPA filters in series, the first filter in each series being within the process cell where it can be removed remotely and treated as solid waste (see 4.3.5.1). Subsequent filters will be an exterior fan-filter facility. The system is illustrated in Drawings 7238-100-HVF-4, 7238-100-HVF-5, and 7238-100-L-7.

5.0 TECHNICAL ANALYSES

5.1 WASTE CHARACTERISTICS

The high level waste calcines arriving at the CCF for conversion to glass may vary widely in their physical, chemical, and radiation characteristics. Differences in fuel type, reprocessing flowsheets, and calcination procedures will be contributors to these variations. Time from reactor discharge has a major effect on the thermal and radiation properties of nuclear wastes.

Calcines are formed by thermal treatment of aqueous waste solutions to form dry solids which are principally oxides of the various waste constituents. Alkali metals, whose oxides are relatively unstable, are a partial exception. In waste containing significant alkali metal concentrations it will probably be necessary to convert the alkali metals and nitrates to compounds more stable than simple oxides before shipment to the CCF or RSSF.

Shipments to the CCF through the year 1990 will result predominantly from LWR-U processing, which is the reference design. Projections indicate a small amount of PWR-Pu and HTGR waste may also have reached the 10 CFR 50 age limit of 10 years by 1990. It should therefore be possible to accommodate small amounts of these wastes in the CCF by flowsheet adjustments or other techniques.

Certain assumptions are made concerning other characteristics of the waste.

- Stability

The dry solid is chemically, thermally, and radiolytically stable to the extent that (1) the equilibrium pressure in the sealed canister will not exceed the safe operating pressure for the canister during the period from canning through a minimum of 90 days after receipt at the CCF, and (2) corrosion of the canister material will not decrease the required design strength of the canister.

- Decay Heat

The radioactive heat generation of each reference design canister (12.75" OD x 15' long) will not exceed 13 kilowatts at the time it leaves the CCF for storage at the RSSF.

- Physical Form

Ideally, the waste calcine will be a free-flowing, homogeneous powder with a well characterized uniform particle size. Alternatively, the waste calcine may be loosely consolidated. In all events, it should be amenable to draining from the canister upon receipt at the CCF/RSSF, with no more than mild external impacting of the canister walls being required to expedite the removal.

5.2 PLANT CAPACITY AND AGE OF WASTE

5.2.1 CCF/RSSF

The CCF/RSSF will be designed to convert, on a routine basis, the calcine generated by the reprocessing of 8 tonnes of uranium fuel per day (2,400 tonnes per year) as young as five years out of the reactor.

5.2.1.1 Discussion of Plant Capacity. The bases for developing the capacity of the CCF/RSSF are the modified predictions of reprocessing loads and startup dates contained in ORNL-TM-4631, August 1974, J. O. Blomeke, C. W. Kee and R. Salmon, "Projected Shipments of Special Nuclear Material and Wastes by the Nuclear Power Industry." These projections were modified by ARHCO to reflect recent known changes in startup dates and waste solidification plans for the FRP's. Figure 5-1 shows these projections as the accumulated backlog of calcine filled canisters (1' in diameter x 15' long), and shows the effect on this backlog when the CCF/RSSF goes into operation in January 1983, with the capacity to convert the calcine produced from reprocessing 8 MTU per day.

It appears reasonable that the fuel reprocessors will have the capability to incorporate their calcine into glass by 1990; thus, no additional calcine filled canisters will be generated beyond that date. The CCF/RSSF can work off the backlog of 5,300 canisters, at the rate of 600 per year, by the year 1999. This would appear to be a reasonable plant lifetime of less than 20 years.

With this capacity to convert the calcine resulting from reprocessing 8 MTU per day, the CCF/RSSF can adequately demonstrate the calcine conversion process and the capacity will closely approach that which is forecast for future fuel reprocessing plants.

FIGURE 5-1

CALCINE CANISTER ACCUMULATED BACKLOG
AND CCF/RSSF WORKOFF

However, since this CCF/RSSF capacity will produce a backlog of approximately 5,300 canisters by 1990, storage of the backlog will be a significant problem. Reducing this backlog could be accomplished by (1) increasing the capacity of the CCF/RSSF after the first few years of operation, (2) building a second CCF/RSSF, or (3) shortening the time when industry CCF's can be on-line. It does not appear practical at this time, from a material handling and technology standpoint, to increase the capacity of the first CCF to demonstrate the calcine conversion process beyond two canisters per day (waste equivalent to 8 MTU/day).

5.2.1.2 Discussion of Age of Waste. The bases for establishing the normal age of calcine to be converted at the CCF/RSSF are also the predictions of ORNL-TM-4631. From the calculated heat loads at various ages, and the practicalities of shipping cask size, weight, and heat removal systems, it appears that five-year-old waste would be the youngest waste which is practical to ship. This age is therefore the design base for the CCF/RSSF normal operation, and is used for shielding calculations, heat removal within the process equipment system, cell heat loads, etc.

For demonstration purposes, it might well be desirable to convert three-year-old waste on a one-time or occasional basis. The batch used would be smaller and perhaps some equipment alterations would be necessary; but, such a demonstration would be feasible. The data from this demonstration could be extrapolatable to six-month-old waste, although it is not considered reasonable to attempt an actual demonstration. This is primarily because the effluent cleanup system probably would not be able to safely contain the shorter-lived effluents.

5.2.2 CCF/FRP

The CCF/FRP will be designed to convert the waste from 5 tonnes of uranium fuel per day (1,500 tonnes per year) as young as one year out of the reactor. Limited amounts of fuel as young as six months out of the reactor will also be converted under special conditions.

It must also be possible to extrapolate the data from the special testing to the design of a facility that can convert waste six months out of the reactor as a routine full-scale operation.

5.2.2.1 Discussion of Plant Capacity. The CCF/FRP is to become an annex to a fuel reprocessing plant with the prime purpose of converting the calcine from that FRP to a glass product suitable for storage in the RSSF. It would appear, therefore, that the CCF capacity should be identical to that of the FRP that it serves. Since current conceptual plans call for the CCF/FRP to be adjacent to the 5 tonnes of uranium fuel per day Allied General Nuclear Services, it should have the capacity for processing the waste from that amount of fuel. Factors tending to contradict such a decision include the following:

- Backlog Disposal

The CCF may not get started as soon as the FRP, and the FRP may be producing calcine which will be stored in the FRP basin until it can be converted in the CCF. In the case being considered, the tentative startup date for AGNS calcine production is 1979, and the tentative startup date for the CCF is 1983. Allied General Nuclear Services will have storage space for one year's waste production as a liquid, leaving three years' waste at 1,500 tonnes/year, which will backlog as a calcine. The calcine from 4,500 tonnes would fill about 1,000 standard canisters 12.75 inches in diameter by 15 feet long.

The above is believed to be the worst backlog condition. This amount of backlog might prove difficult to handle in a reasonable length of time. However, a delay in AGNS startup or a failure to negotiate a working agreement between the ERDA and AGNS would modify the above hypothesis. The decision to design the CCF for 5 tonnes per day capacity must be re-examined in the light of later developments.

Another factor to be considered is the possible shipment of the calcine generated prior to the availability of the CCF to the RSSF. Such material could be stored in the RSSF as a calcine, or returned to the CCF at a later date, to be converted to a glass form.

- Calcine From Another FRP

It might be worthwhile to provide extra capacity at a single CCF/FRP to permit it to convert calcine from other FRP's, thereby reducing the number of CCF's required by industry. This idea was abandoned because

the resulting facility would become very similar to the CCF/RSSF and could best be accomplished by changing the site of the CCF/RSSF to the vicinity of an FRP.

- Pilot Plant at an FRP

Another alternative would be to design a small-capacity pilot plant adjacent to an FRP. This arrangement would permit process demonstration without regard to throughput rates. However, this approach would delay the availability of a full-scale CCF, and the backlog of calcine would be substantial.

5.2.2.2 Discussion of Age of Waste. A basic requirement for an FRP handling fuel from early light-water reactors is that the fuel must be about six months out of the reactor before being reprocessed. This permits decay of short-life fission products. The high level waste from the fuel may be either converted immediately to calcine (as planned by General Electric) or stored as a liquid for as long as five years, as permitted by 10 CFR 50, Appendix F. Current plans at AGNS provide a liquid storage averaging about six months, for a total time out of reactor of one year.

The age of waste will have a substantial effect on the CCF design because of the higher heat loads and higher radiation intensity. One-year-old waste was selected as the nominal design age for the first CCF/FRP since that is believed to be the minimum age of waste that will be processed through the AGNS facility under normal conditions. However, in recognition of the fact that AGNS may decide to eliminate the liquid storage step, or that other FRP's may be designed without any liquid storage, the CCF/FRP will be designed to handle six-month-old waste on a demonstration basis.

The essential differences between CCF's for young waste and those for older waste are (1) younger waste generates more heat requiring special equipment designs to prevent overheating; (2) younger waste releases more radioactive off-gas; and (3) younger waste has higher radiation levels, which will require additional personnel shielding and will shorten the life of organic materials, thereby requiring additional maintenance.

5.3 WASTE ACCEPTANCE CRITERIA

The CCF/RSSF shall be designed and equipped to accept the same calcine that is acceptable to the RSSF. The criteria are in the process of being developed.

The CCF/FRP shall be designed and equipped to convert whatever calcine is produced by its host plant.

5.4 SITE DESCRIPTION

Formal selection of a site for the RSSF and CCF/RSSF has not yet been announced by the ERDA. However, a reference site located at the ERDA's Hanford reservation has been selected for use in those aspects of the conceptual design which require specific site information. The conceptual design is intended to represent a facility which could be located at any government-owned site in the United States at which certain minimum required site characteristics are met. It is believed that the Hanford reference site features are sufficiently typical of other potential sites to facilitate reevaluation and modification of site-related design features when the selected site is announced.

5.4.1 Location

The reference site is located within the ERDA's Hanford reservation in the southeastern part of the State of Washington, as shown in Figure 5-2. The Hanford reservation has served as a nuclear center since 1943, and has not been opened to the public since its inception.

The specific reference site lies on a plateau near the geographical center of the reservation, near the 200 West Area, as shown in Figure 5-3. The site area available is about 2,000 acres of which about 1,100 acres would be needed for the RSSF and a CCF. This area includes Section 35 and portions of Sections 31 and 36 of Township 13 North, Range 26 East. The plot plan is shown in Drawing 7238-100-CR-6.

The reference site for the CCF/FRP is the Allied General Nuclear Services Plant, whose site information is published in their Final Safety Analyses Report Docket No. 50-332. The plot plan is shown on Drawing 7238-100-CF-6.

The detailed characteristics of the Hanford site are reported in WASH-1539 (Draft), "Environmental Statement, Management of Commercial High Level and Transuranium-Contaminated Radioactive Waste," September 1974.

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FIGURE 5-2
LOCATION OF HANFORD AEC RESERVATION

FIGURE 5-3

MAP OF HANFORD AEC RESERVATION

5.5 SHIELDING

For the purposes of this comparison study, the cell wall shielding provided (6 ft of ordinary concrete or 4 ft of high density concrete) for both concepts is the same. After one concept is selected for continuing conceptual design work, a more sophisticated shielding analysis will be made.

5.6 GLASS CHARACTERISTICS

Glass formed in the CCF will be a silicate with additions of zinc, boron, alkali and alkaline earths, and/or lead. The glass will be formulated to achieve a highly nonleachable product containing 20-35 weight percent calcine. The fission products and actinides in the calcine become part of the glass matrix, thereby greatly reducing their potential for dispersion into the biosphere.

Glass has tremendous strength in compression, but can be cracked by rapid cooling. The severity of cracking is a direct function of the cooling rate. The thermal conductivity of high level waste glass is about $0.8 \text{ watts/m}^2/\text{°C/m}$ at room temperature and increases as much as a factor of 4-10 between room temperature and $1,000 \text{ °C}$. The glass has a density of over 3.2 g/cc and does not contain open porosity.

While the quantity of glass produced will be a function of the chemical composition of the calcine, a relatively pure calcine can be expected to have a glass volume of about 1.4 cubic feet per tonne of fuel reprocessed. The total volume of waste will increase due to addition of glass frit and an average value of 2 cubic feet per tonne of fuel has been assumed as a basis for conceptual design.

Criteria for the glass product are still under development.

6.0 SAFETY ANALYSIS

6.1 INTRODUCTION

This analysis presents the safety considerations which pertain to the planned CCF, whose function is to convert calcine into a glass material on a demonstration plant scale.

The primary advantages to be attained by incorporation of calcine into glass are more favorable leachability and dispersibility characteristics, resulting in reduced risk of accidental waste transport into the surrounding environment. Waste leachability in water would be reduced by a factor of about 100,000 and dispersibility would be reduced by virtue of the particle size ranges being measurable in inches, rather than in millimeters or microns. The monolithic glass form also provides about a factor of four improvement in heat transfer characteristics (i.e., increase in bulk thermal conductivity) over the calcine form.

The safety analyses which have been performed at the current state of CCF design development are preliminary due to the preliminary design status. Additional and more detailed safety analyses will be required as the design work progresses. Safety analysis topics requiring additional process or facility definition are identified in these preliminary analyses.

The purpose of these preliminary analyses, developed in conjunction with the facility preliminary design, is to evaluate engineered features which prevent or mitigate potentially unacceptable safety hazards and to identify areas requiring further design development and safety analysis. The conditions and accidents which the facility will be designed to accommodate and control range from those common in all industrial glass production facilities to those specific to plants in which radioactive materials are handled and stored. The safety considerations described in this section are primarily those having potential for loss of radioactive material confinement and/or having the capability of exposing either operating personnel or the general public to a radiation dose in excess of acceptable limits. It is assumed that other types of industrial accidents (e.g., motor vehicle collisions, electrical shock, burns, falling, etc.) are amenable to resolution by standard design practices, administrative control, and industrial safety procedures.

The main steps in the processing of calcine through the CCF where accidents could most probably occur are as follows:

- Receipt of canisters containing calcine from the RSSF
- Optional lag storage of calcine canisters in a water basin
- Removal of calcine from canisters
- Transport and particle size reduction of calcine
- Transport of crushed calcine and blending with glass frit
- Melting, casting, and annealing to form the glass product
- Inspection, sealing, and testing of glass product canisters
- Transfer of glass product canisters to the RSSF.

The CCF would be either an addition to, or an integral portion of another facility. Therefore, these safety analyses have been directed primarily toward safety considerations which are specific to the incorporation of calcine into a glass material. Other specific safety considerations which are identical or similar to those encountered in the other facilities are treated in only a cursory fashion in these safety analyses.

Since the CCF would be built and operated in conjunction with another facility, there would be some safety-related general design philosophies, structural requirements, and administrative policies which would be applicable to both facilities as a whole. Therefore, these items, as they apply to the CCF, are included in this safety evaluation to insure a more complete presentation.

Three categories of operating conditions and accidents have been considered in the safety analyses: (1) normal operations, (2) abnormal operations, and (3) improbable events. This categorization is based on a qualitative evaluation of probability (or frequency) of occurrence and severity of release consequences, as compared to applicable maximum radionuclide concentration and/or radiation dose limits. Further definition of these operating and accident categories is provided in the following paragraphs.

6.2 NORMAL OPERATING CONDITIONS

Radioactive material releases during normal operating conditions involve very small quantities of radioactive materials released during routine planned operating conditions. Normal operations include some anticipated equipment or process failures that require deviation from routine procedures, but do not include those failures which result in lengthy shutdown time or which cause a radioactive material release from its normal confinement.

During normal operations, the radiation exposures to the general public and the radionuclide concentrations in plant liquid and gaseous effluents shall be in accordance with the ERDA's policy of maintaining releases as low as practicable. In any event, these exposures and concentrations will be no greater than 10 percent (arbitrarily determined design philosophy value) of the maximum limits presented in 10 CFR 20.

6.3 ABNORMAL OPERATING CONDITIONS

The CCF will incorporate design features which mitigate the consequences of postulated abnormal operating conditions and which facilitate safe recovery from such situations. The conditions considered in these safety analyses include those that might result from major equipment failures, operator errors, or unplanned process variations which may occur sometime during the plant operating life. Some of these abnormal conditions are expected to result in minor contamination spread; however, such contamination will be predominantly confined to operating areas and recovered. In any case, abnormal operation shall not result in radiation exposure to operating personnel or to the general public in excess of the limits presented in 10 CFR 20. Furthermore, the result of abnormal operating conditions, in terms of average radionuclide concentrations, both within and beyond the site boundary, shall not exceed the limits.

Certain abnormal operations create a potential for radiation exposure to operating personnel, radioactive material released (in liquid or gaseous effluents), or inadequate removal of radioactive decay heat. Therefore, the concrete shielding used for CCF hot cells will be designed for continued effectiveness during and after credible abnormal and accident occurrences. Confinement barriers to an atmospheric discharge of radioactive waste are provided by the building structures off-gas treatment system, and ventilation exhaust filtration systems. The normal ventilation air path in the facility will

be from areas of low contamination potential to areas of higher contamination potential. Exhaust air from contaminated areas will pass through at least two sets of HEPA filters, in series, prior to discharge. The facility design is such that inadequate removal of radioactive decay heat will be an infrequent problem. Prompt recovery methods and procedures will be available for use, even under accident conditions, to restore adequate waste cooling before high temperatures could threaten waste confinement.

6.4 IMPROBABLE EVENTS

The safety evaluation includes analyses of highly improbable accident conditions which are not expected to occur during the operating life of the facility; however, design features which further reduce the probability and possible magnitude of waste confinement loss, which could result from these events, are justified by the potential consequences. The improbable events category includes not only credible occurrences but also some events which are considered to be incredible due either to their natural low probability of occurrence or to their prevention by facility siting or design and administrative controls.

If an improbable event occurs, plant effluent radionuclide concentrations or radiation exposure to the general public could conceivably exceed limits. However, design philosophy dictates that the maximum credible accident (in terms of quantity released) shall not result in radiation exposure to any member of the general public which corresponds to greater than 2.5 rem whole body (10 percent of the 25 rem whole body exposure guideline presented in 10 CFR 100, entitled, "Reactor Site Criteria").

The CCF cells and associated off-gas treatment and ventilation exhaust air filtration systems will be designed as Class I confinement barriers capable of withstanding design basis accident conditions. The methods of preventing loss of waste confinement due to the potential occurrence of improbable events are based upon the same basic design philosophies as those used in the RSSF conceptual design.

6.5 ATMOSPHERIC DISCHARGES

The presence of low level radioactive contamination in most portions of the CCF, and the formation of very small amounts of induced activity where high level waste neutron fluxes are present, will result in slight but essentially continuous

radioactive discharges to the atmosphere. These discharges will be minimized by the use of at least two sets (in series) of HEPA filters on the ventilation exhaust air from potentially contaminated areas and, to some extent, by ventilation air flow control. Routine "housekeeping" procedures will minimize the amount of contamination available for resuspension in ventilation air. In any case, the normal gaseous effluent dispersion and dilution will result in concentrations at the site boundary which are far below the nonoccupational limits.

6.6 LIQUID WASTES

Liquid decontamination agents will be used in the cleanup of contaminated plant areas, equipment, and waste canisters. The spent decontamination solutions, and other liquid wastes that may be contaminated, will be held in a suspect waste tank while laboratory analyses are being performed. If these analyses show that an "as low as practicable" criterion is satisfied, the wastes will be transferred to a surface disposal pond. Wastes for which surface disposal is not acceptable will be routed to the waste treatment system for concentration and recalcination. The resulting calcine will be blended with incoming calcine for incorporation into a glass material.

6.7 SOLID WASTES

Operation of the CCF will generate low level contaminated solid waste which will be stored within the CCF. This waste, unlike the high level radioactive waste, results primarily from the occasional decontamination work which must be done in the facility. It consists primarily of disposable clothing, rags, paper products, laboratory chemicals, and ion exchange resins. Final storage of this low level solid waste material, in appropriately designed packages, will be performed at an approved ERDA or commercial disposal site.

7.0 ENVIRONMENTAL ASSESSMENT

No environmental assessment has been made of the impact of constructing and operating a CCF, since neither a concept nor a site has yet been chosen.

However, potential sites for the RSSF have been assessed in WASH-1539, "Environmental Statement: Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste," September 1974; and sites of FRP's which might host a CCF/FRP have been individually assessed in their own environmental statements.

When a CCF concept and site are chosen, a specific environmental assessment will be made prior to the request for budget approval.

8.0 CAPITAL COST ESTIMATES AND CONSTRUCTION SCHEDULES

8.1 CAPITAL COST

The capital costs given in this section are based on preliminary engineering studies, without full design integration with the basic facility to which the CCF will be attached. Design studies and cost estimates for the CCF/RSSF are more complete because of an earlier starting date for the study. Also, both the RSSF and CCF are new facilities being designed by the same parties. In the case of the CCF/FRP, it was necessary to make unilateral interface assumptions which may not be accepted by the FRP management when the FRP is finally selected. However, in both cases an attempt has been made to equitably divide the cost between the CCF and the basic RSSF or FRP.

The capital costs given in this section cover only the costs of the facilities described in this report. The adequacy of such facilities to handle the output of the nuclear industry is beyond the scope of this study. However, it should be noted that the CCF/FRP is designed to handle the output of only one FRP, while several FRP's are expected to start operation during the 1980's. The CCF/RSSF is of larger capacity to handle the output from more than one FRP; however, the CCF/RSSF is also of limited capacity and would not handle the total industry output of calcine much beyond 1986.

Cost estimate summaries for the two facilities are given on Tables 8-1 and 8-2.

8.2 CONSTRUCTION SCHEDULE

The construction schedule is based on project funding in fiscal year 1977 with hot start up in January 1983. Time for licensing the facility in accordance with 10 CFR 70 is included. The CCF construction schedule (Figure 8-1) shows two concurrent schedules, one for process equipment and a second for the facility. The process equipment schedule is time consuming because a large percentage of such equipment is of new design, or must be adapted to remote operation. This operation requires careful integration. But, the time required for the integrated schedule is expected to be no longer than the requirements for a single facility construction schedule.

TABLE 8-1

CCF/RSSF
SUMMARY ESTIMATE OF COST
(\$ millions)

<u>DESCRIPTION</u>	<u>AMOUNT</u>	<u>TOTAL</u>
<u>Construction Cost</u>		
Yardwork	0.1	
CCF Building	15.0	
CCF Filter, Fan House & Stack	1.0	
Communications & Alarm	1.5	
Instrumentation	2.5	
Canisters	0.4	
Checkout, Vendor's Assistance & Startup	0.5	
Production Equipment (N.S.C.) Including Indirect Costs	6.0	
Total Direct Cost		27.0
Indirect Cost*		6.0
TOTAL CONSTRUCTION COST		\$33.0
<u>Design Engineering & A/E</u>		7.7
<u>License Fee</u>		0.3
<u>Contingency</u>		
Construction & Indirect Cost	7.6	
Engineering	1.2	11.0
Production Equipment (N.S.C.)	2.2	
Subtotal		\$52.0
<u>Escalation</u>		
Construction, Indirects, License & Contingency @.57	20.0	
Engineering Title I @.19	0.5	
Engineering Title II @.26	1.7	28.0
Engineering Title III @.42	0.8	
Production Equipment (N.S.C.) @.57	5.0	
TOTAL PROJECT COST		\$80.0

*Indirect Cost based on Total Direct Cost, excluding the Production Equipment (N.S.C.) which includes applicable Indirect Costs.

TABLE 8-2

CCF/FRP
SUMMARY ESTIMATE OF COST
(\$ millions)

<u>DESCRIPTION</u>	<u>AMOUNT</u>	<u>TOTAL</u>
<u>Construction Cost</u>		
Yardwork	0.4	
CCF Building	11.5	
CCF Filter, Fan House & Stack	0.6	
Communications & Alarm	1.6	
Instrumentation	1.9	
Canisters	0.4	
Checkout, Vendor's Assistance & Startup	0.5	
Production Equipment (N.S.C.) Including Indirect Costs	<u>3.1</u>	
Total Direct Cost		20.0
Indirect Cost*		<u>5.0</u>
TOTAL CONSTRUCTION COST		\$25.0
<u>Design Engineering & A/E</u>		6.0
<u>License Fee</u>		0.3
<u>Contingency</u>		
Construction & Indirect Cost	6.5	
Engineering	1.0	8.7
Production Equipment (N.S.C.)	1.2	
Subtotal		<u>\$40.0</u>
<u>Escalation</u>		
Construction, Indirects, License & Contingency @.57	15.6	
Engineering Title I @.19	0.3	
Engineering Title II @.26	1.1	20.0
Engineering Title III @.42	0.5	
Production Equipment (N.S.C.) @.57	2.5	
TOTAL PROJECT COST		<u>\$60.0</u>

*Indirect Cost based on Total Direct Cost, excluding the Production Equipment (N.S.C.) which includes applicable Indirect Costs.

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FIGURE 8-1
CCF CONSTRUCTION SCHEDULE
(Based on licensing under 10 CFR 70)

9.0 OPERATING COSTS

No dollar value has been placed on the operating cost of the two facilities; however, a few of the more significant items to be considered in the comparison of the two concepts are given below.

- Both CCF's will be adjacent to a large facility performing related work. This will permit them to share manpower, supervision, personnel facilities, etc., with the basic facility to about the same degree.
- The CCF/RSSF will be required to receive incoming canisters of calcine, which must be stored, opened, emptied, and refilled while the CCF/FRP will receive calcine through a pipe and process it immediately. These operations at the CCF/RSSF will require additional operations and maintenance personnel.
- The incoming canisters at the RSSF are not expected to be satisfactory as the final glass containment barrier, at least initially, because their condition cannot be verified prior to filling with glass. As a result, an overpack container of known quality will be added to each unit. The overpack canisters represent a substantial extra-material cost.

INITIAL WASTE STORAGE AREA
(191 STORAGE UNITS)

U.S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE KAISER ENGINEERS	
CCF/RSSF PLOT PLAN	
RETRIEVABLE SURFACE STORAGE FACILITY	
7298-100-CR-6	
12/6/74	

DATE	BY	DESCRIPTION	REVISIONS

DATE	BY	DESCRIPTION	REVISIONS

U. S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE		Kaiser Engineers Richland, Washington	
CCF/RSSF		HVAC FLOW DIAGRAM	
SECOND FLOOR		CALICHE CONTAINMENT FACILITY/RSSF	
7239-100-NVR-5		DRAWING STATUS	
REVISIONS		REFERENCE DRAWINGS	
NEXT USED ON		DRAWING STATUS

GENERAL NOTES

1. ONLY NON-STANDARD INSTRUMENTATION IS SHOWN
2. THE FOLLOWING SERVICES ARE SUPPLIED FROM RWSF: RAW, FIRE PROTECTION, TREATED & DEMINERALIZED WATER
3. NON-RADIOACTIVE & SANITARY WASTES GO TO RWSF

U. S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE	
KAISER	
CCF/RWSF UTILITIES SERVICES FLOW DIAGRAMS	
SCALE: CONVERSION FACILITY	
NONE 7238-100-PR-3

SECTION A 7238-100-AR-1

SECTION B 7238-100-AR-1

SECTION C 7238-100-AR-1

NAME	ABBREVIATION	EQUIPMENT ENVELOPE SIZE			CELL SIZE			REMARKS
		LENGTH	WIDTH	HEIGHT	LENGTH	WIDTH	HEIGHT	
ANALYTICAL CELL	AC	16'	6'	10'	22'	6'	12'	
CANISTER CLOSURE QUALITY ASSURANCE	CC/QA	22'	12'	36'	35'	13'	42'	
DECANNING & CALCINE CONVERSION	D & CC	42'	12'	90'	55'	13'	53'	
EFFLUENT TREATMENT CELL	ECC	36'	12'	36'	44'	13'	42'	
HOT MAINTENANCE	HM	12'	12'	20'	19'	13'	21'	
CANISTER/OVERPACK TRANSFER CELL	OTC	—	—	—	16'-6"	5'-6"	23'-6"	
TRANSFER CELL	TC	—	—	—	16'-6"	5'-6"	23'-6"	

LEGEND
REGULAR CONC.
HIGH DENSITY CONC.

GRAPHIC SCALE
1" = 10' 0" 20' 30'

U. S. ATOMIC ENERGY COMMISSION HIGHLAND OPERATIONS OFFICE Kaiser Engineers		CCF/RSSF SECTIONS	
DRAWING NO. 7238-100-AR-2		SCALE: CONVERSION FACILITY / RSSF	
DATE: 11-1-74		BY: [Signature]	
CHECKED BY: [Signature]		DATE: 11-1-74	
DRAWING STATUS: []		NEXT USED ON: []

[illegible]

ARH-LD-108

U.S. ATOMIC ENERGY COMMISSION RICHMOND OPERATIONS OFFICE	
KAISER ENGINEERS	
CALCLINE CONVERSION FACILITY / FRP	
PLOT PLAN	
7299-100-05-G	
12/6/72	

NO.	DATE	BY	CHKD.	DESCRIPTION
1	12/6/72	J. L. ...	...	...
2	...	...	...	...
3	...	...	...	...
4	...	...	...	...
5	...	...	...	...
6	...	...	...	...
7	...	...	...	...
8	...	...	...	...
9	...	...	...	...
10	...	...	...	...
11	...	...	...	...
12	...	...	...	...
13	...	...	...	...

[illegible]

U. S. ATOMIC ENERGY COMMISSION RICHMOND OPERATIONS OFFICE		Kaiser ENGINEERS		HVAC FLOW DIAGRAMS FIRST FLOOR		1200-100-HVF-4	
DATE	BY	CHKD	APPD	DATE	BY	CHKD	APPD
12/1/54	W. J. KAISER	W. J. KAISER	W. J. KAISER	12/1/54	W. J. KAISER	W. J. KAISER	W. J. KAISER
REVISIONS				REVISIONS			
NO.	DATE	BY	DESCRIPTION	NO.	DATE	BY	DESCRIPTION
1	12/1/54	W. J. KAISER	INITIAL DESIGN	1	12/1/54	W. J. KAISER	INITIAL DESIGN
2	12/1/54	W. J. KAISER	REVISED FOR CONSTRUCTION	2	12/1/54	W. J. KAISER	REVISED FOR CONSTRUCTION
REFERENCE DRAWINGS				REFERENCE DRAWINGS			
NO.	DATE	BY	DESCRIPTION	NO.	DATE	BY	DESCRIPTION
1	12/1/54	W. J. KAISER	INITIAL DESIGN	1	12/1/54	W. J. KAISER	INITIAL DESIGN
2	12/1/54	W. J. KAISER	REVISED FOR CONSTRUCTION	2	12/1/54	W. J. KAISER	REVISED FOR CONSTRUCTION
NEXT USED ON				NEXT USED ON			
NO.	DATE	BY	DESCRIPTION	NO.	DATE	BY	DESCRIPTION
1	12/1/54	W. J. KAISER	INITIAL DESIGN	1	12/1/54	W. J. KAISER	INITIAL DESIGN
2	12/1/54	W. J. KAISER	REVISED FOR CONSTRUCTION	2	12/1/54	W. J. KAISER	REVISED FOR CONSTRUCTION

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COOLING WATER SYSTEMS

FIRE WATER SYSTEM

DEMINERALIZED WATER SYSTEM

RADIOACTIVE LIQUID WASTE SYSTEM

INERT GAS FIRE PROTECTION SYSTEM

COMPRESSED AIR SYSTEMS

CHILLED WATER SYSTEM

WELDING GAS SYSTEM

EMERGENCY WATER SYSTEMS

STEAM SYSTEM

CELL DECONTAMINATION SYSTEM

AQUEOUS MAKE-UP (AMU) SYSTEM

GENERAL NOTES

DOMESTIC WATER SYSTEM

U. S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE KAISER ENGINEERS	
CCF/FRP UTILITIES & SERVICES FLOW DIAGRAM	
CALCINE CONVERSION FACILITY / FRP	
7238-100-PF-3	

REV	DATE	DESCRIPTION
1	10/1/68	ISSUED FOR CONSTRUCTION
2	10/1/68	REVISIONS

REV	DATE	DESCRIPTION
1	10/1/68	ISSUED FOR CONSTRUCTION
2	10/1/68	REVISIONS

SECTION A
723B-100-AF-1

SECTION B
723B-100-AF-1

CRANE CANYON PLAN

PARTIAL PLAN DOCK AREA

TABLE OF CELLS								
NAME	ABBREVIATION	EQUIPMENT ENVELOPE SIZE			CELL SIZE			REMARKS
		LENGTH	WIDTH	HEIGHT	LENGTH	WIDTH	HEIGHT	
CONVERSION CELL	C.C.	42'	12'	36'	54'	13'	42'	
CAN CLOSURE & QUALITY ASSURANCE	CC/QA	22'	12'	36'	33'	13'	42'	
HOT MAINTENANCE	H.M.	12'	12'	20'	21'	13'	26'	
ANALYTICAL CELL	A.C.	16'	6'	10'	24'	6'	12'	
TRANSFER CELL	T.C.	—	—	—	16'	13'	13'	

LEGEND

- REGULAR CONC.
- HIGH DENSITY

ELEVATION - OPERATING PLATFORMS

U. S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE KAISER ENGINEERS		CCF/FRP SECTIONS CALCINE CONVERSION FACILITY / FRP	
723B-100-AF-2		11/6/74	

ARH-LD-108

FUTURE
BARNWELL
CALCINER BLDG.

GRAPHIC SCALE
1" = 10' - 0"
10' 0" 20' 30'

U.S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE	
KAMFER ENGINEER	
CCF/FRP PLANS	
CALCINE CONCEPT FACILITY / FRP	
1298-100-AF-1	
12/9/74

GROUND FLOOR PLAN

SECOND FLOOR PLAN

U.S. ATOMIC ENERGY COMMISSION RICHLAND OPERATIONS OFFICE	
KAMFER ENGINEER	
CCF/FRP PLANS	
CALCINE CONCEPT FACILITY / FRP	
1298-100-AF-1	
12/9/74	