CNSI NON-PROPRIETARY TOPICAL REPORT

RDS-1000 RADIOACTIVE WASTE
DEWATERING SYSTEM

RDS-25506-01-P

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ABSTRACT

The Rapid Dewatering System, RDS-1000, developed by Chem-Nuclear Systems, Inc. (CNSI) is a self-contained portable system for the accelerated dewatering of particulate radioactive waste slurries. The system significantly decreases dewatering time from that of current conventional methods used in the nuclear power industry. Three years of extensive testing by CNSI, including lab scale, full-scale and over-the-road certification, has produced a rapid dewatering system far exceeding the requirements of 10CFR Part 61, 61.56. The system is compact, simple, and easy to operate. The RDS-1000 provides measurable end points, and is compatible with CNSI's disposable waste containers (liners), including the 21-300 steel and High Integrity Container. Measured noise levels are well within the current unprotected OSHA limits for unprotected stay time of eight hours.

1.0 INTRODUCTION

Chem-Nuclear Systems, Inc. (CNSI) has been providing dewatering processes since 1975. Currently, CNSI provides dewatering of ion exchange bead resins, diatomaceous earth mixtures, activated carbon, and other filter media. The dewatering process is accomplished in CNSI's High Integrity Containers (HICs) and steel liners. These are right circular cylinders of various sizes. CNSI certifies these waste containers to meet disposal site acceptance criteria. This certification is based on the results of extensive testing programs which verify the ability of the dewatering process to meet these criteria.

CNSI has developed and tested a new mechanical system for the rapid dewatering of resins, precoats and other types of waste slurries. The Rapid Dewatering System (RDS-1000) employs a high flow vacuum system in conjunction with the CNSI waste containers.

Redundant tests were performed on full size steel liners and High Integrity Containers. Testing included dewatering of bead resin and precoat medias. These classes of waste forms represent the worst case media for dewatering commonly found in the nuclear industry. Certification of these worst case media also certifies media that may be dewatered with less difficulty. Certification of the RDS-1000 using the largest containers and most difficult test media certifies the equipment for use with containers of smaller size and similar design.

The test procedure and the results obtained clearly demonstrate that the RDS-1000 is capable of rapidly dewatering these systems to meet the limits for free-standing water currently specified by the disposal sites.

2.0 PROCESS DESCRIPTION

The CNSI RDS-1000 system is certified to dewater most types of media used in PWR and BWR nuclear power plants. Use of a vacuum pump to remove water through CNSI's proprietary liner filtering system provides simple, error-free operation. The system is comprised of:

- Container Fillhead (CNSI's standard Dewatering Fillhead)
- Plant Connection Stand
- Control Console/System
- Rapid Dewatering Skid
- Waste Container, Interconnecting Hoses, and Cables

The RDS-1000 makes it possible to dewater containers to a media-specific certifiable end point which can be visually confirmed. The system uses a positive displacement pump to remove the major portion of free water from the container. A closed loop high velocity air flow is then employed to rapidly remove the remaining interstitial water. The extracted water is removed from the air stream via a moisture separator, and is returned to the plant waste system.

3.0 SYSTEM OPERATION

System operation is simple, requiring only one operator. The system components are placed and connected, and the dewatering liner is leveled. Then electrical power, service water and air are connected, leak tested, and the system is ready to receive waste.

The Process Flow Diagram (PFD) is shown in Figure 3-1. After waste transfer through an automatic waste inlet valve, the excess water is pumped from the liner through CNSI's proprietary media-specific filtering system and then returned to the plant, leaving the solids in the liner. The remotely controlled fill operation is viewed via a video monitor on the control panel.

A remote level control system detects and monitors the waste level in the liner, minimizing operator exposure during dewatering operations. Overfill protection is provided through this system and an independent level control in the fillhead, either of which will automatically close the waste inlet valve. The operator can also manually activate this valve, if necessary.

A dewatering pump is activated to remove the excess slurry water during waste transfer.

The vacuum pump is turned on, and air is recirculated through the liner and moisture separator after all waste has been received, and the gross dewatering is complete. This air flow is maintained until the liner meets the specified acceptance criteria.

4.0 EQUIPMENT DESCRIPTION

The major components of the RDS-1000 and their functions are described in the following paragraphs:

4.1 Dewatering Fillhead

The first component is a universal dewatering fillhead, containing a TV camera and light. The camera provides remote observation of the waste in the container during the media transfer and dewatering operation. The fillhead provides connections for controls and piping between the disposable container and the dewatering system.

All hose connections on the fillhead are the quick disconnect type to facilitate semi-remote removal from the container, and to minimize radiation exposure. The fillhead contains a high level float switch which is a backup to the primary level control. This redundant control assures automatic closure of the waste isolation valve to prevent overfilling the liner.

4.2 Plant Connection Stand

This unit is the interface for all connections between the plant's systems and the portable dewatering system. Its components are:

- A remotely operated valve to control influent to the processing liner.

- A diaphragm pump with connections to the fillhead for initial gross dewatering.

- Manifolds for air and water supplies to control elements and flushing systems.

4.3 Control System

A control panel, containing electrical and pneumatic controls, allows remote operation of all components and monitoring of individual parameters. A video monitor for the liner is provided as well as temperature and pressure indicators for the process variables. Audible and visual alarms are included to alert the operator of any abnormal conditions affecting overall system performance.

#2
#3

4.4 Rapid Dewatering Skid

The Rapid Dewatering Skid consists of the vacuum pump, moisture separator, air conditioning unit, and piping interface to the plant connection stand. Pressures and temperatures are monitored at various points on this component to safeguard mechanical operations. A safety relief valve precludes overpressurization of the liner, and a HEPA filter is installed to ensure against accidental discharge of potentially contaminated air to the environment.

4.5 Disposal Containers

The RDS-1000 system is compatible with CNSI dewatering waste containers.

These containers and their dewatering internals are designed to ensure uniform dewatering of the waste slurries. They are vertical cylinders equipped with CNSI proprietary internals. They are fabricated and inspected in accordance with the CNSI Quality Assurance Program.(1)

4.6 Power Distribution

The RDS-1000 contains all the auxiliary electrical equipment required for operation such as the motor controls, interlocks, alarms and electrical wiring.

The electrical system, with flame-resistant wire jacketing and insulating material, is fabricated to industrial standards. The system motors are UL approved, and all electrical equipment and devices are rated for continuous service.

4.7 Equipment Arrangement

The waste container is placed in a remote area or in a cask or shield. The fillhead is mounted directly on top of, and mated to the waste container. The plant connection stand and RDS-1000 skid are positioned in the radiological control area. However, they can be located remotely from the waste container.

The control panel should be located in a clean area near the liner, plant stand and RDS-1000 skid. It may be located in the control area, if necessary.

5.0 QUALITY ASSURANCE PROGRAM

CNSI's Quality Assurance Program is designed to ensure that the systems or components developed by CNSI will perform satisfactorily in service. It meets the requirements of 10CFR50 Appendix B and 10CFR71 Subpart H. This Quality Assurance Program is active in every stage of equipment and system development from design to fabrication and testing.

The American National Standard: "Solid Radioactive Waste Processing System for Light-Water-Cooled Reactor Plants", ANSI/ANS 55.1-1979, was used to develop design criteria and to complement the CNSI Quality Assurance Program.

5.1 Test Completion Criteria

The operating method and completion criteria were established for each category of media prior to certification testing, and are summarized below:

Resin: Fill the liner with waste slurry. Dewater with the positive displacement, air operated diaphragm pump. Stop dewatering, and immediately start drying phase and dry until the water collection rate is acceptable and the minimum specified drying time has been achieved.

Precoat: Fill the liner with waste slurry. Dewater with the positive displacement air operated diaphragm pump. Stop dewatering and immediately start the drying phase. Continue drying for a minimum specified time and until the water collection rate is acceptable. Stop drying.

5.2 Acceptance Criteria

A data base exists for the minimum moisture contents of resins and precoats, based on extensive previous full-scale tests and vendor supplied water retention capacities (WRC).

The minimum moisture content of the specific test media used has also been established by WRC tests based on standard ASTM-D2187.

A test is considered successful when: the total free-standing water (FSW) is less than or equal to 0.5 percent of the total waste volume of the container under test.

Redundant successful tests must be completed by identical methods for a category of waste. A minimum of one of the tests is road tested.

Successful completion of a test series for each of the dewatered material types is adequate proof that the RDS-1000 system is a viable alternate to the more conventional dewatering methods.

5.3 ALARA

A safety evaluation was conducted and is presented in Appendix A.

The RDS-1000 System was designed with ALARA as one of the major design criterion. The occupational exposures received from operation of this system will be minimized by the following features:

- Flushing provisions in the fillhead, plant stand, moisture separator, and piping system.
- Remote location of the control panel. #2
- Operation with the liner in a shield or cask, as necessary.
- Automatic control of the waste inlet valve.
- Quick disconnect hose fittings and fillhead anchors.
- HEPA filtration of all discharge air. #1
- Stainless steel components designed for easy decontamination with a minimum of crud traps.

6.0 SYSTEM TESTING AND RESULTS

6.1 Purpose

The purpose of the tests was to obtain data to verify the efficiency of the RDS-1000 as a Rapid Dewatering System. The test data gathered is submitted as evidence to substantiate the dewatering capability of the RDS-1000 unit. The test program also established a completion end point and defined an acceptable test criterion to be used in future operations of the RDS unit.

6.2 Description of Tests

Multiple full-scale tests were performed with the RDS-1000 unit and associated liners. The test results are divided into two basic groups: precoat and bead resin. Two test methods were used, depending upon the category of waste (precoat or bead). The two methods were repeated exactly for each certification test.

6.2.1 Bead Resin

The test method for the granular waste category utilized commercial mixed bed bead resin test media. CNSI's experience has shown this type of resin to be the most difficult to dewater of those most commonly encountered in nuclear service.

The media was saturated with water and thoroughly mixed prior to being transferred to the test container.

A resin test liner was fabricated, inspected and placed into position on supports which allowed access to bottom sample ports. The test liner was then leveled and connected to the RDS System.

The test liner was filled with resin to the liner top. Normal filling operations were simulated. More resin was added as needed, to maintain the liner as full as practicable.

The remaining space in the liner was then filled with water and the liner was allowed to stand overnight.

The RDS-1000 test began with an gross dewatering via positive displacement pump. The water was collected in a reservoir and measured. The RDS-1000 unit was then operated in the drying phase to the end of each test.

Samples of the resin bed were extracted, as the drying phase proceeded. Additional samples were taken when the drying phase was completed.

The test liner was also checked for free-standing water (FSW) at the bottom drain ports immediately after drying. The test liner was allowed to sit undisturbed for a minimum of 16 hours and rechecked for FSW at the bottom drain ports.

Additional samples were taken prior to, and after road tests. The test liner was allowed to stand after a road test, and additional FSW checks were performed and documented.

When a test was complete, the test media was rewetted and transferred back to the reservoir or remixed. Remixing prior to another resin test was accomplished by pumping half of the resin out of the test liner into a reservoir. The resin remaining in the test liner and the resin in the reservoir was then recirculated to assure homogeneity prior to the next test. The resin in the reservoir was then pumped back into the test liner, and the mixture was again recirculated.

6.2.2 Precoat

The test method for the precoat waste category utilized commercially available fibrous filter media. This media is one of the most difficult to dewater in the precoat class.

A reservoir containing the test media was mixed to eliminate stratification. This media was stored wet in the reservoir to assure saturation prior to testing.

The precoat test liner was fabricated, inspected and placed into position in the same manner as the resin test liner.

The liner was then filled with waste media slurry until solids were observed at the high level position.

The test liner was dewatered while being filled to simulate actual field conditions. The initial dewater phase began immediately with the diaphragm pump. The water from the initial phase was collected in a reservoir and measured.

The drying phase was then started. Samples were taken throughout the drying phase and the moisture content of the samples was analyzed and documented. Additional samples were taken when the drying phase was completed.

Road tests were performed, and samples were taken prior to, and after the tests. The liner was allowed to stand several days and then additional samples were taken.

Upon test completion, the test liner was rewetted, and the test media pumped out. The internals were examined for damage and deformation. This allowed the precoat test liner and internals to be reused for additional precoat tests.

If an additional precoat test was required, the test media was pumped back into the test liner from the respective precoat reservoir.

Different methods of filling the test liner were evaluated. Complete reslurry of the test media was found to be the worst case condition in relation to dewatering. All certification tests were conducted with reslurried media.

6.3 Resin Test Results

Certification resin tests were successfully conducted. All tests were conducted as prescribed. The test data was documented and proves that the RDS-1000 is very efficient in dewatering bead resins. It also proves that the system can meet the prescribed acceptance criteria.

6.4 Precoat Test Results

Certification precoat tests were also conducted and proved the efficiency of the RDS-1000 to dewater this media type. The tests demonstrated the ability of the system to meet the acceptance criteria within the specified time period.

7.0 TEST MEDIA

7.1 Bead Resin

The bead resin media used in all bead tests was a commercially available gel resin. The bead is several years old, depleted and saturated with crud and fines. This mixture of resin and fines, with some carbon, is considered the worst case bead test media.

7.2 Precoat Media

The precoat media used in all precoat tests was a commercially available filter media. It is a mixed powdered resin/fibre precoat material having less than 2% whole resin beads.The same batch was used in all tests.

The test media is several years old and was obtained in a crud-saturated and depleted condition. The media contains trace amounts of oil. The media is considered the precoat worst case.

7.3 Precoat Media--Test Number 7

Test Number 7 was performed to evaluate operation of the RDS unit with a larger liner. The precoat media used during test Number 7 consisted of the precoat used in earlier tests, plus an additional mixture of precoat, bead resin and diatomaceous earth. This was necessary to completely fill the larger liner.

The additional mixture consisted of approximately 80 volume percent used precoat. The remaining volume is 15 percent depleted bead resin and 4 percent diatomaceous earth. The remaining 1 percent was a different precoat. Mixtures such as this are commonly found in the industry. Therefore this provides an acceptable test media.

7.4 Other Media

CNSI has developed a testing and quality assurance program which prove the ability of the RDS-1000 to dewater waste slurries in CNSI waste containers. Additional waste types will be certified in accordance with this program. The test data will be documented and retained.

8.0 CONCLUSIONS

Based on the CNSI dewatering data base and test results, the following conclusions may be drawn in relation to the RDS-1000 unit and its capabilities with each category of media:

8.1 Resin Conclusions

The RDS-1000 unit is capable of dewatering gel type bead resin waste. The resin may be dewatered within 5-1/2 hours. The RDS-1000 can be successfully operated with CNSI's HIC and steel type liners with this media and CNSI proprietary internals.

8.2 Precoat Conclusions

The RDS-1000 unit is capable of dewatering precoat type waste. The precoat can be dewatered within 10 hours. The RDS-1000 may be operated with CNSI's HIC and steel type liners with this media and CNSI proprietary internals.

8.3 Other Media

The RDS-1000 unit may be used to dewater other categories of waste and waste mixtures. However, additional certification work for each generic waste type shall be completed, per the CNSI testing and quality assurance program prior to employing the RDS-1000 for the waste form in question.

9.0 REFERENCES

9.1 CNSI Quality Assurance Program, QA-AD-001

9.2 ANSI/ANS 55.1--1979, "Solid Radioactive Waste Processing System for Light-Water-Cooled Reactor Plants"

9.3 ASTM-D2187-77, "Tests for Physical and Chemical Properties of Particulate Ion Exchange Resins."

RDS 1000 PROCESS FLOW DIAGRAM

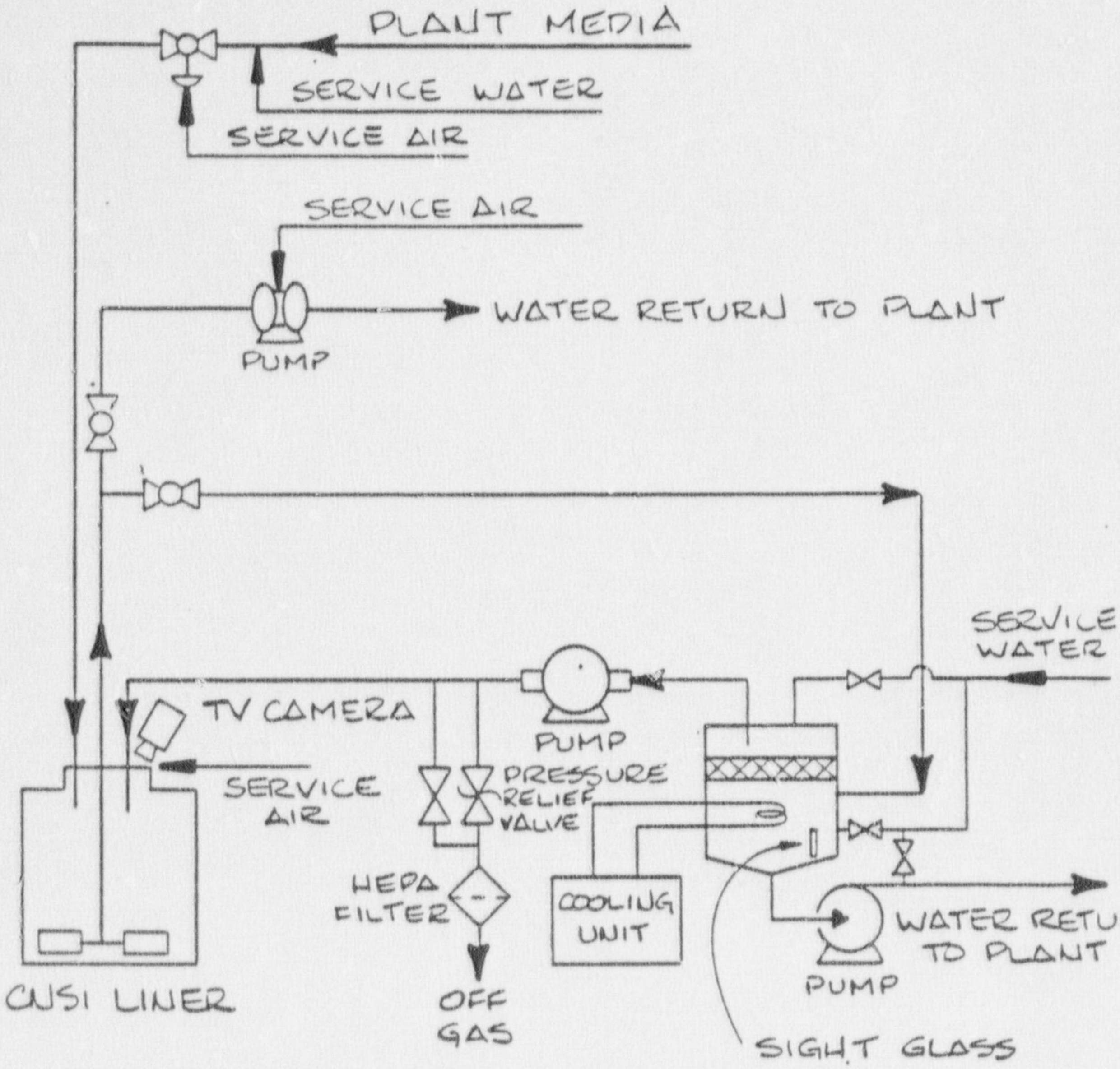

FIGURE 3.1

Figure 3-1: RDS-1000 Process Flow Diagram

APPENDIX A

SAFETY EVALUATION REPORT
FOR THE
CHEM-NUCLEAR SYSTEMS, INC.
RAPID DEWATERING SYSTEM

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1.0 REFERENCES

1.1 NRC, *Nuclear Regulatory Guide* No. 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants."

1.2 Title 10, *Code of Federal Regulations*, Part 20, "Standards for Protection Against Radiation."

1.3 Title 10, *Code of Federal Regulations*, Part 71, "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions."

1.4 American National Standard ANSI N199-1976 (ANS 55.2), *Liquid Radioactive Waste Processing Systems for Pressurized Water Reactor Plants*.

1.5 American National Standard ANSI N197-1967 (ANS 55.2) *Liquid Radioactive Waste Processing System for Boiling Water Reactor Plants*.

1.6 American National Standard ANSI ASME B31.1, *Code for Pressure Piping*.

1.7 *ASME Boiler and Pressure Vessel Code*, Section IX, "Welding and Brazing Qualifications."

1.8 *ASME Boiler and Pressure Vessel Code*, Section VIII, "Pressure Vessels."

1.9 Nuclear Regulatory Commission Office of Inspection and Enforcement Bulletin No. 79-19.

1.10 CN-AD-019, Chem-Nuclear Systems, Inc., *ALARA Policy*.

1.11 CN-AD-003, Chem-Nuclear Systems, Inc., *Procedure for Document Preparation*.

1.12 QA-AD-001, Chem-Nuclear Systems, Inc., *Quality Assurance Program*.

1.13 EN-AD-002, Chem-Nuclear Systems, Inc., *Design Control Procedure*.

1.14 CAEC-007, California Energy Commission, *Low-Level Radioactive Waste Management, Volume I: Current Power Reactor Low-Level Radwaste*, 1978.

1.15 US Atomic Energy Commission, *Final Environmental Statement Concerning Proposed Rule Making Action: Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Practicable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents*, Volume II, *Analytical Models and Calculations*, 1973.

2.0 INTRODUCTION

The CNSI Rapid Dewatering System (RDS-1000) is designed to comply with pertinent Federal Regulations and constructed in accordance with applicable ANSI Standards. Mobile radwaste processing systems are required to comply with regulations in these general areas:

- On-site operations at the power station.
- Low-level radwaste disposal.

For on-site operations at nuclear power stations, 10 CFR 50 provides general quality standards and requires that systems and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance to safety of the function to be performed. A mobile radwaste reprocessing system is not a Safety Class System as defined by N18.2a, American National Standard Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants.

Nuclear Regulatory Guide 1.143 presents design guidance for waste processing and recognizes the fact that the impact on safety is limited. Regulatory Guide 1.143 references ANSI Standards N197-1976 and N199-1976, which state recommendations for the design, construction, and performance of liquid radwaste processing systems. It should be noted, however, that these ANSI Standards concern installed plant systems and do not consider the special requirements of mobile process systems.

It is important to recognize that Regulatory Guide 1.143 and the ANSI Standards which are referenced provide regulatory guidance, not requirements for radwaste systems. Regulatory Guide 1.143 is useful in generating overall design and quality requirements, but the unique requirements of mobile systems must be considered in engineering a safe yet cost-effective system.

CNSI mobile systems comply with the guidelines of Regulatory Guide 1.143 where safety and engineering considerations dictate. All welding of pipe, vessels and valves on CNSI mobile systems is performed by welders qualified to ASME Section IX.

3.0 SYSTEM DESCRIPTION

The Rapid Dewatering System is used to transfer resin to the disposal containers and to dewater the resin in the liner remotely. The system process flow diagram is shown in Figure 1 and consists of the following major components:

3.1 Plant connection stand, consisting of:

- A remotely operated valve to control influent to the processing liner. This valve is interlocked to close on High Waste Level, Hi Hi Level (mechanical float in fillhead). and decreasing air pressure or loss of electrical power;

- o A diaphragm pump with connections to the fillhead for gross initial dewatering;

- o Manifolds for air and water supplies to control elements and flush components.

This unit is the interface for all connections between the plant's systems and the portable system.

3.2 A universal dewatering fillhead containing a TV camera and light. The camera provides remote visual observation of the container level during the resin transfer operation and dewatering. The fillhead provides for connections and control between the disposable container and the dewatering system.

Connections on the underside of the fillhead can connect to break away fittings in order to facilitate remote removal from the container and to reduce exposure. The fillhead external connections are camlocks. The fillhead contains a Hi-Hi level float switch; this is a back-up to the FAVA level control for automatic closure of the waste isolation valve.

3.3 The Rapid Dewatering Skid consists of the vacuum pump, moisture separator, air conditioning unit, and piping interface to the plant connection stand. Pressures and temperatures are monitored at various points on this component to safeguard mechanical operations. A HEPA filter is installed downstream of the safety relief valve and manual valve bypass to ensure against accidental discharge of air to the environment.

3.4 Control panel containing electrical and pneumatic controls to allow remote operation of all components and monitoring of individual parameters. A video monitor of the liner is provided as well as temperature and pressure indications of primary components. Audible and visual alarms are included to indicate any abnormal conditions affecting overall system operation.

3.5 FAVA level system is used for monitoring the resin level in the container and provides automatic closure of the waste valve. A second operation uses the same monitoring system and separate probes mounted in the moisture separator to control moisture separator water level by activating a pump.

4.0 PROCESS AREA

The RDS-1000 dewatering system is located in a controlled area containing shielding for the process container. Access is limited to the utility and CNSI operating personnel trained to operate the system in a safe manner.

5.0 TECHNICIAN TRAINING

The CNSI Technician operating the RDS-1000 dewatering system is required to complete training in Health Physics and industrial safety and undergo training in the operation of the dewatering system for qualification as a Systems Technician. The training includes courses presented by CNSI at the Barnwell Site and Health Physics and Safety courses required by the utility for unescorted access to the process area in which the portable dewatering system is located.

After completion of basic courses, the operator must spend sufficient time in actual system operations under the supervision of a qualified CNSI Technician to gain familiarity with actual system operations and to become knowledgeable in procedures and policies. After this training and satisfactory performance in actual operations, the Technician is qualified to operate the system without supervision.

6.0 SUMMARY AND CONCLUSIONS

The safety aspects of the RDS-1000 dewatering system are summarized below:

- The high level alarm will alert the operator to stop the transfer.
- The Hi-Hi level float switch will cause the waste valve to automatically close and prevent liner overflow.
- The RDS-1000 dewatering system will be located within a controlled area.
- CNSI operating personnel are trained to operate the system in a safe manner in accordance with CNSI and utility approved procedures.
- Use of The Rapid Dewatering System should significantly reduce personnel exposure without compromising plant or personnel safety.
- A safety relief valve set at 1 psig has been installed between the pump and container to prevent overpressure.
- A thermal switch will automatically shut down the pump in the event of pump case temperature exceeding 240°F.

7.0 ACCIDENT EVALUATION

7.1 Postulated Accident Analysis

The design, fabrication, and operation of the CNSI RDS-1000 Unit is in accordance with the appropriate NRC, ASME, ANSI, and IEEE Codes and Standards to ensure the safe and reliable dewatering of the waste. Nonetheless, accidents are statistically plausible, and have the potential for the release of radioactivity to the surrounding area. A description of plausible accidents and an analysis of the releases that may occur are summarized in this section.

7.2 Fire

The only source of fire is the electrical power and control system when these components are used. In the event of an electrical fire, the fail-safe control system is designed to prevent leakage of radioactive materials. Materials used in the construction of the RDS-1000 will not support combustion.

When available, fire fighting equipment is provided to the operator to perform the initial fighting of the fire with backup provided by the station fire brigades.

7.3 Pressure Changes

7.3.1 Overpressure

Overpressure could result from two possible conditions. The first is by media temperature in the container reaching 212°F; thereby, causing free water to form steam (experience has shown that media temperature reaching 212°F is an unlikely event). This event could occur during either the initial gross dewatering or drying phase. Media temperature in the container is monitored, and in the unlikely event of an excursion, water can be reintroduced into the container through the fillhead skirt or camera flush.

The second possibility occurs during the drying phase. Line plugging on the inlet to the blower could produce a temporarily higher than normal pressure on the blower discharge. Since blower discharge valve is opened prior to system operation during the startup position valve lineup, Safety Valve PSV-1 (set to relieve at + 1 psi) would prevent container overpressure in either of the above conditions. Off-gas through PSV-1 is directed to a HEPA filter or the plant off-gas system or both, if required to prevent the spread of contamination

7.3.2 Vacuum

A vacuum condition in the liner is prevented during the initial dewatering phase since the liner is vented through the HEPA filter on the blower skid. Vacuum in the container is controlled since the pressure drop occurs across the dewatering filters and media.

7.4 Equipment Failures

7.4.1 Waste Isolation Valve

The waste isolation valve, when employed, is provided with a manual override to enable the opening of the valve, should it fail in the closed position. Manual override will allow the completion of the waste fill and flushing cycle so that the dewatering of the current waste batch can proceed and allow repairs to be made between batches under relatively low exposure conditions. Failure of the waste isolation valve in the open position is backed up by the telephone communications with the utility operator, i.e., if the valve does not shut when the correct waste volume has been transferred, waste flow can be stopped by the utility staff.

7.4.2 Airborne Release

Dewatering operations do not normally result in airborne release. Safety precautions such as grab air samples or continuous air monitoring are taken at the discretion of the utility.

7.4.3 Liquid Pathway

There is credible liquid pathway offsite due to the double barrier of liner and cask and the coupling to the utility drain systems.

7.4.4 Incident Scenarios

Statistically, a release of radioactive material may occur during the transfer operation or while the radioactive waste is in the container prior to dewatering. In this regard, two scenarios are envisaged: a filling hose rupture and a bottom-weld rupture of a full liner. These potential accident conditions are fully evaluated in Section 8.0.

7.4.5 Case I

A hose rupture during filling activities is seen to be the least serious of the scenarios. This is because the quantity of radioactivity spilled is a function of operator response time and the quantity of radioactivity in the filling hose at any given time. The operator response time is dependent upon observance of the malfunction and the time necessary for physically closing the waste isolation valve. During operation, the operator is positioned near the control station and visually monitors the transfer process. It is estimated that no more than two minutes would elapse between hose rupture and valve closing. since flow rates of 25, 50, and 100 gallons per minute are expected, the worst-case scenario is a spill of 200 gallons. Table 8.1 shows that if this scenario happens, cobalt-58 and -60, cesium-134 and -137, iodine-131, and manganese-54 will contribute 5.44 percent of MPC at the site boundary (10 CFR 20, Appendix B, Table II, Column 1, Soluble, 1 Dec. 1978).

7.4.6 Case II

A bottom weld rupture of a full liner is seen as the most serious of the incident scenarios but is even less likely than Case I. It is only more serious because the total volume spill is greater. The largest liner dewatered contains a maximum of 2,281 gallons of waste (305 ft^3) and, depending on the contact radiation readings, are filled either in or out of a cask. If the waste stream is high activity the liner is inserted into a cask and then filled. Thus, a bottom weld rupture in this operational mode would cause the spill of 2,281 gallons maximum into a cask and the contents would be contained. Therefore, no release to the environment is envisaged.

7.4.6.1 If the waste stream is low activity or the liner is not filled in a cask, then a bottom weld rupture could spill the contents and environmental release is possible. Table 8-1 shows that if this scenario occurred, the listed radionuclides would contribute 65.36 percent of the MPC allowable under Table II.

8.0 ACCIDENT EVALUATION

8.1 Case I, Hose Rupture

8.1.1 Co-58 MPC

1. Release rate:

$$\frac{1.67\ \text{gal}}{\text{sec}} \times \frac{1\ \text{ft}^3}{7.48\ \text{gal}} \times \frac{1.2\ \text{E-3 Ci}}{\text{ft}^3} = 2.68\ \text{E-4}\ \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (100,000):

$$2.68\ \text{E-4}\ \frac{\text{Ci}}{\text{sec}} \times 1\ \text{E+6}\ \frac{\text{uCi}}{\text{Ci}} \times \frac{1}{100{,}000} = 2.68\ \text{E-3}\ \frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$7.75\ \text{E-4}\ \frac{\text{sec}}{\text{m}^3} \times 2.68\ \text{E-3}\ \frac{\text{uCi}}{\text{sec}} \times \frac{1\ \text{E-6 m}^3}{1\ \text{ml}} = 2.1\ \text{E-12}\ \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{2.1\ \text{E-12}\ \frac{\text{uCi}}{\text{ml}}}{3\ \text{E-8}\ \frac{\text{uCi}}{\text{ml}}} \times 100\% = 7.0\ \text{E-3}\ \%\ \text{of MPC}$$

8.1.2 Co-60

1. Release rate:

$$\frac{1.67 \text{ gal}}{\text{sec}} \times \frac{1 \text{ ft}^3}{7.48 \text{ gal}} \times 1.4 \text{ E-3} \frac{\text{Ci}}{\text{ft}^3} = 3.18 \text{ E-4} \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (100,000):

$$3.1 \text{ E-4} \frac{\text{Ci}}{\text{sec}} \times 1 \text{ E+6} \frac{\text{uCi}}{\text{Ci}} \times \frac{1}{100{,}000} = 3.1 \text{ E-3} \frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$7.75 \text{ E-4} \frac{\text{sec}}{\text{m}^3} \times 3.1 \text{ E-3} \frac{\text{uCi}}{\text{sec}} \times \frac{1 \text{ E-6 m}^3}{1 \text{ ml}} = 2.4 \text{ E-12} \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{2.4 \text{ E-12} \frac{\text{uCi}}{\text{ml}}}{3 \text{ E-8} \frac{\text{uCi}}{\text{ml}}} \times 100\% = 2.4 \text{ E-2 \% of MPC}$$

8.1.3 Cs-134

1. Release rate:

$$\frac{1.67 \text{ gal}}{\text{sec}} \times \frac{1 \text{ ft}^3}{7.48 \text{ gal}} \times 8.5 \text{ E-3} \frac{\text{Ci}}{\text{ft}^3} = 1.9 \text{ E-3} \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (100,000):

$$1.9 \text{ E-3} \frac{\text{Ci}}{\text{sec}} \times 1 \text{ E+6} \frac{\text{uCi}}{\text{Ci}} \times \frac{1}{100{,}000} = 1.9 \text{ E-2} \frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$7.75 \text{ E-4} \frac{\text{sec}}{\text{m}^3} \times 1.9 \text{ E-2} \frac{\text{uCi}}{\text{sec}} \times \frac{1 \text{ E-6 m}^3}{1 \text{ ml}} = 1.47 \text{ E-11} \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{1.47 \text{ E-11} \frac{\text{uCi}}{\text{ml}}}{1 \text{ E-9} \frac{\text{uCi}}{\text{ml}}} \times 100\% = 1.5 \text{ \% of MPC}$$

8.1.4 Cs-137

1. Release rate:

$$\frac{1.67\ \text{gal}}{\text{sec}} \times \frac{1\ \text{ft}^3}{7.48\ \text{gal}} \times 1.69\ \text{E-2}\ \frac{\text{Ci}}{\text{ft}^3} = 3.77\ \text{E-3}\ \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (100,000):

$$3.77\ \text{E-3}\ \frac{\text{Ci}}{\text{sec}} \times 1\ \text{E+6}\ \frac{\text{uCi}}{\text{Ci}} \times \frac{1}{100{,}000} = 3.77\ \text{E-2}\ \frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$7.75\ \text{E-4}\ \frac{\text{sec}}{\text{m}^3} \times 3.77\ \text{E-2}\ \frac{\text{uCi}}{\text{sec}} \times \frac{1\ \text{E-6}\ \text{m}^3}{1\ \text{ml}} = 2.92\ \text{E-11}\ \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{2.92\ \text{E-11}\ \frac{\text{uCi}}{\text{ml}}}{2\ \ \text{E-9}\ \frac{\text{uCi}}{\text{ml}}} \times 100\% = 1.5\ \%\ \text{of MPC}$$

8.1.5 Iodine-131

1. Release rate:

$$\frac{1.67\ \text{gal}}{\text{sec}} \times \frac{1\ \text{ft}^3}{7.48\ \text{gal}} \times 1.4\ \text{E-3}\ \frac{\text{Ci}}{\text{ft}^3} = 3.1\ \text{E-4}\ \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (10,000):

$$3.1\ \text{E-3}\ \frac{\text{Ci}}{\text{sec}} \times 1\ \text{E+6}\ \frac{\text{uCi}}{\text{Ci}} \times \frac{1}{10{,}000} = 3.1\ \text{E-2}\ \frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$7.75\ \text{E-4}\ \frac{\text{sec}}{\text{m}^3} \times 3.1\ \text{E-2}\ \frac{\text{uCi}}{\text{sec}} \times \frac{1\ \text{E-6}\ \text{m}^3}{1\ \text{ml}} = 2.4\ \text{E-11}\ \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{2.4\ \text{E-11}\ \frac{\text{uCi}}{\text{ml}}}{1\ \text{E-9}\ \frac{\text{uCi}}{\text{ml}}} \times 100\% = 2.4\ \%\ \text{of MPC}$$

8.1.6 Manganese-54

1. Release rate:

$$\frac{1.67 \text{ gal}}{\text{sec}} \times \frac{1 \text{ ft}^3}{7.48 \text{ gal}} \times 6 \text{ E-4 } \frac{\text{Ci}}{\text{ft}^3} = 1.34 \text{ E-4 } \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (100,000):

$$1.34 \text{ E-4 } \frac{\text{Ci}}{\text{sec}} \times 1 \text{ E+6 } \frac{\text{uCi}}{\text{Ci}} \times \frac{1}{100{,}000} = 1.34 \text{ E-3 } \frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$1.34 \text{ E-3 } \frac{\text{uCi}}{\text{sec}} \times 7.75 \text{ E-4 } \frac{\text{sec}}{\text{m}^3} \times \frac{1 \text{ E-6 m}^3}{1 \text{ ml}} = 1.04 \text{ E-12 } \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{1.04 \text{ E-12 } \frac{\text{uCi}}{\text{ml}}}{1 \text{ E-8 } \frac{\text{uCi}}{\text{ml}}} \times 100\% = 1.04 \text{ E-2 \% of MPC}$$

8.2 Case II, Bottom Weld Rupture

8.2.1 Cobalt-58

1. Release rate:

$$\frac{80.3 \text{ gal}}{\text{sec}} \times \frac{1 \text{ ft}^3}{7.48 \text{ gal}} \times 6 \text{ E-5 } \frac{\text{Ci}}{\text{ft}^3} = 6.44 \text{ E-4 } \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (100,000):

$$6.44 \text{ E-4 } \frac{\text{Ci}}{\text{sec}} \times 1 \text{ E+6 } \frac{\text{uCi}}{\text{Ci}} \times \frac{1}{100{,}000} = 6.44 \text{ E-3 } \frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$6.44 \text{ E-3 } \frac{\text{uCi}}{\text{sec}} \times 7.75 \text{ E-4 } \frac{\text{sec}}{\text{m}^3} \times \frac{1 \text{ E-6 m}^3}{1 \text{ ml}} = 4.99 \text{ E-12 } \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{4.99 \text{ E-12 } \frac{\text{uCi}}{\text{ml}}}{3 \text{ E-8 } \frac{\text{uCi}}{\text{ml}}} \times 100\% = 1.66 \text{ E-2 \% of MPC}$$

8.2.2 Cobalt-60

1. Release rate:

$$\frac{80.3\ \text{gal}}{\text{sec}} \times \frac{1\ \text{ft}^3}{7.48\ \text{gal}} \times 7.0\ \text{E-5}\ \frac{\text{Ci}}{\text{ft}^3} = 7.5\ \text{E-4}\ \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (100,000):

$$7.5\ \text{E-4}\ \frac{\text{Ci}}{\text{sec}} \times 1\ \text{E+6}\ \frac{\text{uCi}}{\text{Ci}} \times \frac{1}{100{,}000} = 7.51\ \text{E-3}\ \frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$7.51\ \text{E-3}\ \frac{\text{uCi}}{\text{sec}} \times 7.75\ \text{E-4}\ \frac{\text{sec}}{\text{m}^3} \times \frac{1\ \text{E-6}\ \text{m}^3}{1\ \text{ml}} = 5.82\ \text{E-12}\ \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{5.82\ \text{E-12}\ \frac{\text{uCi}}{\text{ml}}}{1\ \text{E-8}\ \frac{\text{uCi}}{\text{ml}}} \times 100\% = 5.82\ \text{E-2}\ \%\ \text{of MPC}$$

8.2.3 Cesium-134

1. Release rate:

$$\frac{80.3\ \text{gal}}{\text{sec}} \times \frac{1\ \text{ft}^3}{7.48\ \text{gal}} \times 4.25\ \text{E-4}\ \frac{\text{Ci}}{\text{ft}^3} = 4.56\ \text{E-3}\ \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (100,000):

$$4.56\ \text{E-3}\ \frac{\text{Ci}}{\text{sec}} \times \frac{1\ \text{E+6}\ \text{uCi}}{1\ \text{Ci}} \times \frac{1}{100{,}000} = 4.56\ \text{E-2}\ \frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$4.56\ \text{E-2}\ \frac{\text{uCi}}{\text{sec}} \times 7.75\ \text{E-4}\ \frac{\text{sec}}{\text{m}^3} \times \frac{1\ \text{E-6}\ \text{m}^3}{1\ \text{ml}} = 3.54\ \text{E-11}\ \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{3.54\ \text{E-11}\ \frac{\text{uCi}}{\text{ml}}}{1\ \text{E-9}\ \frac{\text{uCi}}{\text{ml}}} \times 100\% = 3.54\ \%\ \text{of MPC}$$

8.2.4 Cesium-137

1. Release rate:

$$\frac{80.3\ \text{gal}}{\text{sec}} \times \frac{1\ \text{ft}^3}{7.48\ \text{gal}} \times 8.45\ \text{E-4}\ \frac{\text{Ci}}{\text{ft}^3} = 9.07 \times \text{E-3}\ \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (100,000):

$$9.07\ \text{E-3}\ \frac{\text{Ci}}{\text{sec}} \times \frac{1\ \text{E+6 uCi}}{1\ \text{Ci}} \times \frac{1}{100{,}000} = 9.07\ \text{E-2}\ \frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$9.07\ \text{E-2}\ \frac{\text{uCi}}{\text{sec}} \times 7.75\ \text{E-4}\ \frac{\text{sec}}{\text{m}^3} \times \frac{1\ \text{E-6 m}^3}{1\ \text{ml}} = 7.03\ \text{E-11}\ \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{7.03\ \text{E-11}\ \frac{\text{uCi}}{\text{ml}}}{2.0\ \text{E-9}\ \frac{\text{uCi}}{\text{ml}}} \times 100\% = 3.52\ \%\ \text{of MPC}$$

8.2.5 Iodine-131

1. Release rate:

$$\frac{80.3\ \text{gal}}{\text{sec}} \times \frac{1\ \text{ft}^3}{7.48\ \text{gal}} \times 7.0\ \text{E-5}\ \frac{\text{Ci}}{\text{ft}^3} = 7.51\ \text{E-4}\ \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (10,000):

$$7.51\ \text{E-4}\ \frac{\text{Ci}}{\text{sec}} \times 1\ \text{E+6}\ \frac{\text{uCi}}{1\ \text{Ci}} \times \frac{1}{10{,}000} = 7.51\ \text{E-2}\frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$7.51\ \text{E-2}\ \frac{\text{uCi}}{\text{sec}} \times 7.75\ \text{E-4}\ \frac{\text{sec}}{\text{m}^3} \times \frac{1\ \text{E-6 m}^3}{1\ \text{ml}} = 5.82\ \text{E-11}\ \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{5.82\ \text{E-11}\ \frac{\text{uCi}}{\text{ml}}}{1\ \text{E-10}\ \frac{\text{uCi}}{\text{ml}}} \times 100\% = 58.2\ \%\ \text{of MPC}$$

8.2.6 Manganese-54

1. Release rate:

$$\frac{80.3\ \text{gal}}{\text{sec}} \times \frac{1\ \text{ft}^3}{7.48\ \text{gal}} \times 3\ \text{E-5}\ \frac{\text{Ci}}{\text{ft}^3} = 3.22\ \text{E-4}\ \frac{\text{Ci}}{\text{sec}}$$

2. Partition factor (100,000):

$$3.22\ \text{E-4}\ \frac{\text{Ci}}{\text{sec}} \times 1\ \text{E+6}\ \frac{\text{uCi}}{1\ \text{Ci}} \times \frac{1}{100{,}000} = 3.22\ \text{E-3}\ \frac{\text{uCi}}{\text{sec}}$$

3. At site boundary:

$$3.22\ \text{E-3}\ \frac{\text{uCi}}{\text{sec}} \times 7.75\ \text{E-4}\ \frac{\text{sec}}{\text{m}^3} \times \frac{1\ \text{E-6}\ \text{m}^3}{1\ \text{ml}} = 2.50\ \text{E-12}\ \frac{\text{uCi}}{\text{ml}}$$

4. Percent of MPC:

$$\frac{2.50\ \text{E-12}\ \frac{\text{uCi}}{\text{ml}}}{1\ \text{E-8}\ \frac{\text{uCi}}{\text{ml}}} \times 100\% = \underline{2.50\ \text{E-2}\ \%\ \text{of MPC}}$$

8.3 The following information is presented:

8.3.1 Case I

Maximum spill rate: 100 gallons per minute
1.67 gallons per second

8.3.2 Chi/Q

$7.75\ \text{E-4}\ \frac{\text{sec}}{\text{m}^3}$ (see Note 8.4.3)

8.3.3 Partition Factors (see Note 8.4.1)

Iodine-131	10,000
Other radionuclides	100,000

8.3.4 Maximum Liner Size

318 ft^3 (approximately 2,379 gallons)

8.3.5 Usable Liner Volume

305 ft^3 (2,281 gallons)

8.3.6 Cases I and II

No consideration is made for material absorbed on surfaces for the following reasons:

a. Calculated percent of MPC shows a small instantaneous value for all radionuclides;

b. Calculated values are considered conservative by a cumulative value of at least 100;

c. These scenarios have a small probability of occurrence;

d. Case I release is easily corrected and of short-term duration.

8.4 Notes

8.4.1 Iodine Partitionary Factor = 10,000 (P.F.)

Effluent source terms were conservatively developed by assuming entrainment from liquid phase to vapor phase would occur on the same basis as a system operating on the principle of evaporation. Gray, et al., 1979, BNFP, 1976, reports entrainment factors of 10^{-6} for such a system (P.F. = 1,000,000). In the case of evaporation by boiling, a higher rate of release of radionuclides with off-gas vapors occurs than would be expected from routine operation of pumps, valves, and water transfer, and certainly from the case in question. Therefore, assumption of a factor of 10,000 is considered to be extremely conservative for iodine, especially considering the solution will be basic and force the iodine present toward the ionic form. The partitioning factor is also supported in the literature by data presented in WASH 1258, Volume 2, USAEC, July 1973.

8.4.2 Partitionary Factor--Other Isotopes = 100,000

For calculation purposes, partitionary factors for isotopes other than iodine (these radionuclides are less volatile than iodine) was chosen as 100,000. Again, this value is conservative (see above) and with industry experience.

8.4.3 Chi/Q = 7.75×10^{-4} sec/m^3

This factor was calculated as an average of worst case Chi/Q values from six typical operating nuclear plants. Since a generic application of site-specific Chi/Q values is necessary for a typical application, an additional conservative factor of 5 was inserted.

8.4.4 Isotopic Content

Data presented in this document were calculated from data given in CAEC-007, March 1978. Table 8.3 (p. 251, CAEC-007) was utilized to calculate the percentage of radionuclides in the process waste. Additionally, CAEC-007 was utilized to calculate the isotopic waste content based on reported specific activity of pressurized and boiling water reactors and is reported in Table 8-1 under the waste stream specific activity. A telephone survey of several nuclear plants was conducted to ascertain the validity of the isotopic content used in the evaluation. In all cases sampled, the values used are conservative in relation to actual reported values.

8.4.5 Scaling Factor

Since Case II deals with low activity waste, typical radiation levels of 150-250 mR/hr were scaled down by a factor of 20. These values still remain conservative when compared to actual reported values.

8.4.6 Total Maximum Permissible Concentration

Total maximum permissible concentration is determined by:

$$\frac{C_a}{MPC_a} + \frac{C_b}{MPC_b} + \frac{C_c}{MPC_c} \cdots + \frac{C_n}{MPC_m} = \text{less than unity}$$

8.4.7 Spill Rate Calculations

Spill rate calculations are:

$R = A\,2\,[gh]^{1/2}$ where:

R = volume of liquid discharged per unit time

A = area of orifice (2.94 E-2 m^2)

g = gravitational constant ($9.8\ m/s^2$)

h = height of liquid above orifice (2.73 m)

$(2.94 \text{ E-2 } m^2)(2)(5.17)$

$$.304\ \frac{m^3}{sec} \times 264.2\ \frac{gal}{m^3}$$

$$80.3\ \frac{gal}{sec}$$

8.4.8 Time Required to Empty Liner

$$(2281 \text{ gal})\left(\frac{1 \text{ sec}}{80.3 \text{ gal}}\right) = 28.4 \text{ sec.}$$

TABLE 8-1

CASE I AND II INCIDENT SCENARIOS AND THE RESULTING PERCENT CONTRIBUTION TO TABLE II MPC

[1]Radionuclide	[2]Table II MPC (uCi/ml)	S.A. Waste Stream		[5]S.A. in 200 gal (uCi)	[6]Concentration at Site Boundary		Percent of MPC	
		[3]Case I (Ci/ft^3)	[4]Case II (Ci/ft^3)		Case I (uCi/ml)	Case II (uCi/ml)	Case I	Case II
Cobalt-58	3 E-8	1.2 E-3	6.0 E-5	3.2 E-4	2.1 E-12	2.81 E-12	7.0 E-3	1.66 E-3
Cobalt-60	1 E-8	1.4 E-3	7.0 E-5	3.7 E-4	2.4 E-12	3.28 E-12	2.4 E-2	5.82 E-2
Cesium-134	1 E-9	8.5 E-3	4.25 E-5	2.3 E-5	1.47 E-11	1.99 E-11	1.5	3.54
Cesium-137	2 E-9	1.69 E-2	8.45 E-4	4.5 E-5	2.92 E-11	3.96 E-11	1.5	3.52
Iodine-131	1 E-10	1.4 E-3	7.0 E-5	3.7 E-4	2.4 E-11	3.28 E-11	2.4	58.2
Manganese-54	1 E-8	6.0 E-4	3.0 E-5	1.6 E-4	1.04 E-12	1.40 E-12	1.04 E-2	2.5 E-2
Percent of MPC[6]							5.44	55.36

[1] From CAEC-007, 1978

[2] 10 CFR 20, Appendix B, Table II, Column I, Soluble

[3] Calculated from CAEC-007, 1978

[4] Scaled down by a factor of 20 to account for lower level

[5] S.A. = Specific Activity

[6] See calculations, Cases I and II

RDS 1000 PROCESS FLOW DIAGRAM

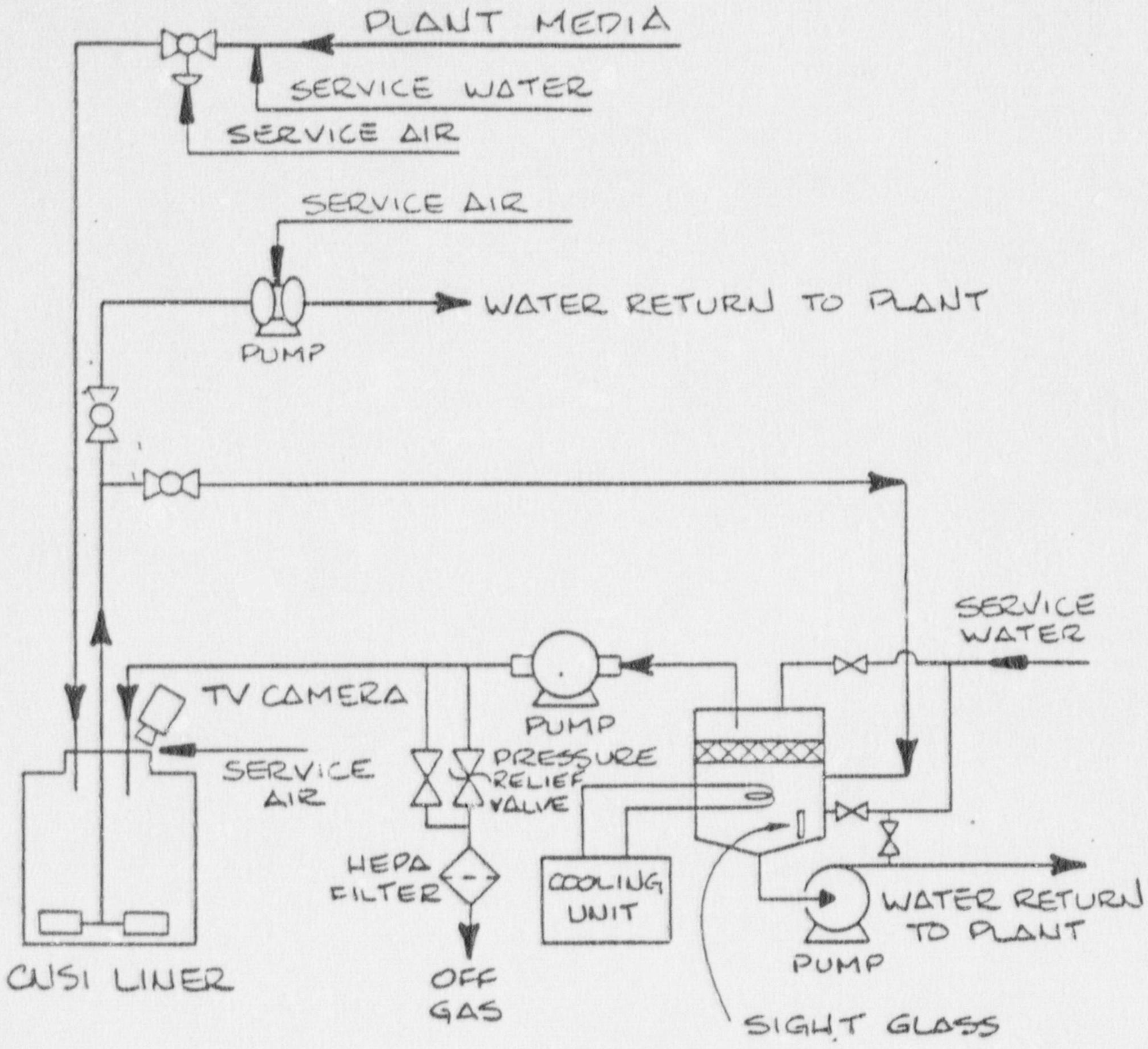

FIGURE 1