SOUTH CAROLINA ELECTRIC AND GAS COMPANY

VIRGIL C. SUMMER NUCLEAR STATION

PROCESS CONTROL PROGRAM

PACKAGING OF LOW-LEVEL RADIOACTIVE WASTES

DATE OF ORIGINAL ISSUE:

DECEMBER 23, 1981

PREPARED BY: Gary J. Guy
Gary J. Guy
Technical Support Engineer

APPROVED BY: Melvin N. Browne
Melvin N. Browne, Assistant
Manager Technical Support

REVIEWED BY PSRC
J G Connelly 4/15/83
CHAIRMAN DATE

REVISION	DATE	APPROVED
2	4/15/83	J G Connelly

1.0 SCOPE

1.1 Purpose

The purpose of this Process Control Program for the Virgil C. Summer Nuclear Station is to establish a set of process parameters which provide reasonable assurance that the packaged radioactive wastes meet applicable Department of Transportation (DOT), Nuclear Regulatory Commission (NRC), and South Carolina State regulations for shipment and offsite burial at an approved site. Additionally, reasonable assurance is provided that the acceptance criteria of said burial facility are met.

1.2 Applicability

This Process Control Program shall be used by all personnel for the packaging of low level radioactive wastes. This program includes Chem-Nuclear Systems Incorporated (CNSI) personnel operating CNSI supplied equipment.

2.0 References

2.1 Virgil C. Summer Nuclear Station Final Safety Analysis Report, Chapter 10 and 11, FSAR Questions 321.17, through 321.23.

2.2 SCE&G Corporate ALARA Plan.

2.3 Virgil C. Summer Nuclear Station Technical Specification 3/4.11.3.

2.4 Virgil C. Summer Nuclear Station Quality Assurance Program.

2.5 CNSI Quality Assurance Program, QA-AD-001, and CNSI Process Control Program, in 4313-01354-01.

2.6 CNSI Operating Procedures for Cement Solidification and Dewatering Units, as applicable SD-OP-036 and FO-OP-003.

2.7 CNSI Topical Report, 4313-01354-01.

2.8 NUREG 0472, Radiological Effluent Technical Specifications for PWR.

2.9 Branch Technical Position-ESTB 11-3, Design Guidance for Solid Radioactive Waste Management Systems Installed in Light-Water-Cooled Nuclear Power Reactor Plants.

2.10 ANSI 199, Liquid Radioactive Waste Processing Systems for Pressurized Water Reactor Plants.

2.11 NRC Regulatory Guide 1.143, Design Guides for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Cooled Nuclear Power Plants.

2.12 SRP 11.4 Rev. 2 July, 1981 "Solid Waste Management Systems".

2.13 10CFR50, Appendix A.

3.0 System Description

3.1 Process Description

The Waste Processing System is designed to dewater and/or solidify radioactive wastes, evaporator bottoms, ion exchange resin slurries and sludges. The process utilizes a CNSI skid-mounted portable cement solidification unit and dewatering equipment.

The cement process makes use of the readily available Portland cements and hydrated lime ($Ca(OH)_2$) to solidify liquid wastes. The process is initiated by transferring liquid waste into the CNSI disposable liner. The waste is then conditioned by adding conditioning chemicals as required. (Conditioning chemicals may also be preloaded into the liner). With continuous agitation provided by the installed mixer blades, cement is added to develop a thick paste like slurry which will solidify to a hard, water-free end product.

3.2 Process Parameters

Cement undergoes four separate reactions during its curing time which permanently combines cement, water and a variety of ions found in waste streams to form a stable, solid concrete end product. Certain chemicals and metallic ions present in the waste act as accelerators or retardants to these reactions. By pretreating the waste with chemicals designed to limit or neutralize these effects, a controlled, acceptable cure time can be achieved and the waste-to-additive ratio will be significantly improved. Each of the reactions is exothermic and by controlling the speed of reaction and minimizing the total cement addition by the use of certain additives, the heat developed by large volume solidifications will also be minimized.

The sample verification procedure (Section 5.0) will serve to verify the exact pretreatment required to achieve the optimum waste-to-additive ratio. The amount of additives and cement to be used for sample and full scale solidifications are provided by Exhibit 2.

3.3 Waste Processing Unit Description

3.3.1 The waste processing unit contains all piping, support, control and monitoring equipment necessary to dewater and/or solidify radioactive waste (Reference 2.6).

3.3.2 The Waste Processing Unit is composed of several processing subsystems, each controlling a specific function of the process. These subsystems include waste transfer, chemical addition, cement conveyor, vent, and dewater systems. Control functions for the unit are incorporated into the solidification control panel.

3.3.3 Most of the waste processing unit components are arranged on skids to provide flexibility of operations. The cement conveyor, control panel, pump skid, hydraulic skid and fillhead contain most of the major elements of the mobile unit.

3.3.4 A closed-circuit television system is an integral part of the unit and allows the operator to monitor the solidification or dewatering process.

3.4 System Operation

3.4.1 Before beginning any waste processing, Health Physics is to determine the liner type and size, the cask type and size, the waste transfer requirements, and the process operation requirements.

3.4.2 Resin Dewatering

Primary spent resins and steam generator blowdown resins may be dewatered by the portable unit as determined by Health Physics. Whenever secondary side condensate polisher resins require disposal as solid radwaste as determined by Health Physics, dewatering equipment in the Turbine Building will be used in conjunction with the Process Control Program. The Dewatering Completion Record (Exhibit 1) shall be used as the documentation data sheet.

3.4.2.1 Establish or verify that the liner is in a level position (visual determination).

3.4.2.2 Connect the suction hose to the outlet connection on the liner and to the suction of the dewatering pump.

3.4.2.3 Connect one end of the outlet hose to the discharge of the dewater pump and direct the other end to the dewater return connection.

3.4.2.4 Connect the service air hose to the service air supply and the dewatering pump.

3.4.2.5 Establish service air to the pump.

3.4.2.6 Adjust the pump air supply valve to establish a minimum pumping rate of 2 strokes per second. Enter the time in the operating log and the Dewatering Completion Record.

3.4.2.7 Continue pumping for a minimum of 8 hours then shut off the pump. Record shut-off time in the operating log and the Dewatering Completion Record.

3.4.2.8 Let the vessel stand for a minimum of 16 hours.

3.4.2.9 Repeat Steps 3.4.2.5 and 3.4.2.6. Continue pumping for 4 hours then shut off the pump. Record shut-off time in the operating log and the Dewatering Completion Record.

3.4.2.10 Disconnect the suction hose from the outlet connection of the liner. Complete the Dewatering Completion Record (Exhibit 1).

3.4.3 Cement Solidification

As determined by Health Physics, liquid radwaste from the Chemical Drain Tank and the Waste Evaporator Concentrates Tank or other waste storage tanks, e.g. Spent Resin Storage tanks, will be solidified using the cement process.

3.4.3.1 Before beginning any waste processing with the Cement Solidification Unit, the CNSI operator shall complete a successful sample verification in accordance with the Sample Verification Procedure of Section 5.0.

3.4.3.2 The successful sample solidification parameters are included in the Solidification Information Sheets (Exhibit 2). These parameters are amplified for full scale solidification values, as appropriate.

3.4.3.3 Actual full scale solidification shall then be conducted using the parameters calculated in the CNSI Solidification Worksheet II (Exhibit 4).

3.4.3.4 Sequence of Operation - The conditioning chemicals may be preloaded into the liner or added to the waste while mixing. The addition of chemicals or waste usually may be interrupted without ill effect. The mixer may also be secured during waste or chemical addition with no effect on the process, however, it must remain in operation during the cement addition. After cement addition, the mixer is secured and the process is complete.

3.4.3.5 Mixer Speed - The mixer speed should be high enough to allow complete mixing of waste conditioner and cement. Generally, the speed will be set at 40 RPM while adding conditioning chemicals and 40 to 75 RPM when starting cement addition. The speed will be increased to 100 RPM after two-thirds of the cement has been added.

3.4.3.6 Waste-to-Cement Ratio (by volume) - The normal waste-to-cement/conditioner ration (by volume) will be approximately 2 to 1 up to 3 to 1 for evaporator concentrates and liquid wastes, and above 2.5 to 1 for resins, powdex and other solids.

If normal ratios are exceeded, cure time may be delayed and the solidified product may have free-standing water on its surface.

3.4.3.7 Cure Time - Cure time will usually be 12 to 36 hours and the temperatures may rise during this time to 200°F. The liner should be ventilated until temperature starts decreasing indicating a completed reaction.

4.0 REQUIREMENTS FOR SAMPLE VERIFICATION

4.1 General Precautions

NOTE: IF DIFFICULTIES ARE ENCOUNTERED WITH ANY PART OF THIS VERIFICATION PROCEDURE OR UNEXPECTED RESULTS ARE OBTAINED, CONTACT HEALTH PHYSICS.

4.1.1 The chemicals and cement used are considered non-toxic and safe to handle, however, care should be used to avoid breathing dust. If a liquid caustic is used for special applications, follow the safety precautions.

4.2 Radiological Precautions

4.2.1 The operator shall be subject to the applicable Health Physics and safety precautions of the Virgil C. Summer Nuclear Station.

4.2.2 Laboratory gloves, face shield and an apron shall be worn while handling, collecting and testing of all samples.

4.2.3 The operator shall establish radiologically clean and contaminated zones in the sample process area to prevent the possible spread of contamination.

4.3 Prerequisities

4.3.1 Waste Recirculation

4.3.1.1 Due to the importance of obtaining a representative sample for use in the verification procedure, the operators shall confirm that the contents of the waste storage tank have either been recirculated for a minimum of three volume turnovers or are adequately mixed to achieve a homogeneous mixture.

4.3.1.2 Any number of mechanical operations of the waste storage tank may negate the effects of previous recirculation/agitation period. These operations would include the following:

4.3.1.2.1 Introduction of additional waste into the storage tank after recirculation has commenced.

4.3.1.2.2 Securing of recirculation while drawing the verification sample.

4.3.1.2.3 Shifting from a recirculation mode to a transfer mode.

4.3.1.3 If any of the situations listed above occur, it will be necessary to repeat the recirculation process and sample verification procedure of Section 5.0 in order to re-establish the solidification process parameters.

4.3.2 Health Physics/Chemistry shall identify the waste properties as far as practicable, i.e.; oil content, density, type, estimated activity. Waste containing oil above one percent by volume shall not be solidified by this PCP.

4.3.3 Resins that are to be dewatered only are sampled to determine activity. The sample count is to be performed by Health Physics.

4.3.4 The remainder of this sample verification program applies to cement solidification.

4.3.4.1 <u>Equipment</u>

Equipment required for use during the sample verification procedure is listed in Table 1. The table indicates the minimum quantity required to begin a verification procedure.

The operator shall ensure that all necessary equipment is available or adequate substitutes are available.

The operator shall ensure that additives received comply with the chemical composition necessary for this process.

4.3.4.2 Sample Acceptance Criteria - In order to ensure acceptable solidification has occurred, the operator shall confirm that all acceptance criteria are met as follows:

4.3.4.2.1 Visual inspection of the mixture after cement addition to confirm that the mixture is homogeneous with no free water on the surface.

4.3.4.2.2 Visual inspection of the end product after hardening to indicate a uniform, liquid free, free standing monolith.

4.3.4.2.3 The end product resists penetration when probed with a pencil size probe.

CAUTION: The concrete Matrix must be less than 175°F and indicate a steady, positive decreasing temperature prior to sealing. It must also be water free. It may be desirable to add a small amount of dry cement to absorb any condensate liquid on the billet surface and container walls. The liner shall not be sealed within 30 hours of mixing completion.

4.3.4.3 Requirements for Sample Verification

4.3.4.3.1 Verify that all material listed in Table 1 is available and ready to use in the area for solidification sampling.

4.3.4.3.2 Use the CNSI Solidification Worksheet I (Exhibit 3) for all sample solidifications.

4.3.4.3.3 Sample Requirements

4.3.4.3.3.1 A sample shall be solidified prior to full scale solidification of waste. If there is no change in the chemical composition of the waste as verified by Health Physics, test results and full scale solidifications will be conducted prior to the tenth batch solidified from the same source of waste.

4.3.4.3.3.2 The operator shall ensure that the sample is representative (i.e.; thoroughly mixed) and that the sample line is properly purged prior to drawing the PCP sample.

NOTE: If the initial test specimen from a tank fails to verify SOLIDIFICATION, collect and test representative samples from that tank until three consecutive test specimens demonstrate SOLIDIFICATION.

5.0 Sample Verification

5.1 Samples may be obtained at the Chemical Drain Tank, & the Waste Evaporator Concentrates Tank. Spent resin sampling is accomplished at the sample point on the resin transfer line.

5.2 For cement solidification, calculate & record the available information on Exhibit 3 for all waste type sample verifications.

NOTE: WASTE SOLIDIFIED ON A SMALL SCALE WILL CURE MUCH SLOWER BECAUSE OF THE EXCESSIVE SURFACE TO VOLUME RATIO FOR HEAT TRANSFER. SAMPLE STORAGE IN AN APPROVED CONSTANT TEMPERATURE OVEN WILL ENABLE A MORE MEANINGFUL EVALUATION ON AN OVERNIGHT BASIS.

6.0 ADMINISTRATIVE PROCEDURES

6.1 Maintenance of Records

6.1.1 Dewatering

The operator shall confirm that the completed Dewatering Completion Record is accurate and in compliance with the dewatering procedure. The operator shall retain original and forward one copy to Health Physics.

6.1.2 Cement Solidification

The operator shall retain originals and forward one copy of the completed sample verification forms to Health Physics.

TABLE 1

EQUIPMENT REQUIRED FOR TESTING SAMPLES

250 ML Plastic Beakers with Lids (6)
600-1000 ML Containers with Lids (6)
Stirring Devices (5)
Pipettes (2)
Pipettor
0-212°F Thermometer
pH Paper: Wide Range (1.0 to 11.0)
 Narrow Range (8.0 to 12.0)
0-600 or 0-1000 gm Triple Beam Balance
If Liquid Caustic is Used:
 Hydrometer, Range 1.000-1.200
 50 ML Buret (2)
 Ring Stand
 Buret Clamp (2)
Marking Pen
Sample Heating Oven, Thermostatically Controlled from 100°F to 180°F.
Kitchen Strainer, 1/16" Openings
Graduated Cylinders, 250 ml (2)

Chemicals to be used should be taken from the full scale solidification chemicals listed on the respective figure for each waste form.

EXHIBIT 1

Virgil C. Summer Nuclear Station

DEWATERING COMPLETION RECORD

Vessel Designation: ____________ Vessel Serial: ____________

Proc. Step	Description	Date	Time	Operator
3.4.2.6	Start dewatering pump	____	____	________
3.4.2.7	Secure dewatering pump	____	____	________
	Total pumping time: (Must be ≥ 8 hours)		____	________
3.4.2.8	Let vessel stand for ≥ 16 hours			
3.4.2.9	Start dewatering pump	____	____	________
	Secure dewatering pump	____	____	________
	Total pumping time: (Must be ≥ 4 hours)	____	____	________

EXHIBIT 2

SOLIDIFICATION INFORMATION SHEETS

A. PCP SOLIDIFICATION OF BORIC ACID CONCENTRATES (PWR WASTES)

1.0 Sample Verification

NOTE: THE CHEMICAL ADDITIVES USED FOR PCP PREPARATION SHOULD BE THOSE ACTUALLY USED IN FULL SCALE SOLIDIFICATION AND SHOULD BE STORED IN CAPPED CONTAINERS.

1.1 From the waste analysis supplied by the utility, determine the appropriate additives from the following chart and enter the amounts on CNSI Solidifcation Worksheet I. Use minimum amounts of cement and lime in accord with waste properties and past experience.

CHART 1

Boron Content Of Waste (PPM)	Boric Acid Equivalent (By Weight)	Cement (gms)	Lime (gms)	Calcium Chloride (gms)	*CNSI Moderator S-4 (gms)	*Sodium Hydroxide (50% Solu)
0- 3,500	0-2%	190-240	10-20	3.0	10	2.5 ml**
3,500- 7,000	2-4%	180-230	20-30	3.0	10	2.5 ml**
7,000-10,500	4-6%	170-220	30-40	3.0	10	2.5 ml**
10,500-14,000	6-8%	160-210	40-50	3.0	10	2.5 ml**
14,000-17,500	8-10%	150-200	45-60	3.0	10	2.5 ml**
17,500-21,000+	10-12%+	145-190	50-70	3.0	10	2.5 ml**

*Typical Amounts Or As Required, If Any, By Test Results. **Or 5 ml of 25% Solu.

1.2 Notify Health Physics that preparations for verification testing have been completed and request that a sample be taken.

1.3 Freshly screen sufficient lime and cement in separate containers to avoid undispersed lumping in the samples.

1.4 Add calcium chloride, CNSI Moderator S-4, and lime (as indicated in Chart 1) to a 600-1000 ml container.

1.5 Ensure that the waste sample is uniform by heating to 140°F or more if necessary and then add 200 ml to each container. Mix thoroughly using wide blade spatula and then check the pH of each sample with narrow range paper and record results on CNSI Solidification Worksheet I. The pH at this point should be at least 10.5. Continue mixing and retesting if the pH is low, and add more lime if necessary. Record weight of lime added on CNSI Solidification Worksheet I.

NOTE: LIME AND BORIC ACID WASTE DO NOT REACT QUICKLY TOGETHER. BE SURE TO MIX THOROUGHLY FOR AT LEAST 3 MINUTES BEFORE DECIDING TO ADD MORE LIME BASED UPON CONFIRMING THAT THE pH IS STILL LOW.

1.6 Add the appropriate amount of cement to the container(s) while continuing mixing with spatula. Blend mixture(s) thoroughly.

1.7 Using a pipet, add the sodium hydroxide solution, if required, and mix thoroughly.

1.8 Transfer sample mixture(s) to 250 ml beaker(s). Fill to approximately 1/4" of the top.

1.9 Place lids securely on samples and immediately transfer to oven controlled at 135° ± 5°F. Then cure for 6-24 hours, according to experience.

1.10 Remove the samples from the oven, and allow to cool for at least 2 hours before removing the lid(s) and evaluating solidification results according to guidelines of Paragraph 4.3.4.2.

NOTE: OBTAINING A FIRM, DRY PCP PRODUCT AT 130°F WILL NORMALLY ASSURE THAT A TEST FORMULA WILL PROVIDE A RAPID AND ACCEPTABLE FULL-SCALE SOLIDIFICATION WITH A CLEARLY MEASURABLE EXOTHERM. TO DEMONSTRATE <u>ONLY</u> THE EXPECTED FINAL PRODUCT <u>HARDNESS</u>, THE SEALED SAMPLE SHOULD BE CURED AT 170 ± 5°F FOR 18-24 HOURS TO COMPLETE THE HARDENING REACTIONS.

NOTE: THE 2 HOUR COOLING PERIOD CAN BE DELETED IF EXPERIENCE WITH THIS PARTICULAR WASTE STREAM INDICATES THAT NO WATER IS STANDING ON THE SAMPLE AND IT MEETS THE REQUIREMENTS OF 4.3.4.2.

2.0 FULL SCALE CALCULATIONS (Boric Acid Concentrates)

2.1 Determine the volume (cubic feet) of waste to be received in the liner. Refer to Table 2 for usable liner volumes and also consider past experience and allowable cask payloads.

2.2 The amounts of cement and lime required are determined by using the information in the table below. The ratio of cement to lime varies according to the analyzed level of boric acid in the waste.

Waste Analysis PPM Boron	Equivalent Boric Acid Content	*Weight Of Lime Per Ft^3 Of Waste	*Weight Of Cement Per Ft^3 Of Waste
0- 3,500	0-2%	4.0-8.0 Lbs.	59.4 - 75.0 Lbs.
3,500- 7,000	2-4%	6.4-9.5 Lbs.	56.2 - 71.8 Lbs.
7,000-10,500	4-6%	9.5-12.7 Lbs.	53.1 - 68.7 Lbs.
10,500-14,000	6-8%	12.7-15.8 Lbs.	50.0 - 65.6 Lbs.
14,000-17,500	8-10%	14.1-19.0 Lbs.	46.8 - 62.4 Lbs.
17,500-21,000+	10-12%+	15.8-22.1 Lbs.	45.2 - 59.2 Lbs.

* Lime and Cement factors selected are based on boron analysis, PCP results, and past experience.

2.3 Determine the full scale formula and level alarm settings by completing CNSI Solidification Worksheet II.

2.4 The volume of caustic required, if any, for full scale solidification is dependent on a number of variables, such as waste composition and ambient conditions. The maximum volume of caustic is 10 gallons of 25% concentration or 5 gallons of 50% concentration. These amounts are not to be exceeded without supervisor's approval.

B. PCP Solidification Of Particulate Wastes (Resin Beads, Powdex And Diatomaceous Earth Slurries)

1.0 Sample Verification

NOTE: THE CHEMICAL ADDITIVES USED FOR PCP PREPARATION SHOULD BE THOSE ACTUALLY USED IN FULL SCALE SOLIDIFICATION AND SHOULD BE STORED IN CAPPED CONTAINERS.

1.1 Arrange with Health Physics to assign a special test area which contains adequate protection from the anticipated higher radiation levels of bead resins.

1.2 Notify Health Physics that the preparations for verification testing have been completed and request that a waste sample be supplied.

1.3 Transfer 100 ml of resin from the sample container to a 250 ml disposable beaker and allow solids to settle. Typically, there will be a layer of water on top of the resin beads. Centrifuged powdex will show no separation of liquid.

NOTE: WHEN RADIATION LEVELS ARE EXCESSIVE, THE SAMPLE AMOUNT MAY BE REDUCED TO AS LITTLE AS 25 ML. BE SURE TO REDUCE OTHER ADDITIVES BY THE SAME RATIO.

1.4 Measure and record on CNSI Solidification Worksheet I the waste pH using the wide range pH paper. Add lime ($Ca\ (OH)_2$) in 2 gm increments until a pH of 10.5 to 11.5 is reached by a narrow (9-13) range pH paper. Stir thoroughly after each addition of lime and add 3 more grams after the desired pH range is reached. Record the total amount of lime added on CNSI Solification Worksheet I for particulate wastes.

Alternate Method: Where lime is not acceptable (i.e.; cannot be added to the slurry) substitute 50 percent sodium hydroxide solution for lime in Step 1.4 and add in one ml increments until a pH of 11 to 11.5 is reached before proceeding with Steps 1.5 through 1.7.

NOTE: LIME IS THE PREFERRED AGENT FOR PRE-TREATMENT OF ION-EXCHANGE TYPE WASTES, SINCE IT IS MORE COMPATIBLE WITH CEMENT REACTIONS AND FORMS A MORE STABLE END PRODUCT.

1.5 Add cement slowly while stirring until a smooth homogeneous mix is obtained. The amount added for a 100 ml waste sample may be 80 to 150 gms depending on resin type, quantity of lime added and amount of water in the slurry. Record amount of cement added on the CNSI Solidification Worksheet I.

1.6 Place the lid over the beaker and store the sealed mix in an oven controlled at 120-130°F for 18-24 hours. Then allow sample to cool for at least 2 hours before removing lid and evaluating solidification.

1.7 Evaluate the sample using the guidelines of Paragraph 4.3.4.2. If the samples does not meet the acceptance criteria, contact the CNSI Supervisor, Solidification Services for possible formula modifications.

2.0 FULL SCALE CALCULATIONS (BEAD-TYPE OR PARTICULATE WASTES)

2.1 Determine the volume of waste material to be received and the amounts of cement and lime or sodium hydroxide solution required by completing the CNSI Solidification Worksheet II for bead-type or particulate wastes. Reduce the calculated amounts as necessary to comply with weight and radiation limitations imposed by waste activity and shielding requirements.

C. PCP Solidification of Miscellaneous Aqueous Wastes (Not Representing Typical BWR OR PWR Concentrates)

1.0 Sample Verification

NOTE: THE CHEMICAL ADDITIVES USED FOR PCP TESTING SHOULD BE THOSE ACTUALLY USED IN FULL SCALE SOLIDIFICATION AND SHOULD BE STORED IN CAPPED CONTAINERS.

1.1 Notify Health Physics that preparations for verification testing have been completed and that a sample is required.

1.2 Measure out 200 ml of radwaste sample in a 600-1000 ml disposable container.

1.3 Add 120 to 140 grams of Portland Cement and mix well with spatula.

1.4 Add 80 to 100 grams of lime and mix well with spatula.

NOTE: ON A NEW WASTE SAMPLE, START WITH MINIMUM QUANTITIES OF CEMENT OF LIME TO FORM A SMOOTH MIX NOT PRODUCING EXCESSIVE BLEED LIQUID.

1.5 Transfer (pour) sample mixture into 250 ml plastic breaker, filling to within 1/4 inch of the top.

1.6 Press lid tightly over sample container and store in an approved constant-temperature oven. The sealed sample should be held at 120-130°F for 18-24 hours.

NOTE: IT IS NECESSARY TO HOLD SAMPLE MIXTURES AT ELEVATED TEMPERATURES TO SIMULATE SOLIDFICATION CONDITIONS OF FULL SCALE OPERATIONS.

1.7 Remove sample from oven and allow to cool for at least 2 hours before unsealing. Evaluate solidification using guidelines of Paragraph 4.3.4.2.

1.8 Contact the CNSI Supervisor, Solidification Services if the test sample containing maximum amounts of cement and lime still fails to meet solidfication requirements. A significant change in typical cement to lime ratio or reformulation with an approved additive may be necessary.

2.0 Full Scale Calculations

2.1 Determine the volume (cubic feet) of waste to be received, referring to the table in Table 2 for usuable liner volumes.

2.2 Compelete the CNSI Solidification Worksheet II for Miscellaneous Aqueous wastes to determine actual chemical requirements and level control settings.

EXHIBIT 3

CNSI SOLIDIFICATION WORKSHEET I
(PCP Solidification Of Particulate Wastes)

NOTE: THIS INFORMATION IS CONSIDERED PROPRIETARY AND IS NOT TO BE RELEASED OR COPIED WITHOUT WRITTEN PERMISSION OF CHEM-NUCLEAR SYSTEMS, INC.

Waste Identification Date:______ Operator:______ Utility:_____

Type Of Waste: (Resins Beads, Powdex, Sludge) ________________
Waste Activity: (Reported Curie Content) ________________
pH: (Reported By Utility) ________________
Description: (Color, Uniformity, Free Liquid) ________________

____

Sample Preparation

(a) Volume Of Waste (In 250 ml Container): ____ml (Notes (1&2)

NOTE 1: THE VOLUME OF FLUIDIZED WASTE MUST BE CONTROLLED AS NEARLY AS POSSIBLE TO THE 100 ML MARK IN THE 250 ML TEST BEAKER, SINCE FULL-SCALE CALCULATIONS ARE NORMALLY FIGURES ON THIS AMOUNT. REMOVE WATER FROM, OR ADD WATER TO, THE WASTE SAMPLE RECEIVED AS NECESSARY SO THAT A FLUID MATERIAL IS FORMED. NO MORE THAN ABOUT 1/16-1/8 INCH OF LIQUID SHOULD SEPARATE QUICKLY FROM THE 100 ML TEST SAMPLE.

NOTE 2: IF THE RADIATION LEVEL OF THE WASTE PREVENTS USING A 100 ML SAMPLE, THE TEST MAY BE RUN WITH LESS WASTE MATERIAL, BUT THE SOLIDIFICATION SUPERVISOR MUST BE CONTACTED FOR VERIFICATION OF THE FULL-SCALE FORMULA.

(b) pH Of Sample: (Tested By CNSI) ________________
(c) Alkaline Agent To Be Added: ________(Indicate Lime Or Caustic)

(d) pH Adjustment Summary

Increment	Amount	pH After Mixing
1	______	________________
2	______	________________
3	______	________________
4	______	________________

(e) Additional Lime ______ gm ________________

(f) Total Lime, (d)+(e)______ gm (or total caustic, (d) _____ml)

(g) Cement Added to Obtain Smooth, Uniform Mix ______gm

NOTE 3: DO NOT EXCEED 100 GRAMS OF CEMENT PER 100 ML OF WASTE UNLESS AN EARLIER TEST USING THE SAME WASTE SAMPLE INDICATED THAT MORE CEMENT WAS REQUIRED.

Oven Temperature At Start Of Test ________°F
Time Sample In Oven (Sealed) ________hrs.
Oven Temperature When Sample Removed ________°F
Time Outside Oven Before Unsealing ________hrs.

Solidification Results

Free Liquid, If Any ___________ml (Approximate)
Relative Set (Very Hard, Firm, Soft) ___________
Unusual Appearance (Color, Foam, Stratification) _______________

EXHIBIT 4

CNSI SOLIDIFICATION WORKSHEET II
(Full-Scale Solidification Of Particulate Wastes)

NOTE: THIS INFORMATION IS CONSIDERED PROPRIETARY AND IS NOT TO BE RELEASED OR COPIED WITHOUT WRITTEN PERMISSION OF CHEM-NUCLEAR SYSTEMS, INC.

Volume Information Date: _____ Operator: ______ Utility: ________

(a) Usable Liner Volume (Table 2) ________ Ft^3

(b) Liner Ft^3/Inch Of Height (Tables 2) _______ Ft^3/In.

Waste Alarm Height (To The Nearest 0.1 Inch)

(c) Waste Volume = $\frac{\text{(a)}}{\text{(Liner Vol.)}}$ x 0.643* = ______ Ft^3

*A factor providing for 2.5 to 1.0 waste volume to binder ratio, and a 10% volume allowance for additional cement, if required, to assure a satisfactory mix. Express result to the nearest cubic foot.

(d) Waste Alarm Height = $\frac{\text{(c)}}{\text{(Waste Vol.)}} \div \frac{\text{(b)}}{\text{(V/H Ratio)}}$ = ____ Inches

Lime Weight And Height (Nearest Lb. & 0.1 Inch)
(If caustic is to be used, see note below)

(e) Lime WT. = $\frac{\text{gm}}{\text{SWI, (f) Lime}}$ x 0.623** x $\frac{\text{(c)}}{\text{(Waste Vol.)}}$ = _____ Lbs.

(f) Lime Height= = $\frac{\text{(e)}}{\text{(Lime WT.)}} \div 137^{***} \div \frac{\text{(b)}}{\text{(V/H Ratio)}}$ = ___ Inches

***Approximate fluid lime density, Lbs./Ft^3

Cement Weight And Alarm Height (Nearest Lb. & 0.1 Inch)

(g) Cement WT. = $\frac{\text{gm}}{\text{SW I, (g)}}$ x 0.623** x $\frac{\text{(c)}}{\text{(Waste Vol.)}}$ = ______ Lbs.

**A factor converting grams PCP additive weight per 100 ml waste sample to pounds required per ft^3 waste.

(h) Cement Height = $\frac{\text{(g)}}{\text{(Cement WT.)}} \div 173^{****} \div \frac{\text{(b)}}{\text{(V/H Ratio)}}$ = ___ Inches

****Typical true cement density, Lbs./Ft^3

(i) Cement Alarm Height = (d)+(f)+(h) = _______ Inches

NOTE: IF 50% CAUSTIC IS USED INSTEAD OF LIME, DETERMINE GALLONS REQUIRED AS FOLLOWS, BUT DISREGARD THE HEIGHT OCCUPIED. THE FACTOR .0748 CONVERTS ML OF CAUSTIC PER 100 ML WASTE TO GALLONS CAUSTIC PER FT^3 WASTE.

$\frac{\text{ml}}{\text{SW I, (f) caustic}}$ x .0748 x $\frac{\text{(c)}}{\text{(Waste Vol.)}}$ = _____ Gallons

TYPICAL SAMPLE CALCULATIONS FOR WORKSHEET II
(Particulate Wastes)

NOTE: THIS INFORMATION IS CONSIDERED PROPRIETARY AND IS NOT TO BE RELEASED OR COPIED WITHOUT WRITTTEN PERMISSION OF CHEM-NUCLEAR SYSTEMS, INC.

A slurry of radioactive mixed bed resin beads is to be dewatered and solidified in a L6-80 liner. After adjusting a laboratory sample so that 100 ml of fluidized material was measured for testing, it was found that (4) four portions of lime (2 grams each) raised the pH to about 11. Addition of three more grams of lime and 90 grams of cement formed a smooth mix, which set firm and dry in the sealed container after 20 hours in an oven controlled at about 125°F.

(a)	Usable Liner Volume (Table 2)	= 79 Ft^3
(b)	Liner Volume/Height Ratio (Tables 2)	= 1.53 Ft^3/Inch
(c)	Waste Volume = 79 X 0.643	= 51 Ft^3
(d)	Waste Alarm Height = 51 ÷ 1.53	= 33.3 Inches
(e)	Lime Weight = 11 x 0.623 x 51	= 350 Lbs.
(f)	Lime Height = 350 ÷ 137 ÷ 1.53	= 1.7 Inches
(g)	Cement Weight = 90 x 0.623 x 51	= 2860 Lbs.
(h)	Cement Height = 2860 ÷ 173 ÷ 1.53	= 10.8 Inches
(i)	Cement Alarm Height = 33.3 + 1.7 + 10.8	= 45.8 Inches

EXHIBIT 5

CNSI SOLIDIFICATION WORKSHEET III (Process Summary - Particulate Wastes

NOTE: THIS INFORMATION IS CONSIDERED PROPRIETARY AND IS NOT TO BE RELEASED OR COPIED WITHOUT WRITTEN PERMISSION OF CNSI.

Utility:________
Operator:________
Waste Tank________

1. Waste Slurry Addition No. 1:

Start Time______ Date_____
Finish Time______ Date_____

2. Dewatering No. 1, If Necessary:

Start Time______ Date_____
Finish Time______ Date_____

3. Waste Slurry Addition No. 2, If Necessary:

Start Time______ Date_____
Finish Time______ Date_____

4. Dewatering No. 2, If Necessary:

Start Time______ Date_____
Finish Time______ Date_____

5. Water Added To Re-Fluidize, If Necessary:

Time______ Date_____ Estimated Volume Added_______Gal.

6. Waste Temperature After Mixing: ______°F

7. Lime Added:

Start Time______ Date_____
Finish Time______ Date_____ Weight _____Lbs.

8. Temperature After Mixing In Lime: _____°F

9. Cement Added:

Start Time______ Date_____
Finish Time______ Date_____ Weight_____Lbs.

10. Additional Cement Added, If Necessary: _____Lbs.

11. Temperature After All Cement Added: _______°F

12. Agitation Stopped: Time______ Date_____

13. Initial Temperature After Agitation Stopped _____°F

6 Hours Later (From Chart Recorder) _____°F
12 Hours Later (From Chart Recorder) _____°F
24 Hours Later (From Chart Recorder) _____°F

14. Peak Temperature Time______ Date_____

15. Fillhead Removed: Time______ Date_____

16. Liner Capped: Time______ Date_____

17. Observations, Additional Comments:___________________________

TABLE 2

Liner and Cask Calculations

Liner	L21-300	L21-235	L14-195	L14-170	L8-120	L7-100	L6-80
Diameter	82"	82"	76"	74"	61"	74.5"	58"
Height	104.5"	79"	75.5"	69.37"	71.5"	37"	54"
Total Volume, (FT^3)	317	241	196	174	120	93	82
Usable Volume, (Ft^3, 2" Safety Factor)	311	235	190	169	116	88	79
Ft^3/In. Of Height	3.05	3.05	2.62	2.52	1.69	2.52	1.53
Weight (Lbs.)	2400	1800	1650	1550	1100	1250	1100
Cask Payload, (Lbs.)	27250	27250	17700	14000	20000	13000	7500

U.S. Nuclear Regulatory Commission April 18, 1983

If you have any questions concerning this matter, please get in touch with R. H. Shell at FTS 858-2688.

Very truly yours,

TENNEESSEE VALLEY AUTHORTIY

L. M. Mills

L. M. Mills, Manager
Nuclear Licensing

Sworn to and subscribed before me
this 18th day of April 1983

Bryant M. Lowery
Notary Public
My Commission Expires 4/8/86

Enclosures (3)
cc: U.S. Nuclear Regulatory Commission
Region II
Attn: Mr. James P. O'Reilly Administrator
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30303

ENCLOSURE 1

Letters From TVA To NRC-OIE Region II

A27 820928 022

400 Chestnut Street Tower II

September 28, 1982

BLRD-50-438/82-27
BLRD-50-439/82-24

U.S. Nuclear Regulatory Commission
Region II
Attn: Mr. James P. O'Reilly, Regional Administrator
101 Marietta Street, Suite 3100
Atlanta, Georgia 30303

Dear Mr. O'Reilly:

BELLEFONTE NUCLEAR PLANT UNITS 1 AND 2 - INSOLUBLE GLUE USED FOR PURGE DAMS IN STAINLESS STEEL PIPING - BLRD-50-438/82-27, BLRD-50-439/82-24 - FINAL REPORT

The subject deficiency was initially reported to NRC-OIE Inspector R. V. Crlenjak on March 22, 1982 in accordance with 10 CFR 50.55(e) as NCR 1725. This was followed by our interim reports dated April 22 and June 18, 1982. As discussed with Mr. Crlenjak by telephone on September 10, 1982, our final response was delayed. Enclosed is our final report.

If you have any questions concerning this matter, please get in touch with R. H. Shell at FTS 858-2688.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L. M. Mills, Manager
Nuclear Licensing

RHS:DLT:ATK
Enclosure
cc: Mr. Richard C. DeYoung, Director (Enclosure)
Office of Inspection and Enforcement
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

cc (Enclosure):
ARMS, 640 CST2-C
J. W. Anderson, 902 HBB-K
L. S. Cox, Bellefonte
A. W. Crevasse, 401 UBB-C (2)
H. N. Culver, 249A HBB-K
H. J. Green, 1750 CST2-C
J. A. Raulston, W10C126 C-K
H. S. Sanger, Jr., E11B33 C-K
F. A. Szczepanski, 417 UBB-C
J. D. Wilcox, Bellefonte-NRC

PDR

Dupe of 8210050247

ENCLOSURE
BELLEFONTE NUCLEAR PLANT UNITS 1 AND 2
INSOLUBLE GLUE USED FOR PURGE DAMS IN STAINLESS STEEL PIPING
NCR 1725
BLRD-50-438/82-27, BLRD-50-439/82-24
10 CFR 50.55(e)
FINAL REPORT

Description of Deficiency

Some glue used in installation of purge dams in stainless steel piping appeared insoluble during flushing activities, and minor glue residual remains in piping at purge dam locations. This problem was anticipated during the resolution of nonconformance report (NCR) 835. The disposition of NCR 835 directed discontinuing the use of Elmers Glue-All and recommended using Elmers School Glue. The insoluble glue residual has been identified as Elmers Glue-All used before NCR 835 and Elmers School Glue that has been affected by heat from welding activities. When purge dams are located too close to the welds, the currently used and normally soluble Elmers School Glue will char and become much less soluble.

Safety Implications

It has been determined through tests and analyses described below that no condition adverse to the safe operation of the plant exists. This conclusion is based on the following observations:

1) The purge dams will not cause stress corrosion cracking of the pipe.

2) Very little purge dam residual remains on the pipe wall after preoperational flushing. The residual remaining will all dissolve during plant operation. Solubilized purge dam material is not harmful to the systems. Any particles that may break loose before dissolution is complete will not obstruct any piping or instrument lines.

Corrective Action

Based on the attached supporting information, TVA has concluded that glue residual left in piping systems will not cause a safety problem. Laboratory tests have shown that even the glue that was initially thought to be insoluble will dissolve. Flushing of systems thus far has shown that demineralized water flushing can achieve removal of enough of the purge dam residue so that the possibility of large pieces breaking loose is highly unlikely. TVA will revise the acceptance criteria for proof flushing particulates to allow purge dam particles up to 1/8-inch in any dimension. This revision will be accomplished by November 8, 1982.

In addition, purge dam residual on the pipe wall will be acceptable provided that the system has met the proof-flush acceptance criteria. The reactor coolant pump seal water injection line in the Makeup and Purification System will be flushed with acetic acid to remove as much of the purge dam residue as possible. This will be accomplished by October 15, 1983. TVA has revised the welding specifications to ensure that purge dams are placed far enough from the weld to prevent charring of the glue. TVA has also increased welder awareness that substitution of the specified Elmers School Glue is not permitted. No other TVA nuclear plants are affected by this problem.

ATTACHMENT

SUPPORTING INFORMATION FOR NCR 1725

Metallurgical Testing

Metallurgical testing and chemical analysis has shown that residual purge dam materials remaining in contact with 304 stainless steel will have no detrimental effects on the piping material during operation of the plant.

The Dissolvo Water soluble purge paper (WLD-60) contributes virtually all of the halides present in the purge dam residue. Specific ion tests have shown leachable chlorides in the range of 170-200 parts per million.

Tests show that purge dam materials closer than 3/4-inch from the edge of a weld reach a temperature of approximately 600° F. At this temperature the material carbonizes to the extent that it flakes off much the same as food in a self-cleaning oven, and subsequent flushes remove the flaking material.

Two potential modes of cracking have been addressed:

1. Stress Corrosion Cracking (SCC)

   The purge dam residue is a minimum of 3/4-inch from the edge of the weld. This is beyond the distance at which residual stresses from welding are present. In the absence of tensile stress, SCC does not occur.

2. Intergranular Stress Corrosion Cracking (IGSCC)

   The heat affected zone (HAZ) of the weld extends to a maximum of approximately 3/16-inch from the edge of the welds. As stated previously, the purge dams are located a minimum of 3/4-inch from the weld and, therefore, the potentially aggressive environment is not present in the HAZ.

Additional tests performed at TVA Singleton Laboratory determined that no harmful effects should be expected even if the purge dam materials were left in contact with the base material. Samples of glue with added chloride levels of over 1000 ppm were baked on pipe samples and autoclaved at 150° F and 550° F in borated water. After 24 hours virtually all chlorides were leached from the glue at both temperatures. The 304 stainless base materials were subsequently examined microscopically for corrosive effects.

After 96 hours of exposure there was no apparent attack. Because virtually all chlorides leach out of the glue after 24 hours of exposure, TVA anticipates no adverse effects from the relatively small amount of material remaining.

TVA can anticipate no harmful effects on the stainless steel pipe as a result of purge dam residuals remaining in contact with the stainless steel pipe during system operation.

Acetic Acid Testing and Flushing

Laboratory testing was performed to determine what solvents are available that could be used to remove the glue from the pipe. Testing showed that acetic acid was the most promising solvent. Acetic acid aided in the removal of the noncharred glue; however, it did not have an appreciable effect on the charred glue. The second interim report on NCR 1725 stated that acetic acid would be tried out on a system that had not been previously flushed. Since there were no systems available that had not been flushed, the trial was run on the Reactor Building Spray System (with the exception of the spray headers and the sodium hydroxide tank and piping).

The Reactor Building Spray System had been previously flushed with water, but removal of a flanged spool piece revealed noncharred purge dam residual on the pipe wall. Thus the pipe interior could be visually inspected before and after the acetic acid flush. The system was flushed with 5 percent acetic acid for approximately 24 hours at temperatures up to 145° F. Inspection of the piping after the acetic acid flush showed that most of the purge dam residuals had been removed from the pipe wall.

Autoclave Tests

Autoclave testing was performed to determine what effect high temperature water will have on charred glue since it is the most insoluble. Stainless steel coupons were prepared using both Elmers Glue-All and Elmers School Glue. Coupons were baked in an oven at 400° F and 500° F to simulate purge dams that were placed too close to the welds. Half of the coupons representing all of the above conditions were soaked in acetic acid to simulate acetic acid flushing of the piping systems.

The coupons were placed in the autoclave which contained borated water representative of reactor coolant. The autoclave was operated at temperatures ranging from 200° F to 500° F to identify temperature effects on the glue. The test results show that the charred glue will dissolve, and that the autoclave temperature is the only variable that has an effect on the dissolution rate of the charred glue. At 200° F, about 6 percent of the charred glue dissolved in 90 hours. At 300° F, 19 percent of the charred glue dissolved in 78 hours; at 400° F, 84 percent of the charred glue dissolved in 51 hours; and at 500° F, over 93 percent of the charred glue dissolved in 40 hours.

These results show that given enough time, the glue deposits will eventually dissolve. The results also show that any glue particles that get into the reactor will dissolve in the reactor, since it operates at 600° F.

Demineralized Water Flushing

Several systems have been flushed with demineralized water to date. These include the Spent Fuel Cooling and the Reactor Building Spray Systems. Three flow paths on the Spent Fuel Cooling System were flushed with unheated demineralizer water. One flow path could not meet the acceptance criteria of 1/32-inch by 1/16-inch particle size. However, the particles were less than 1/8-inch. The flow path was then flushed with 180° F water. After the hot water flush, the acceptance criteria could still not be met, even though the particles being detected were still less than 1/8-inch. Spool pieces were removed so that the pipe interior could be visually examined. Reactor building spray train B was also flushed with cold demineralized water before the acetic acid flush. The path was flushed to the 1/32-inch 1/16 inch particulate acceptance criteria with demineralized water. Inspection of the pipe interior after the flush showed some noncharred purge dam glue ridges in the pipe. Flushing of these and other flow paths has demonstrated that the systems can be flushed to a point where only tightly adherent glue ridges are left in the pipe and that only small particles break loose from these ridges during system operation.

Safety Analysis of Particulates

All of the systems were analyzed with respect to problems which could be caused by particulates breaking loose from purge dam residuals during plant operation. The analysis was based on the assumption that glue particles up to 1/8-inch could be present in the operating systems. Based on this analysis, plant safety will not be compromised with glue particles up to 1/8-inch present in the Waste Disposal (WD), Chemical Addition and Boron Recovery (CA&BR), Reactor Building Spray (RBS), Core Flooding (CF), Decay Heat Removal (DHR), Spent Fuel Pool Cooling and Cleanup (SFPCC), and Makeup and Purification (MU&P) Systems. Pumps in the RBS, DHR, SFPCC and MU&P Systems are equipped with cyclone separators in the seal water supply so that particles in the seal water would be removed before getting to the pump seals. The water in instrument sense lines is stagnant; therefore, it is highly unlikely that purge dam particles could find their way into instrument lines or cause problems.