2290

CHEM-NUCLEAR SYSTEMS

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1.0 SUMMARY

Chem-Nuclear Systems (CNS) was selected by Fluor Daniel Fernald (FDF) to perform rigorous testing of a proven and commercially available chemical-based remediation technology to evaluate its potential use on Silos 1 and 2 residues at the Fernald Environmental Management Project (FEMP). Proof of Principle (POP) testing was conducted from June 4, 1998 to May 27, 1999 at the Chem-Nuclear Consolidation Facility in Barnwell, South Carolina. The tests of the chemical-based stabilization technology were performed using non-radioactive surrogates which simulated selected chemical and physical characteristics of the Silo 1 and 2 residues. This testing demonstrated the ability of the CNS stabilization/solidification process to treat Silos 1 and 2 residues to meet regulatory, processing, storage, transportation, and disposal requirements. The results of this demonstration provide FDF with technology-specific information on safety, reliability, implementability, cost and schedule associated with application of the CNS process. These results also support the development of preliminary conceptual design for a full-scale remediation facility.

CNS utilized a chemical-based solidification/stabilization technology to treat the silos residues. The technology involves the use of relatively small amounts of a chemical additive (anhydrous tri-sodium phosphate) to control lead leachability combined with binder chemicals (Type I Portland cement and Type F flyash) to form a relatively high-strength waste-and-concrete matrix. Two formulas were developed for each silos' surrogate. The first formula was optimized to meet fifty (50%) of the Resource Conservation Recovery Act (RCRA) Toxicity Characteristic (TC) levels for metals (i.e., to produce waste forms which leached metals at less than half of the TC regulatory limit). The second formula was optimized to meet the Rev. 0 RCRA Universal Treatment Standards (UTS) for TC metals. This yields a total of six optimized treatment formulas (See Table 1.0-1). The planning process for developing these formulas is detailed in Section 2.0.

The CNS-developed solidification formula for the Demonstration Surrogate (SO) was applied during the 72-hour Pilot-scale demonstration. In each of three 24-hour periods, (following decanting activities), approximately 4,357 lbs. of 30 percent by weight (%wt) surrogate was systematically processed into non-hazardous waste forms. The demonstration proceeded smoothly and safely without any system downtime. Following the 72-hr demonstration, the decanted liquid was solidified using the same solidification formula used for the demonstration surrogate. A detailed account of actual laboratory and field events leading to the successful completion of formula development and the 72-hour demonstration is given in Section 3.0.

Throughout the process of formula development and the 72-hour demonstration, data were collected to verify the effectiveness of the process and to provide data for conceptual engineering of a full-scale

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facility utilizing this technology. A compilation of the data collected during the project is presented in Section 4.0.

Interpretation of data collected, as well as critical analysis of anomalies that occurred during formula development and the 72-hour demonstration, was essential to the successful completion of the POP demonstration. These data and observations play a key role in the design and will be given consideration in the establishment of a full-scale facility. Section 5.0 discusses the results and conclusions from the POP demonstration.

Engineering services for design and construction of a full-scale facility were supplied by Parsons Infrastructure and Technology Group, Inc. Their personnel maintained contact with the CNS project manager throughout the POP system planning/development process and participated in the actual 72-hour demonstration. Comprehensive details regarding data application, facility arrangement and descriptions of individual subsystems and cost estimates are provided in section 6.0.

TABLE 1.0-1 RCRA and UTS Treatment Standards

Constituent	TC Limit (ppm TCLP)	TC Performance Specification (ppm TCLP)	UTS Limit (ppm TCLP)
Arsenic (As)	5.0	2.5	5.0
Barium (Ba)	100.0	50.0	21.0
Cadmium (Cd)	1.0	0.5	0.11
Chromium (Cr)	5.0	2.5	0.60
Lead (Pb)	5.0	2.5	0.75
Mercury (Hg)	0.20	0.10	0.025
Selenium (Se)	1.0	0.5	5.7
Silver (Ag)	5.0	2.5	0.14
Antimony (Sb)	--	--	1.15
Beryllium (Be)	--	--	1.22
Nickel (Ni)	--	--	11
Thallium (Tl)	--	--	0.20
Vanadium (V)	--	--	1.6
Zinc (Zn)	--	--	4.3

2.0 PROOF OF PRINCIPAL TEST DESCRIPTION

This section describes the Bench Scale and Pilot-scale testing process description, and project quality assurance.

2.1 Bench Scale Testing - Demonstration Surrogate, Silo 1 and Silo 2

A laboratory scale testing sequence was designed to provide practical formulas to solidify/stabilize three surrogate waste compositions in order to satisfy specified waste form requirements. Three additives were considered for application: tri-sodium phosphate (anhydrous), fly ash and

Type I Portland Cement. Concentrations of these constituents relative to surrogate weight were varied in order to develop optimum formulas. Specifically, the bench scale test was designed to:

1. Assess the effectiveness of tri-sodium phosphate to control lead leachability;

2. Determine appropriate proportions of Portland Cement and fly ash as binders to produce a final product that is leach resistant relative to 50% the RCRA TC limits and the UTS limits for specified metals;

3. Evaluate the feasibility of surrogate decanting and binder minimization to increase waste loading in the final treated product; and,

4. Verify that the optimized treatment formula produces a final product that meets the minimal compressive strength requirements.

Anhydrous tri-sodium phosphate powder (TSP) was selected as a potential additive for control of lead leachability and is to be introduced, when necessary, as a pre-treatment chemical. Using TSP in this fashion potentially enables subsequent binder addition to proceed more smoothly, and allows the necessary proportions of binder to be added effectively. Phosphate derivatives coat particles of lead compounds in the surrogate; this causes them to become less reactive toward cement, thereby retarding premature thickening of the mixture.

The binder of choice is standard Type I Portland Cement with a proportion of Type F fly ash, 30% by weight, known to enhance leach resistance of cured compositions without sacrificing product strength or durability. Additionally, the inclusion of fly ash facilitates easier mixing of wet pastes and favorably moderates exothermic heat effects during bulk solidification.

Pozzolanic Portland Cement (mixture of Portland Cement and fly ash) offers a combination of properties that are well-suited for treatment of mineral slurries, even those containing limited amounts of organic substances. Most types of siliceous particles readily bond to cement and a number of polyvalent cations are chemically incorporated (and made insoluble) in the cured matrix. While hydrated cement represents an open-cell structure, the water to binder ratio (W/B) may be controlled to restrict leach path openings and retard passage of even water-soluble chemicals.

When feasible, optimization of the solidification formulas is undertaken involving a combination of surrogate decanting and binder minimization. Two formulas are developed for each waste surrogate: one that will meet ½ RCRA TC limits and one that meets the more restrictive UTS limits. The consistency of the treated surrogate and its impact on mixing in the 7

Pilot-scale operation are important considerations in optimizing the treatment formulations.

Formulas with promise are subjected to an oven cure. The use of controlled laboratory ovens permits solidification test formulas to be heat-treated to simulate exothermic effects of actual bulk solidification. Appropriate oven curing also provides significantly, but not necessarily fully, cured material in a timely schedule for meaningful determination of properties such as Toxic Characteristics Leachability Procedure (TCLP) leachability.

If a satisfactory waste form emerges from the curing process, it is subjected to TCLP metals analysis provided by a Fernald-approved contract laboratory to verify the leachability effectiveness of the treatment. Compressive strength analysis, while part of the acceptance criteria, is not considered during formula development since the threshold set by FDF is very low (50 psi) and experience has shown that most solidified forms easily exceed this limit. Final products from the optimized treatment formulas are tested to verify that the strength criteria are met.

Laboratory top loading balances are checked daily, when in use, with certified weights to ensure accuracy in mass determination of chemicals. Samples collected for laboratory analysis are transferred under Chain-of-Custody tc ensure administrative integrity of the sample results.

2.2 Pilot-Scale Test

The overall objective of the pilot-scale test (72-hour demonstration) was to simulate the functions and operations of key systems of the CNS waste stabilization/solidification process to demonstrate the viability of a full-scale facility. Specifically, the pilot-scale test was designed to:

1. Demonstrate, through successful operation of a pilot-scale facility, that a full-scale facility based on this specific technology can consistently meet the regulatory, processing, storage, transportation, and disposal requirements for the Silos 1 and 2 residues.

2. Generate test results that will allow scale-up of key pilot plant operations to a full-scale facility and which can be used as preliminary design data for the full-scale facility.

3. Generate data that can be used to evaluate technology-specific aspects of safety, reliability, implementability, cost, and schedule for the full-scale facility.

Figure 2.2-1 (see page nine) provides an overview of the basic waste stabilization process utilized by CNS. The pilot-scale test utilized a single process line operating 24-hours per day for a 72-hour period.

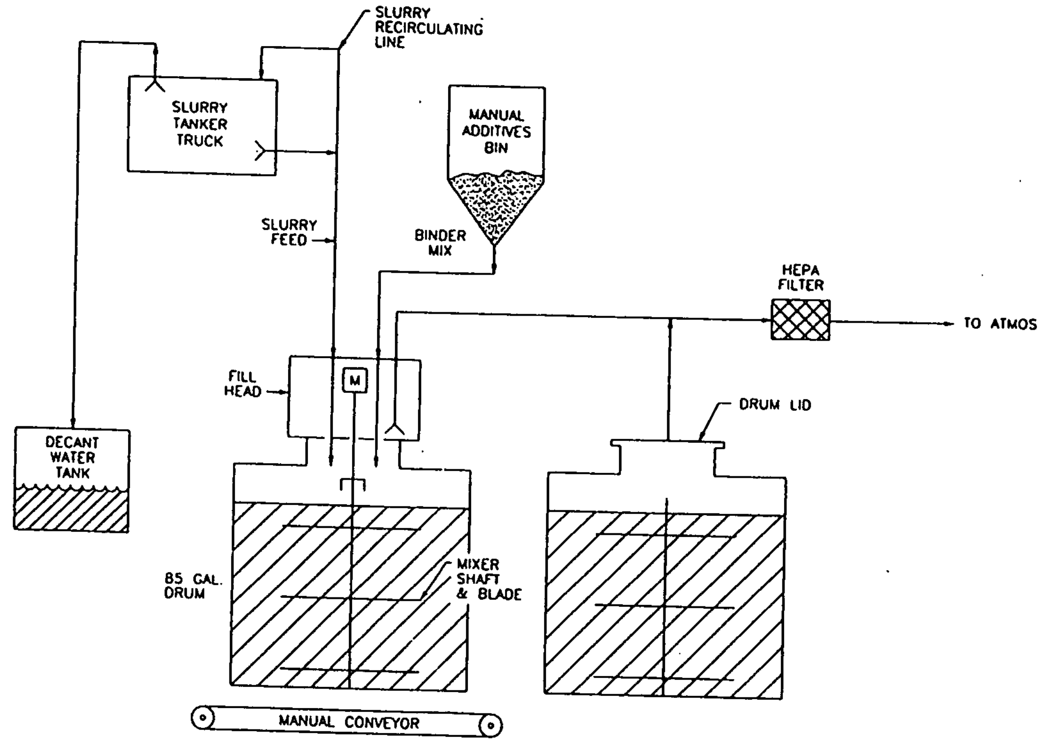
The pilot-scale facility is comprised of four primary process systems; the slurry feed system, the binder and dry additives system, the treatment system, and the VVS. Significant aspects of each primary systems that must be demonstrated along with the sampling and data collection necessary to allow scale-up to the full-scale facility are discussed below.

In addition to the primary process systems, data were collected to facilitate scale-up of selected ancillary systems. Specifically, data were collected on heat liberated during the waste curing to allow for sizing of environmental controls (e.g., Heating Ventilation Air Control (HVAC) service) for the 14-day interim storage area in the full-scale facility. This data also provides a basis for estimating peak internal and external skin temperatures of the full-scale treatment vessels.

Finally, a central objective of the pilot-scale test was to collect sufficient data to verify that the final treated product satisfies the performance requirements for the Silos 1 and 2 residues. FDF has generated testing requirements against six tests/criteria which are defined in the FDF statement of work and are described in detail in the CNS workplan. The six performance requirements include:

1. Uniform and homogenous in appearance with no unmixed layers or pockets;
2. Compressive strength of at least 50 psi;
3. No free standing liquids;
4. TCLP leachate containing less than 50% of the RCRA limits for specified metals;
5. Limited dusting/particulate in treated waste container; and,
6. No RCRA characteristics.

Figure 2. 2-1 Simplified Process System



PILOT–SCALE TEST

Samples of three of the ten batches of treated waste selected by FDF were tested: wet treated waste was formed into cubes for compressive strength tests and samples were cored from the cured waste for TCLP tests. Final weights of the treated waste were collected to provide required inputs to the mass balance.

2.2.1 Slurry Feed System

One objective of the test was to demonstrate that adequate dewatering can be performed on the surrogate slurry utilizing simple settling in the slurry feed tank. Solids content and specific gravity of the decanted water was tested (see table below). Additionally, elemental analysis was performed on the decanted water.

TABLE 2.2.1-1 SUPERNATE SPECIFIC GRAVITY AND % SOLIDS

Specific Gravity of Supernate. This number is based on decanting activities from an 85-gallon drum on December 16, 1998 Using actual 72-hour demonstration surrogate (from mixer tank).	1.05
% solid of supernate based on bench-scale testing.	3.8

A second objective of the pilot-scale test was to demonstrate that the slurry can be adequately re-homogenized once mixing is re-initiated. Samples were taken from the slurry feed tank during subsequent processing operations following re-agitation to confirm the homogeneity of the slurry feed. Slurry feed samples were also tested for solids content, specific gravity, and elemental analysis.

The continuous mixing of the slurry in the slurry feed tank is a standard process specific to the material and the tank configuration. Data were not recorded specific to the tank and mixing arrangement for scale-up.

2.2.2 Binder and Dry Additives System

Typically, CNS prefers sequential addition of the additives and binders to the waste slurry. This allows the additives to dissolve and become fully homogenized in the slurry. This is necessary in order to ensure adequate conditioning and pre-treatment of the slurry. Fly ash and then cement are subsequently mixed into the conditioned slurry to complete the treatment. Sequential addition to the treatment vessel eliminates the need for batching of dry additives and further simplifies the equipment requirements.

The handling of dry bulk materials is a standard industry practice and the parameters and characteristics of the dry materials of

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concern are well known and understood; therefore, the test requirements are limited to confirmation that the correct amounts of additives are added to each treatment vessel. The treatment formula is directly proportional to the amount of slurry, so there are no specific data requirements with regard to the addition of dry additives for scale-up. For the pilot-scale test, dry chemicals were pre-weighed and delivered from a feed bin.

2.2.3 Treatment System

The heart of the CNS system revolves around the use of a single container for treatment and disposal of the treated waste. In the CNS system, the waste slurry, binders, and other additives are added to the treatment vessel through a fillhead. The fillhead also contains a hydraulic motor that is used to turn the mixing blade that is integral to the vessel. The treatment vessel is sealed after the waste cures and becomes the disposal vessel. The mixer blade remains in place and is disposed with the treated waste. This yields a simple process that requires little additional mixing or processing equipment. The additional cost of the sacrificial mixing blades is much less than the additional process equipment and the costs associated with clean-up, maintenance and repair in a standard batch plant operating over an extended period.

Typically, CNS performs dewatering operations within the treatment vessel using disposable sacrificial filter elements. In the case of the Silo 1 and 2 residues, however, the particle size and the presence of "Bento Grout ™" in the slurry would quickly clog the filter elements. Based on lessons learned during bench scale testing, and discussions with Fluor Daniel Fernald, the concept of dewatering from the treatment drums using sacrificial filters was determined not be feasible. The process proposed for the full-scale plant for the Silos 1 and 2 residues would utilize a dewatering stage prior to slurry addition to the treatment vessel.

The most important aspect of the demonstration is to show that the formula (recipe) developed for the demonstration slurry during the bench scale tests can be accurately and consistently duplicated on the pilot-scale level using a single treatment/disposal vessel and fillhead arrangement. The test must show that the integral mixing blade arrangement is capable of generating a homogeneous mixture of treated surrogate waste which consistently passes the necessary treatment performance criteria. It is also necessary to collect sufficient data on the fillhead and mixing blade arrangement to accurately scale-up the mixing requirements for the full-scale facility.

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2.2.4 Vessel Vent System

The off-gas system requirements for the full-scale system include the capture of emissions from the process equipment/vessels to prevent the release of radioactive constituents. For the full-scale facility, the Vessel Vent System (VVS) will capture off-gas emissions from process components by maintaining a slight negative pressure on those components (typically 0.3 inches of water gage). Additionally, prior to lifting the fill-head after mixing, and removing the temporary lid after the initial curing period, the container headspace is purged to the RCS through the VVS. Inleakage to process components in the full-scale facility will also contribute to the total volumetric flow through the VVS.

Based on its design, inleakage data for the pilot-scale test would not be useful in predicting or scaling inleakage estimates for the full-scale facility. Therefore, the headspace in the pilot-scale containers (85-gallon drums) was monitored during slurry filling and during the curing process (near maximum core temperature) to obtain undiluted gas concentrations without regard to inleakage. Inleakage in the full-scale facility will be controlled by design criteria to be within the stated available capacity of the RCS. For the purposes of the scale-up, the measured concentrations for the pilot-scale were diluted by half the capacity of the RCS to yield a conservative prediction of the full-scale concentrations. These results verified that the resultant off-gas captured in the full-scale facility will be within the acceptance criteria of the RCS as specified in the Contract, *Section C.4.3.8* of the Statement of Work.

Since the surrogate material does not generate radon, and since the process does not produce significant amounts of CO_2, SO_x, or NO_x, the important parameters of concern are flow, temperature, humidity, and volatile organic content. During the pilot-scale test, measurements were taken of the specified parameters from the treatment vessel during filling, from the treatment vessel during curing, and from the feed tank during mixing. Volumes of gas released were estimated based on the known geometry and fill rates of the full -scale vessels. Measurements of Volatile Organic Compounds (VOCs), humidity, and temperature taken from stagnant headspaces during the pilot-scale test were used to generate conservative estimates of the parameters to be considered for the full-scale flows. Estimates of radon emanation from the slurry and treated wastes were estimated using data from the OU-4 Feasibility Study (FEMP-OU4FS, Feb 94.

3.0 <u>Test Process Design</u>

This section refers to the Bench Scale surrogate preparation and formulation development, and the 72-hour Pilot-scale demonstration system. 13

3.1 Bench-Scale Development Testing

This section describes the bench-scale development testing that was undertaken to obtain final treatment formulations. Key aspects of the test process and procedures include: surrogate preparation, test process and apparatus, and development procedures for SO, Silo 1 and Silo 2 treatment formulas.

3.1.1 Surrogate Preparation

The SO surrogate material was prepared in the laboratory using the proportions of constituents as directed by FDF. The test formulation was prepared by first blending the dry ingredients, adding and dispersing organic liquids, and finally adding water to achieve a solids concentration of 70 %wt, thereby simulating selected chemical and physical properties of Silos 1 and 2 materials. The heavy-bodied paste was homogenized using a dough hook in a commercial Hobart mixer. Following preparation of the surrogate it was relinquished to FDF for evaluation and subsequent formula modifications. A sample was removed for elemental analysis and CNS retained approximately one quart of surrogate for Process Control Program (PCP); testing of potential solidification formulas after addition of hydrated "Bento Grout ™" and water to obtain a 30 %wt solids concentration.

Modifications were made to the recipe in steps by FDF to alter the plasticity of the formula and to decrease Magnesium Phosphate concentration. The magnesium phosphate was decreased to increase lead leachability as measured by the TCLP analysis. The formula ingredients for the Silo 1 and Silo 2 surrogates were supplied by FDF in 3 kg batches, which were individually blended and then added to a premixed amount of hydrated "Bento Grout ™" /water slurry to produce test materials containing 30 %wt solids.

3.1.2 Test Process Design and Apparatus

Disposable 250ml polyethylene PCP containers were used to prepare test formulations because they allow close observation and rapid qualitative assessment of trial formulas. A typical test was conducted using 100 to 200 grams of representative surrogate to which varying amounts of modifiers and binders were added. Materials were blended by hand in the PCP cup using a spatula. When TSP was added in a formulation, approximately 5 minutes of mixing took place before addition of a binder to allow for dissolution. Upon completion of mixing, the cup was sealed with a plastic lid.

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After 24 – 48 hours at ambient temperature, samples were placed in a 160±5°F oven for 4 to 5 days to accelerate cure time and simulate a full-scale temperature profile. Following curing, samples were transferred to General Engineering Laboratories for analysis. Modifications to formulas were based on workability (a practical viscosity for processing, qualitative judgement based on previous experience), analytical results and drum scale testing.

3.1.3 Demonstration Surrogate (SO) Treatment Formula Development

For the SO the following initial formulations were evaluated for use in the solidification process by preparation of PCP samples in the laboratory. Observations were made regarding the consistency and workability of the initial formulations. In addition, TCLP results were obtained for the TC and UTS constituents and are summarized for the TC/UTS metals in Section 4.0. Table 3.1-1 summarizes the initial SO formulas, observations regarding workability, and TCLP results for critical metals.

TABLE 3.1-1 INITIAL PRODUCT FOR TREATING OF THE DEMONSTRATION SURROGATE SLURRY

Sample	SO-D-1	SO-D-2	SO-D-3	SO-D-4	SO-D-5	SO-U-1	½ RCRA TC Limits (ppm)	UTS Units (ppm)
Surrogate Solids, %wt	40	40	35	30	30	30		
Surrogate weight, g	140	140	121.7	104.3	104.3	70		
Water added, g	-	-	18.3	35.7	35.7	24		
TSP, g	-	0.40	-	-	-	0.54		
Binder blend,g	36	60	92.9	80	100	87		
Sample Weight (including adding binder), g	176	200.40	232.9	220	240	181.54		
Observations	Thick paste, barely mixable.	Thick paste, barely mixable.	Fairly stiff, mixable.	Smooth mix, easily workable.	Smooth mix, workable.	Thick paste, barely mixable.		
TCLP results:								
Pb (ppm)	0.812	0.018	0.010	0.007	0.008	0.008	2.5	0.75
Cr (ppm)	0.041	1.230	1.960	1.510	1.170	1.250	2.5	0.60

The following observations regarding performance of the initial formulations provided a basis for modification of the initial treatment recipes:

1. The small amount of binder in SO-D-1, which produced a very thick mix, indicated a rapid reaction of lead salt particles with the binder, forming complex products. The thickening was determined not to be due to early hydration of cement.

2. The addition of TSP in SO-D-2 apparently inactivated more of the lead salt particles so that more binder could be introduced before reaching the same degree of thickening.

3. Lead leachability appears to be fairly well controlled, but the formula needed to be adjusted to further limit chromium leachability.

Based on these observations, the initial treatment formulas were modified to improve workability and chromium leaching characteristics. Table 3.1-2 summarizes modified SO formulas, observations regarding workability, and TCLP results for critical metals.

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Table 3.1-2 Demonstration Surrogate Slurry Initial Product Formula Modifications

Sample	SO-D-6	SO-U-2	SO-U-3
Formula type	½ RCRA	UTS	UTS backup
Surrogate (decanted), g	140	140	140
Surrogate Solids, %wt	37	37	37
TSP, g	0.7	1.4	2.1
Binder blend, g	70	100	110
Observations:	Gradually formed a smooth, fairly workable mix.	Quite thick but smooth and creamy.	Quite thick but smooth and creamy.
TCLP Result			
Pb (ppm)	NA	NA	NA
Cr (ppm)	NA	NA	NA

NOTE: "NA" INDICATES SAMPLE WAS NOT ANALYSED.

To help evaluate transfer of bench-scale work to the pilot-scale test, the SO-D-6 formula above was utilized in an 85-gallon test solidification. During this test, the viscosity of the mixture increased rapidly until the mixer blade stalled on the first two trials prior to addition of the calculated amount of cement. A sample of actual 72-hour SO was collected, decanted and tested in the lab using a modified SO-D-6 (SO-D-7) The formula produced a somewhat stiffer consistency paste than did its lab counterpart. Additional TSP was added to further inhibit the reaction of lead salts with cement. A longer mixing time was used following addition of the TSP and fly ash to ensure complete reaction of the TSP.

Based upon the actual drum solidification experience using the SO-D-6, formula described above, additional modifications were made to the SO treatment recipes. These modifications (SO-D-7), observations on workability, and TCLP results for critical metals are summarized in Table 3.1-3.

Table 3.1-3 Demonstration Surrogate Slurry Formula Post Drum Test Modifications

Sample	SO-D-7A (B)	SO-U-4A (B)	SO-U-5A (B)
Surrogate (decanted), g	120	120	120
TSP, g	1.8	2.4	3.0
Binder blend, g	60	85.7	94.3
Water/Binder ratio	1.25	0.875	0.795
TCLP Results:			
Pb (ppm)	ND (0.043)	ND (NA)	ND (NA)
Cr (ppm)	2.170 (1.710)	1.490 (NA)	1.050 (NA)

NOTE: SAMPLE SUFFIX "A (B)" INDICATES THE SAMPLES WERE PREPARED IN DUPLICATE. THE FIRST SAMPLE (A) WAS ANALYZED AFTER A 7-DAY CURE WHILE THE SECOND SAMPLE (B) WAS ANALYZED AFTER A FULL 28-DAY CURE. "ND" INDICATES BELOW DETECTION LIMIT. "NA" INDICATES SAMPLE WAS NOT ANALYSED.

The following conclusions were drawn based on these results:

1. Formula SO-D-7A, while not yet cured for a total of 28 days, met the Fernald ½ RCRA requirements for leachability and conferred waste loading efficiency by virtue of 25% volume decanting and minimal addition of binder and additive.

2. Formulas SO-U-4A and SO-U-5A met all the UTS limits except for chromium. The TCLP value appeared to be controlled by the water/binder ratio.

During a third 85-gallon test solidification using formula SO-D-7, addition of all calculated materials was achieved; however, blade speed had decreased to approximately 30 rpm and was deemed unacceptable. Additionally, during the test, water and decanted liquid was returned to the drum when it appeared that the mixer blade would stall. It was determined that: (1) the preliminary formula was responsible for less than satisfactory drum scale results and that the hydraulic power unit (HPU) was undersized for this application, having a pressure relief set at approximately 600 psi. The HPU was replaced with one capable of 2800 psi output.

The following PCP mixes were prepared for TCLP testing, primarily to achieve chromium leaching characteristics which would meet the UTS limits:

Table 3.1-4 Demonstration Surrogate -UTS Formula Modification

Sample	SO-U-6A (B)	SO-U-7A (B)	SO-U-8A (B)
Waste (37 %wt), g	120	100	80
Decant (3.8%wt), g	-	-	21.4
Water added, g	-	5.7	-
TSP, g	3.0	2.5	2.5
Binder blend, g	110	104	112.7
Net solids, %wt	37	35	30
Water/Binder ratio	0.687	0.661	0.630
TCLP Results:			
Pb (ppm)	ND (0.034)	NA (0.024)	NA (0.019)
Cr (ppm)	0.377 (0.536)	NA (0.521)	NA (0.644)

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NOTE: SAMPLE SUFFIX "A (B)" INDICATES THE SAMPLES WERE PREPARED IN DUPLICATE. THE FIRST SAMPLE (B) WAS ANALYZED AFTER A 7-DAY CURE WHILE THE SECOND SAMPLE (A) WAS ANALYZED AFTER A FULL 28-DAY CURE. "ND" INDICATES BELOW DETECTION LIMIT. "NA" INDICATES SAMPLE WAS NOT SUBJECTED TO ANALYSIS.

Conclusions:

1. Formulas represented by SO-U-6B and SO-U-7B met the UTS requirements, in particular the chromium TCLP maximum of 0.60 ppm. Formula SO-U-6B is preferred, since the same 37%wt solid waste is used as for the SO-D-7, ½ RCRA formula.

2. The favorable results for formula SO-U-7B indicated that some surrogate solids' dilution (37% to 35%) did not result in UTS failure.

3. SO-U-6A was less leachable after 28 days as evidenced by a decrease in TCLP chromium to 0.337 ppm from 0.536 ppm for the 7-day cured SO-U-6B. TCLP results for SO-D-7B (28-day cure) exhibited a similar significant decrease in leachability over the 7-day cured SO-D-7A.

3.1.4 Silo1 Surrogate Treatment Formula Development

PCP samples were prepared using decanted Silo 1 surrogate for solidification formula development based on the experience gained during the SO formula development. Table 3.1-5 summarizes the initial treatment formulas, observations regarding workability, and TCLP results for critical metals.

NOTE: SAMPLE SUFFIX "A (B)" INDICATES THE SAMPLES WERE PREPARED IN DUPLICATE. THE FIRST SAMPLE (A) WAS ANALYZED AFTER A 7-DAY CURE WHILE THE SECOND SAMPLE (B) WAS ANALYZED AFTER A FULL 28-DAY CURE. "ND" INDICATES BELOW DETECTION LIMIT. "NA" INDICATES SAMPLE WAS NOT SUBJECTED TO ANALYSIS.

Conclusions:

Based upon the calculated level of chromium from the FDF-supplied surrogate formulation, the tested solidification products achieved acceptable compressive strength and satisfied the ½ RCRA TCLP requirements for chromium as well as all other listed metals.

Table 3.1-5 Silo 1 Surrogate-Initial Formulas for ½ RCRA Limits

Sample	S1-T-1A (B)	S1-T-2A (B)	S1-T-3A (B)
Decanted surrogate, g	140	140	140
Concentration, % wt solids	35.6	35.6	35.6
TSP, g	2.1	4.2	4.2
Binder blend, g	70	70	55
Water/binder ratio	1.26	1.26	1.60
Observations	Very thick, does not appear practical.	Thick but mixable, similar to UTS demo formula.	Smooth paste, similar to ½ RCRA formula.
TCLP Results:			
Pb, ppm	NA	ND (NA)	ND (NA)
Cr, ppm	NA	0.077 (NA)	0.215 (NA)

Based upon the RLP results for the samples listed on Table 3.1-5, formula modifications were made using only Portland cement as the binder. Table 3.1-6 describes those formula changes that should pass ½ RCRA TCLP Units but may fail the corresponding units for UTS.

Table 3.1-6 Silo 1 Surrogate-Cement Only Formula Modification

Sample	S1-T-6A(B)
Surrogate Weight, 37%wt solids, g	140
TSP, g	4.2
Cement only, g	40
Observations:	Smooth mix, easily workable
TCLP Results:	
Lead, ppm	1.370
Chromium, ppm	0.213

NOTE: SAMPLE SUFFIX "A (B)" INDICATES THE SAMPLES WERE PREPARED IN DUPLICATE. THE FIRST SAMPLE (A) WAS ANALYZED AFTER A 7-DAY CURE WHILE THE SECOND SAMPLE (B) WAS ANALYZED AFTER A FULL 28-DAY CURE IF APPROPRIATE. "ND" INDICATES BELOW DETECTION LIMIT. "NA" INDICATES SAMPLE WAS NOT SUBJECTED TO ANALYSIS.

Conclusions:

TCLP analysis for UTS metals indicates that the above formulation would fail the UTS requirement for lead leachability; however, all requirements for ½ RCRA limits would be met (See Table 1/0-2).

3.1.5 Silo 2 Surrogate Treatment Formula Development

PCP samples were prepared using 30%wt solids Silo 2 surrogate for solidification formula development. No decanting was possible due to the paste-like viscosity of the product. Table 3.1-7 provides the initial Silo 2 test formulations, observations regarding workability, and TCLP results fo critical metals.

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Table 3.1-7 Silo 2 Surrogate-Initial Test Formulas

Sample	S2-T-1A (B)	S2-T-2A (B)	½ RCRA TC Limits (ppm)	UTS Units (ppm)
Silo 2 surrogate (solids), g	140	140		
Surrogate %wt solids	30	30		
TSP, g	4.2	4.2		
Binder blend, g	30	55		
Water/binder ratio	3.27	1.78		
Observations	Smooth mix with moderate viscosity, but non-pourable.	Fairly thick mix, but sufficiently workable to form cube samples.		
TCLP Results:				
Pb (ppm)	NA (NA)	ND (NA)	2.5	0.75
Cr (ppm)	NA (NA)	0.229 (NA)	2.5	0.60

NOTE: SAMPLE SUFFIX "A (B)" INDICATES THE SAMPLES WERE PREPARED IN DUPLICATE. THE FIRST SAMPLE (A) WAS ANALYZED AFTER A 7-DAY CURE WHILE THE SECOND SAMPLE (B) WAS ANALYZED AFTER A FULL 28-DAY CURE. "ND" INDICATES BELOW DETECTION LIMIT. "NA" INDICATES SAMPLE WAS NOT SUBJECTED TO ANALYSIS.

Conclusions:

Following 5 days curing at 160±5°F, PCP products S2-T-1A&B and S2-T-2A&B were examined prior to forwarding for TCLP analysis. It was found that the S2-T-1A&B samples had not fully solidified, so further testing was not appropriate. Formula S2-T-2A solidified normally and met the UTS requirements. Modifications were made to the Silo 2 formulas and appear in Table 3.1-8. These changes optimize product waste loading by either reducing the amount of binder blend, or using unmodified Portland cement as the only binder.

Table 3.1-8 Silo 2 Formula Modifications

Sample	S2-T-3A(B)	S2-T-4A(B)
Surrogate weight, g	140	140
TSP, g	4.2	4.2
Binder blend, g	45	0
Cement only, g	0	40
Observations:	Smooth, easily workable mix.	Smooth, easily workable mix.
TCLP results:		
Lead, ppm	0.023	ND
Chromium, ppm	0.381	0.656

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NOTE: SAMPLE SUFFIX "A (B)" INDICATES THE SAMPLES WERE PREPARED IN DUPLICATE. THE FIRST SAMPLE (A) WAS ANALYZED AFTER A 7-DAY CURE WHILE THE SECOND SAMPLE (B) WAS ANALYZED AFTER A FULL

28-DAY CURE IF APPROPRIATE. "ND" INDICATES BELOW DETECTION LIMIT. "NA" INDICATES SAMPLE WAS NOT SUBJECTED TO ANALYSIS.

Conclusions:

TCLP results for sample S2-T-3 satisfied all UTS limits even though binder content was decreased approximately 22% from sample S2-T-2. Sample S2-T-4 exceeded the UTS limit of 600 ppm for chromium; however, it met all ½ RCRA requirements.

3.2 72-hour Pilot-Scale Demonstration

This section provides a description of the approach used to meet the requirements/objectives of the test and a description of the process activities. Key aspects of the 72-hour pilot-scale test are discussed relative to the slurry feed system, the surrogate treatment system, and surrogate curing and sampling. Finally, process anomalies related to operation of the slurry feed pumps and treatment of hold-up material in the slurry feed tank are discussed.

3.2.1 Slurry Feed System

3.2.1.1 **Slurry Dewatering**. In order to optimize solids loading, mixing of the tanker contents was suspended for two days to allow the solids to settle prior to dewatering. Based on a solids content of 3.8%wt solids as determined from laboratory surrogates, a calculated mass of supernate was decanted (based on bench-scale surrogate decanting) from the tanker two days prior to commencement of the 72-hour demonstration. The solids content of the tanker following decanting was presumed to be 37%wt solids. Decanted material was transferred to drums for weighing, then to a 550-gallon poly container for storage, using an air-operated positive displacement dual diaphragm pump equipped with a PVC skimmer suction attachment. For each decanting iteration, 3 liters of supernate were obtained as sample. Of the 3 liters, 250 mls were retained in tall form glass jars and the remainder was composited and distributed to various-sized poly containers for analyses to be performed by General Engineering Laboratories.

3.2.1.2 **Slurry Mixing**. The forward end of the surrogate tanker was elevated approximately 2 feet to produce flow of material aft to the inlet of an air operated positive displacement pump used for recirculation. The pump discharge was initially directed to the tanker's forward most manway to ensure thorough turnover of material. Homogeneity of surrogate in the tanker was maintained by hydraulically powered paddle-wheel type mixing blades. The discharge of the recirculation pump was routed

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through a 1½ inch line to a normally closed air operated valve (WS-1), at the inlet of which flow was redirected back to return to the tanker.

3.2.1.3 **Slurry Feed.** WS-1 was actuated to divert a portion of surrogate recirculation flow through a 1-inch line to the drum fillhead. Closure of WS-1 was controlled automatically by ultrasonic level instrumentation having a setpoint determined at the outset of the demonstration to deliver approximately 600 pounds of surrogate to a drum. The "flag" attached to the drum's mixing blade provided the operator in attendance visual indication of level so that in the event of level control failure, he would be able to close WS-1 electrically to prevent overfilling the drum. Upon completion of drum filling and WS-1 closure, the 1-inch line was manually blown down into the drum with compressed air to preclude clogging from settled out solids.

3.2.1.4 **Fillhead Positioning**. To perform a solidification operation, an 85-gallon drum containing a mixing blade and base plate was moved into position beneath the suspended fillhead. The operator, using an electric hoist, slowly lowered the fillhead and aligned the motor shaft with the mixing blade coupling. When the fillhead was seated on the drum, three clamps located at 120° intervals around its perimeter were fastened to the rolled edge of the drum lip to prevent rotation of the drum or fillhead during mixing. The hydraulic motor was jogged until a "flag", attached to the mixing blade at the desired surrogate level, was visible on the video monitor.

3.2.1.5 3.2.1.5 **Off-gas Parameters.** The pilot-scale off-gas system consisted of an exhaust fan pulling a slight negative pressure on the fillhead headspace and on the curing drums through a standard HEPA filter. The main objective of the pilot-scale off-gas system was to treat (particulate filter) gas displaced from the drums as they were filled and dry chemicals were added. Additionally, parameters were measured and recorded during the pilot-scale test to allow verification that the proposed approach for the full-scale off-gas control system was adequate.

While the treatment drum was filling, drum, temperature, humidity, and VOC concentration of the displaced air was monitored by securing the off-gas system and directly monitoring the gas displaced through an unused connection on the pilot-scale fillhead. VOC content was measured using a Draeger tube calibrated for total VOCs. However, since the VOCs detected are attributable primarily to kerosene, the readings have been adjusted to that specific calibration curve. Temperature, humidity, and VOC concentration readings initially registered ambient conditions and increased through the filling evolution, reaching maximum values at the completion of filling.

3.2.1.6 **Surrogate Treatment System**. In accordance with the work plan, the tanker surrogate was processed in 10 batches. Batches 1 through 8 consisted of 2 drums each; batches 9 and 10 consisted of 3 drums each.

3.2.1.7 **Slurry Feed Sampling and Process Monitoring**. During processing of the second drum of each batch, a 250 ml sample of surrogate was obtained from the recirculation line discharge in a glass jar. As the drum was filling, humidity and VOC readings were taken at a spare fillhead connection. The HEPA filter system was energized to create a slight negative pressure in the drum and the temperature monitoring system was verified in operation. Rotation of the drum-mixing blade was initiated and controlled by the operator using the (HPU). A dial indicator on the HPU was adjusted to maintain mixing rate (shaft speed) between 70 and 80 rpm through the remainder of the solidification operation. Mixing rate and hydraulic pressure were monitored periodically and recorded for scale up engineering calculations.

3.2.1.8 **Addition of Binder and Dry Chemicals**. Application of the solidification formula developed for the SO to meet the ½ RCRA limits (SO-D-7) was commenced with the addition of 1.5% by weight anhydrous TSP to the surrogate. This was immediately followed by the addition of 15% by weight Type F Fly ash. After a 15 minute mixing period to allow for dissolution of the TSP, 35% by weight of Type I Portland Cement was added to the drum. Another 15-minute mixing period elapsed after which the mixing blade was stopped and the HPU secured (the % of the additive and binder are based on slurry weight).

Binder and dry additives (TSP, flyash and cement) were added to the fillhead by placing the pre-weighed quantities into a bin that fed a 2-inch screw conveyor. The conveyor discharged the additives into the fillhead through the media Inlet (see CNS drawing C-313-D-2792).

3.2.1.9 **Fillhead Removal**. After mixing was completed, the fillhead clamps were released and the fillhead was carefully raised, uncoupling the mixing blade. On two occasions at this point

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during the 72-hour demonstration, shifting of the drum on the conveyor caused the motor shaft to bind in the blade and began to extract it from the drum. The operators stopped elevation of the fillhead, repositioned the drum and completed fillhead removal. In one instance, the uppermost extremities of the blade had to be bent to allow for installation of the drum lid because the blade could not be driven back into the mixture.

Following removal of the fillhead, the drum was rolled from beneath the fillhead on the conveyor. The level transducer and lenses for the video camera and light were checked for cleanliness and a drum for the next solidification was installed.

3.2.1.10 **Treated Surrogate Wet Samples**. From the second drum of each batch, thirty-six 2x4 inch plastic cylinders were filled with processed surrogate, capped and sealed with tape. On the second drum of batches 3, 6 and 9, six standard 2-inch cube molds were filled in addition to the cylinders. These samples were kept at ambient temperature for 24 – 48 hours after which they were placed in 160±5°F ovens for 4 to 5 days to simulate the exothermic reaction temperature profile of full-scale solidification.

3.2.2 Surrogate Curing and Sampling

3.2.2.1 **Treated Surrogate Curing**. A curing lid (consisting of a standard 85-gallon drum lid with two penetrations) was installed on the processed drum. Through the center hole of the lid (approximately 2-inches off-center) a thermocouple was passed into the treated surrogate to a depth of approximately 12 inches below the surface of the treated surrogate. This thermocouple was used to monitor the temperature rise as a result of the exothermic reaction of the curing process. For batches 3, 6 and 9, a second thermocouple was attached to the outside wall of the drum to monitor skin temperature of the drum. A bulkhead hose coupling was attached through the second, off-center hole of the curing lid. The lid band was installed and the drum was moved to a curing area using an overhead crane.

In the curing area, plastic tubing was connected between the hose coupling of the curing lid and the HEPA filter. The thermocouples were connected to a computer-monitored instrument (data-logger), which logged the temperature for each data from the thermocouples point every 15 minutes. Temperature data was automatically uploaded to a spreadsheet.

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3.2.2.2 **Cured Surrogate Sampling**. After 28 days had elapsed following completion of processing, a 2-inch core sample from the second drum from each batch was obtained. Approximately 3 liters of core material from each batch, as well as a top to bottom core removed from batch 6 drum 2, was shipped to FDF for inspection and analysis. Core samples from batches 3, 6 and 9 were sent to General Engineering Laboratories for TCLP analysis and determination of RCRA characteristics results of those core samples are provided in Appendix B (B3D2CORE, B6D2CORE, and B9D2CORE).

3.2.3 Process Anomalies

3.2.3.1 **Bridging of Dry Chemicals**. Some difficulty was experienced with bridging of the chemicals in the auger bin during addition. As the screw conveyor removed chemicals from the bottom of the bin, the remaining chemicals did not flow down into the bin bottom but rather "bridged" creating a void at the inlet to the screw conveyor. This required manual feeding and agitation of the material at the bin. The vibrator mounted on the mechanical auger was significantly oversized and could not be run continuously during chemical feeding. In the full-scale facility additives will be gravity fed from silos located on top of the facility into the processing container.

3.2.3.2 **Slurry Feed Tank Pump Heat-up**. During a system walkdown, a CNS technician noticed excessive heat emanating from the hydraulic system of the surrogate tanker. Upon further investigation, it was discovered that the surrogate level in the semi tanker had dropped below the level of the internally mounted hydraulic mixer motors. Heat from the motors could not be adequately dissipated without the presence of surrogate to act as a cooling medium. Recirculation pump discharge was redirected to fall directly on the motors. With the consent of FDF personnel, the remaining 6 drums for the demonstration were filled with their intended complement of surrogate and staged on the roller conveyor to await processing. The surrogate tanker mixers were secured and the last six drums were processed in reverse order due to their position on the conveyor.

3.2.3.3 **Slurry Feed Tank Holdup Material**. Residue remaining in the tanker following the demonstration was removed and transferred to the poly container of surrogate decant material f[illegible] later processing. No additional water was used for this

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cleaning, rather the liquid decanted previously was returned to the tanker using the dewatering pump to wash down internal surfaces. Structural support components of the mixing tanker retained some amount of solid material believed to consist predominantly of coarse silica.

It was determined via PCP testing that the identical formulation used to solidify the dewatered surrogate could be used to process the decanted liquid. The decanted material was processed in the same manner as described above except that the dewatering pump was used to recirculate and transfer material to drums for processing.

4.0 SAMPLING AND ANALYSIS

Sampling and analysis data were collected during the bench-scale development and pilot-scale testing to characterize various aspects of the CNS solidification process. Specifically, data were collected to characterize the untreated surrogates, bench-scale treated surrogates, pilot-scale treated surrogates, and decant water and off-gas streams from the process.

Data were collected in accordance with the approved sampling and analysis plan submitted with the project work plan. This section provides a tabular summary of the data collected during the process. Sampling logs, a sample chain-of-custody form, analytical data packages, and analytical laboratory logs are included as attachments to this report.

4.1 Untreated Surrogate Analyses

Data were collected to demonstrate that the surrogate slurries met the FDF specifications. CNS collected samples for FDF analysis of the bench-scale work. CNS also collected and analyzed samples of the prepared surrogate feed for the pilot-scale test. FDF completed a suite of tests on the 70-wt% solids surrogate slurries including moisture content, plasticity, TCLP for lead, and pH (to confirm Demo Surrogate limits prior to bench-scale testing activities). CNS completed analysis of the feed prior to decanting during the pilot-scale test for elemental analysis. Results from these analyses are summarized in Table 4-1.

4.2 Bench-Scale Treated Surrogate Analyses

Bench-scale development work required analyses of treated samples of the Demonstration, Silo 1 and Silo 2 surrogates to evaluate performance of selected treatment recipes. A description of the bench-scale test objectives and rationale is provided in Section 2.1. A description of the bench-scale test and procedures is provided in Section 3.1. Initial treatment recipes were tested and then optimized based on workability, surrogate loading, and performance of the treated surrogates under TCLP testing. Results from TCLP testing are provided in Tables 4-2 through 4-5.

Table 4-1 Demonstration Treated Surrogate Elemental Analysis

70%wt solids Lab. Demo Surrogate				30% Solids 72-Hour Demo Surrogate			
Al, ppm	12400	Ni, ppm	2300	AL, ppm	6590	Ni, ppm	743
As, ppm	458	P, ppm	2820	As, ppm	175	P, ppm	2420
Ba, ppm	8230	Pb, ppm	64100	Ba, ppm	4190	Pb, ppm	22300
Ca, ppm	1320	Se, ppm	216	Ca, ppm	589	Se, ppm	107
Cr, ppm	331	Si, ppm	ND	Cr, ppm	106	Si, ppm	ND
Fe, ppm	12400	V, ppm	373	Fe, ppm	5370	V, ppm	93.4
K, ppm	4430	Zn, ppm	504	K, ppm	1750	Zn, ppm	263
Mg, ppm	2540	S, ppm	1940	Mg, ppm	1370	S, ppm	1150
Na, ppm	11200	C, ppm	8	Na, ppm	5430	C, ppm	5.3

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Table 4-2 Final Product Formula for Treating of the Demonstration Surrogate – 1/2 RCRA Metals TCLP Analysis

Sample	Hg ppm	Ag ppm	As ppm	Ba ppm	Be ppm	Cd ppm	Cr ppm	Ni ppm	Pb ppm	Sb ppm	Se ppm	Tl ppm	V ppm	Zn ppm
SO-D-1	ND	ND	0.013	0.260	ND	ND	0.041	0.075	0.812	ND	0.156	0.011	ND	0.004
SO-D-2	ND	0.003	0.085	0.230	0.001	ND	1.230	0.006	0.018	0.031	0.289	0.011	0.014	0.005
SO-D-3	ND	0.002	0.086	0.240	ND	ND	1.960	ND	0.010	0.038	0.333	0.009	0.097	0.010
SO-D-4	ND	ND	0.084	0.230	ND	ND	1.510	ND	0.007	0.029	0.303	0.007	0.081	0.004
SO-D-5	ND	0.002	0.073	0.250	ND	ND	1.170	ND	0.008	0.031	0.270	0.012	0.094	0.045
SO-D-7A	ND	ND	0.084	0.169	ND	ND	2.170	ND	ND	0.034	0.270	ND	0.073	ND
SO-D-7B	ND	ND	0.070	0.160	ND	ND	1.710	0.003	0.043	0.026	0.247	0.019	0.059	0.004
LIMITS (ppm)	0.10	2.5	2.5	50.0	-	0.5	2.5	-	2.5	-	0.5	-	-	-

NOTE: **SAMPLE SUFFIX "A OR B" INDICATES THAT THE SAMPLES WERE PREPARED IN DUPLICATE. THE FIRST SAMPLE (A) WAS ANALYZED AFTER A 7-DAY CURE WHILE THE SECOND SAMPLE (B) WAS ANALYZED AFTER A FULL 28-DAY CURE. IF ONE OF A PAIRED SET OF DUPLICATES IS NOT REPORTED, IT MEANS THAT THE SAMPLE WAS NOT ANALYZED. "ND" INDICATES BELOW DETECTION LIMIT.**

Table 4-3 Final Product Formula for Treating the Demonstration Surrogate Slurry-UTS Metals TCLP Analysis

Sample	Hg ppm	Ag ppm	As ppm	Ba ppm	Be ppm	Cd ppm	Cr ppm	Ni ppm	Pb ppm	Sb ppm	Se ppm	Tl ppm	V ppm	Zn ppm
SO-U-1	ND	ND	0.052	0.280	ND	ND	1.250	ND	0.008	0.030	0.222	0.010	0.095	0.005
SO-U-4A	ND	ND	0.046	0.164	ND	ND	1.490	ND	ND	0.030	0.212	ND	0.089	ND
SO-U-5A	ND	ND	0.048	0.200	ND	ND	1.050	ND	ND	0.031	0.202	ND	0.100	ND
SO-U-6A	ND	ND	ND	0.159	ND	ND	0.377	ND	ND	ND	0.138	0.017	0.067	ND
SO-U-6B	ND	0.002	0.051	0.208	ND	ND	0.536	ND	0.34	0.027	0.180	0.015	0.093	ND
SO-U-7B	ND	ND	0.041	0.222	ND	ND	0.521	ND	0.24	0.029	0.173	0.019	0.093	0.004
SO-U-8B	ND	ND	0.034	0.235	ND	ND	0.644	ND	0.019	0.023	0.157	0.015	0.097	0.004
Limit	0.025	0.14	5.0	21.0	-	0.11	0.60	11						

NOTE: **SAMPLE SUFFIX "A OR B" INDICATES THE SAMPLES WERE PREPARED IN DUPLICATE. THE FIRST SAMPLE (A) WAS ANALYZED AFTER A 7-DAY CURE WHILE THE SECOND SAMPLE (B) WAS ANALYZED AFTER A FULL 28-DAY CURE. IF ONE OF A PAIRED SET OF DUPLICATES IS NOT REPORTED, IT MEANS THAT THE SAMPLE WAS NOT ANALYZED. "ND" INDICATES BELOW DETECTION LIMIT.**

Table 4-4 Surrogate Slurry Silo 1 – 1/2 RCRA Metals Formula TCLP Analysis

Sample	Hg ppm	Ag ppm	As ppm	Ba ppm	Be ppm	Cd ppm	Cr ppm	Ni ppm	Pb ppm	Sb ppm	Se ppm	Tl ppm	V ppm	Zn ppm
S1-T-2A	ND	0.004	ND	0.073	ND	ND	0.077	ND	ND	0.015	0.219	ND	0.065	0.013
S1-T-3A	ND	0.002	ND	0.083	ND	ND	0.215	ND	ND	ND	0.234	ND	0.039	0.011
S1-T-5A	ND	0.006	ND	0.046	ND	ND	0.213	ND	1.370	ND	0.146	ND	0.001	0.004
LIMITS (ppm)	0.10	2.5	2.5	50.0	-	0.5	2.5	-	2.5	-	0.5	-	-	-

NOTE: SAMPLE SUFFIX "A OR B" INDICATES THE SAMPLES WERE PREPARED IN DUPLICATE. THE FIRST SAMPLE (A) WAS ANALYZED AFTER A 7-DAY CURE WHILE THE SECOND SAMPLE (B) WAS ANALYZED AFTER A FULL 28-DAY CURE. "ND" INDICATES BELOW DETECTION LIMIT.

Table 4-5 Surrogate Slurry Silo 2 – 1/2 RCRA Formula TCLP Analysis

Sample	Hg ppm	Ag ppm	As ppm	Ba ppm	Be ppm	Cd ppm	Cr ppm	Ni ppm	Pb ppm	Sb ppm	Se ppm	Tl ppm	V ppm	Zn ppm
S2-T-2A	ND	0.003	0.045	0.080	ND	ND	0.229	ND	ND	0.009	0.305	ND	0.073	0.014
S2-T-3A	ND	0.005	ND	0.071	ND	ND	0.381	ND	0.023	ND	0.248	ND	0.034	0.05
S2-T-4A	ND	0.005	ND	0.077	ND	ND	0.656	ND	ND	ND	0.175	ND	0.025	0.008
LIMITS (ppm)	0.10	2.5	2.5	50.0	-	0.5	2.5	-	2.5	-	0.5	-	-	-

NOTE: SAMPLE SUFFIX "A OR B" INDICATES THE SAMPLES WERE PREPARED IN DUPLICATE. THE FIRST SAMPLE (A) WAS ANALYZED AFTER A 7-DAY CURE WHILE THE SECOND SAMPLE (B) WAS ANALYZED AFTER A FULL 28-DAY CURE. IF ONE OF A PAIRED SET OF DUPLICATES IS NOT REPORTED, IT MEANS THAT THE SAMPLE WAS NOT ANALYZED. "ND" INDICATES BELOW DETECTION LIMIT.

4.3 Characterization of Pilot-Scale Treated Surrogate

Samples of the treated surrogate, cured in the process container, were subjected to TCLP analysis. Table 4-6 provides a summary of the TCLP results. All results were less than ½ of the RCRA TC limits, with the exception of the mercury analysis for Drum 2 of Batch 6. Since there was no mercury in the SO and no mercury in any of the CNS binder or additives, this sample result is presumed to be an artifact of the laboratory analysis and not a valid result.

Table 4-6 Core Samples TCLP Analysis

Sample	Hg ppm	Ag ppm	As ppm	Ba ppm	Be ppm	Cd ppm	Cr ppm	Ni ppm	Pb ppm	Sb ppm	Se ppm	Th ppm	V ppm	Zn ppm
Batch 3 Drum 2	ND	ND	0.015	0.207	ND	ND	0.731	0.010	0.006	ND	0.157	0.007	0.034	0.019
Batch 6 Drum 2	ND	ND	0.012	0.200	ND	ND	0.795	0.009	0.009	ND	0.167	0.010	0.036	0.018
Batch 9 Drum 2	ND	ND	0.009	0.317	ND	ND	0.582	0.009	0.007	ND	0.100	0.008	0.013	0.016

NOTE: "ND" INDICATES BELOW DETECTION LIMIT.

4.4 Decant Water Analysis

Decant water was analyzed to assess requirements for subsequent reuse and ultimate treatment and disposal. Table 4-8 presents the elemental analysis for selected RCRA metals. Table 4-9 presents data on pH, total dissolved solids, and total suspended solids for the decant water.

Table 4-7 Core Samples - RCRA Characteristics

Sample	Cyanide, Reactive, ppm	Sulfide, Reactive, ppm	Paint Filter Test	Flash Pt Closed Cup, °F	Corrosivity pH
Batch 3 Drum 2	ND	ND	PASS	>145	12.8*
Batch 6 Drum2	ND	ND	PASS	>145	12.8*
Batch 9 Drum 2	ND	ND	PASS	>145	12.9*

* pH is for leachate from TCLP analysis. pH does not apply to solids.

Table 4-8 Decant Water Sample RCRA Metals Analysis

Sample	As, ppm	Ba, ppm	Cr, ppm	Ni, ppm	Pb, ppm	Se, ppm	V, ppm	Zn, ppm
Decant	203	1030	3050	893	12100	131	110	40.3

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Table 4-9 Decant Water Analysis

Sample	PH	Solids, Total Dissolved, ppm	Solids, Total Suspended, ppm	Total Carbon, ppm
Decant	9.4	11400	237000	6500

4.5 Off-gas Analysis

Analyses were conducted to demonstrate that the off-gas (vent gas from the treatment/disposal container) would meet the (RCS) acceptance criteria. Table 4-10 presents data on relative humidity, temperature and VOC content for the primary sources of off-gas from the process.

Table 4-10 Off-gas Analysis

Sample	Relative humidity	Temperature	VOC content
Off-gas, During feed filling	99.9%	72.3 – 82.8 F	6 –8 ppm

5.0 RESULTS AND DISCUSSION

This section discusses the results from the bench-scale and pilot-scale tests. The bench-scale tests resulted in the development of formulations for treatment of the Demonstration, Silo 1 and 2 surrogates. Bench-scale tests also provided the basis for understanding some of the key physical and chemical characteristics of the surrogates and binder mixes.

The pilot-scale test demonstrated that the CNS stabilization/solidification process is a robust process capable of reliably processing Fernald Silo surrogates into stabilized forms that meet all of the regulatory, processing, storage, transportation, and disposal requirements. In addition, results from the pilot-scale tests allow scale-up of key pilot plant operations to a full-scale facility with sufficient operational experience to evaluate technology-specific aspects of safety, reliability, implementability, cost, and schedule.

5.1 Bench Scale

5.1.1 Formulation Development

Initial solidification testing of the SO surrogate material containing 30%wt solids showed that a relatively small addition of cement binder caused a sharp increase in mix viscosity such that further binder addition was impractical. However, the mixture hardened to an acceptable solid that easily met TCLP requirements for lead, including the UTS maximum of 0.75 ppm. It was inferred from this result that reactive (leachable) lead in the matrix was being retained chemically by forming insoluble products with cement.

Using TSP as a pretreatment chemical at 1-3% of surrogate weight enabled subsequent binder addition to proceed more smoothly and allowed significantly higher concentrations. Particles of lead compounds in the surrogate, probably lead oxide and lead sulfate, became coated with fairly insoluble phosphate derivatives and became less reactive toward cement.

The low arsenic, chromium and selenium TCLP values for formulation SO-D-1 suggest that a significant amount of lead salt particles were not complexed by binder reactions and were therefore available to form mostly insoluble lead arsenate, lead chromate and lead selenite. With the greater binder content in SO-D-2, fewer active lead salt particles remained to insolubilize these other elements, and greater leaching took place. The fact that more lead was in a reactive (soluble) form in SO-D-1 is indicated by the TCLP value being 45 times higher than found in SO-D-2.

SO-U-6A was less leachable after 28 days as evidenced by the decrease in TCLP chromium to 0.337 ppm from 0.536 ppm for the 7-day cured SO-U-6B. This demonstrated that the oven-curing period, while accelerating cure of the samples did not necessarily provide a fully cured product. TCLP results for SO-D-7B (28-day cure) exhibited a similar decrease in leachability over the 7-day cured SO-D-7A.

Initially, PCP samples S1-T-2A and S1-T-3A were inadvertently tested for elemental analysis rather than for TCLP. Results for total chromium were 68 ppm and 52 ppm respectively, which agrees with a calculated 54 ppm, based upon the published Silo 1 formula and the actual PCP solidification formulas.

Optimizing solidification formulas involved a combination of surrogate decanting and minimal binder addition to meet the respective ½ RCRA and UTS requirements for leachability. For the SO, it was found that 25% by volume could be decanted as a watery phase with a specific gravity of about 1.04. This increased the solids content in the remaining material to about 37%wt. The amount of binder to be added to this material was almost exclusively a function of which chromium TCLP value requirement was to be met. Test values for all other listed elements were well below the maximum levels for either the ½ RCRA or the UTS specifications.

In order to meet the restrictive 0.60 ppm TCLP chromium limit for UTS, it was necessary to almost double the amount of binder indicated to meet ½ RCRA limits, and increase the pre-addition of TSP to 3.0%. This formula produced a thick, but mixable paste. Leach test data suggests that passable chromium values are obtained by lowering the (W/B) to reduce matrix permeability.

5.1.2 Recommended Formulas:

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Table 5.1-1 summarizes the recommended formulas which were developed based on the bench-scale testing and the performance of the final treated surrogate.

Table 5.1-1 Recommended Treatment Formulas

Formula/Description	SO-D /Demo ½ RCRA	SO-U /Demo UTS	S1-T /Silo #1 ½ RCRA	S1-U /Silo #1 UTS	S2-T /Silo #2 ½ RCRA	S2-U /Silo #2 UTS
Developmental Designation	SO-D-7B (Pilot-Scale)	SO-U-6A	S1-T-5B	S1-T-3B	S2-T-4B	S2-T-3B
Initial surrogate (parts)	100	100	100	100	100	100
Dry solids (parts)	30	30	30	30	30	30
Decant Liquid (parts)	21	21	19	19	0	0
Residue Solidified (parts)	79	79	81	81	100	100
TSP(parts)	1.17	1.96	2.43	2.43	3.0	3.0
Flyash (parts)	11.9	21.7	0	9.5	0	9.6
Portland Cement (parts)	27.6	50.7	28.6	22.3	28.6	22.5
Solid Surrogate Form (parts)	119.7	153.4	112.0	115.2	131.6	135.1
Waste Loading, %	25.1	19.6	26.8	26.0	22.8	22.2
Compressive strength (psi)	816	2310	408	212	408	87
TCLP results:						
Hg, ppm	ND	ND	ND	ND	ND	ND
Ag, ppm	ND	ND	ND	0.002	-	-
As, ppm	0.070	ND	ND	ND	0.016	0.038
Ba, ppm	0.160	0.159	0.06	0.061	0.068	0.066
Be, ppm	ND	ND	ND	ND	ND	0.0006
Cd, ppm	ND	ND	ND	ND	ND	ND
Cr, ppm	1.710	0.377	0.296	0.196	0.563	0.360
Ni, ppm	0.003	ND	ND	ND	ND	ND
Pb, ppm	0.043	ND	0.0107	0.014	ND	0.072
Sb, ppm	0.026	ND	ND	ND	ND	0.0143
Se, ppm	0.247	0.138	0.164	0.232	0.187	0.304
Tl, ppm	0.019	0.017	0.0066	0.007	ND	0.0074
V, ppm	0.059	0.067	-	0.017	-	-
Zn, ppm	0.004	ND	-	0.005	-	-
Dusting/ Particulate	ND	ND	ND	ND	ND	ND
RCRA characteristics:						
Cyanide, Reactive, ppm	ND	ND	ND	ND	ND	ND
Sulfide, Reactive, ppm	ND	0.0450	ND	ND	ND	ND
Flash Point, closed cup, °F	>145	>145	>145	>145	145	145
Corrosivity, pH (from leachate TCLP)	12.4	12.3	13.0	12.9	12.8	12.6

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5.2 72-Hour Pilot-Scale Demonstration

5.2.1 Preliminary Drum Scale Testing

Core samples from Test Drums #1, 2 and 3 (prior to the 72-hour demonstration run) were submitted for TCLP for RCRA metals analysis to determine if they were acceptable for disposal in a conventional landfill given the toxic nature of their components and failure on drums 1 and 2 to incorporate all required cement. Additionally, a 2X4 cylinder prepared from drum #3 and subsequently oven cured was submitted. The consistency of the solidified material in drums #1 and 2 remained somewhat plastic even after 28 days of cure time; however, there was not any free water present. Drum #1, which received a greater portion of the required cement, displayed a lower lead value than drum # 2 (6.7 ppm versus 605 ppm) which is consistent with laboratory results for formulas SO-D-1 and SO-D-2 in which binder content was varied. In spite of the fact that all calculated cement was not added to drums #1 and 2, and that drum #3 water content was increased during processing, analytical results indicated that all samples submitted had passed the ½ RCRA criteria. This data, in combination with the 72-hour pilot-scale trend of decreasing drum weight, wherein the binder content would have been somewhat excessive, illustrates the wide latitude in formula allowance with which an acceptable waste form may be obtained.

A practical solidification formula was established for the SO that complies with all ½ RCRA leach requirement, and produces a dry monolith exhibiting compressive strength in excess of 800 psi. The 72-hour pilot-scale formula amount of TSP was 1.5% of surrogate weight, and the Pozzolanic binder (a mix of Portland cement and flyash) was 50% of surrogate weight.

5.2.2 Drum Weight Decline over Time

Twenty-eight days after the completion of the 72-hour pilot-scale test, the #1 drums of each batch were weighed (See Table 4.2-6). The drum weights displayed a generally decreasing trend as the demonstration progressed, from a high weight of 1041 pounds on Batch 1 to 969 pounds on Batch 10. It was determined that this trend was a function of decreasing level in the surrogate tanker which exposed a greater cross section of the paddle wheel mixing blades to the atmosphere. This exposure, in concert with the gel-forming tendency of the mixture, resulted in a large quantity of air being incorporated into the surrogate, similar to the whipping of cream or egg whites. As filling the drums was controlled by level only after the first drum was used to establish a level setpoint which would provide ~600 pounds, the added volume caused by air introduction resulted in lighter loading. This anomaly would not affect a full-scale operation as waste loading into the treatment/disposal container

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is determined by load cell and required quantities of additives and binder would be calculated from a waste weight specific to each container.

5.2.3 Waste Loading Discrepancy

Following the 72-hour pilot-scale test, it was determined that the material decanted from the tanker contained approximately 25% solids versus the presumed 3-4%. Total solids analysis performed on surrogate samples taken during the demonstration indicated a solids concentration of ~29%wt solids instead of the calculated 37%wt solids. It was observed in 250 ml samples of decanted liquid that a gel had formed that would retain the shape of the container with only a few milliliters of clear liquid on the surface. Upon vigorous agitation, the gel would liquefy. Surrogate samples from the 72-hour pilot-scale test experienced the same reaction minus the clear liquid on the surface. This gelling allowed the supernatant liquid to retain high concentrations of solids thereby interfering with the ability to dewater by means of decanting. Gel formation was accelerated by the prolonged period of mixing between addition of chemicals and the 72-hour test. A high degree of gel formation was not immediately evident in samples taken during solidification of Test Drums #1 and #2, which occurred one week after chemical loading. The 72-hour pilot-scale test took place approximately 5 weeks later. Gelling would be prevented in the full-scale operation by minimizing the time that slurry in an intermediate holding tank was subject to aggressive mixing overall, low solids in the surrogate mix resulted from retention of a significant amount of material b support structures within the tanker.

5.2.4 Heat of Hydration Variability

The exothermic reaction, which takes place as cement cures, was monitored in all 22 drums that were processed in the 72-hour pilot-scale test. Generally, the peak temperatures displayed a downward trend as the demonstration progressed. The minimum peak temperature for all drums processed was 111°F (Batch 9, Drum 2) and the maximum was 161°F (Batch 4, Drum 1). The mean peak temperature for all 22 drums was 140°F. If maximum temperatures for only the first drum of each batch are averaged, a mean of 145°F is realized, having a minimum peak temperature for the sample population of 131°F (Batch 9, Drum 1). Several factors contributed to these trends.

The curing lid thermocouple penetration was located in the center of the lid, which was directly above the hollow shaft of the steel mixing blade, requiring an angular insertion into the mixture and resulted in some limited variability in the placement of the thermocouple.

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- An estimated 25 pounds of material was removed from the second drum of each batch during sampling. Typically, this left a cavity in the mix up to one foot deep on one side of the blade that may have affected the temperature profile.

In all cases, an attempt was made to place the thermocouple on the far side of the blade from the sample location (cavity) and not immediately adjacent to the blade itself. These variances are typical of those encountered in an instrumented pilot-scale test and did not significantly effect the accuracy of the modeling and scale-up as indicated by the strong correlation between the actual temperature profiles and the predictions of the analytical model (see figure 6.1-3). Selection of drums Batch 3, Drum 2 and Batch 6, Drum 2 with peak internal temperatures of 152.4 and 151.5° F for modeling provide confidence that the results are relatively conservative.

5.2.5 Summary

As was demonstrated through the laboratory testing, numerous formulas for solidification will produce durable waste forms, which exceed the requirements of FDF for stabilization of Demonstration, Silo 1 and Silo 2 surrogate material. This flexibility was verified during the 72-hour pilot-scale test and proceeding drum scale testing of formulae. Variations that occurred in the 72-hour test were not deleterious to the final outcome of the process but proved its effectiveness over a broad range of conditions.

The historically proven hallmarks of the proposed process by Chem-Nuclear Systems are its simplicity and flexibility. Simplicity of design for movement and solidification of slurry ensures reliability of the process and does not require a high level of technical expertise by operators. Maintenance requirements and system down time are also improved by maintaining a relatively low system complexity. Because all functions are conducted at (or near) ambient temperatures, radiological and physical safety of personnel, equipment and the facility is also enhanced.

6.0 Design Data

This section presents the method used for development of the full-scale facility design based on the chemical stabilization technology demonstrated under this contract. The selected method for the scale-up requires an initial definition of key parameters and assumptions that are established as a basis for the facility. Key parameters and assumptions include constraints and project requirements identified in the FDF contract document and recommendations made by the subsequent "Interface Design Basis," FDF Document 40720-DC-0001, Rev. 0 dated July 31, 1998. These requirements include product performance, regulatory requirements, safety considerations, and schedule constraints.

Utilizing this initial framework, the Process Flow Diagrams (PFDs) and primary process flow streams for the full-scale facility are based on the treatment formulations developed during bench-scale testing and the process information and mass and energy balance data developed during the pilot-scale testing. This information is presented in Section 6.1. The PFDs for the full-scale facility are introduced in Section 6.2 and discussed along with system descriptions in Section 6.4.

Conceptual General Arrangement (GA) drawings are presented in Section 6.3 to illustrate how the primary process equipment could be integrated into a functional full-scale facility. Sufficient detail is provided by the GAs to allow a general understanding of material/container flow, facility operations, space requirements, and utility requirements. Section 6.5 provides cost information on the major pieces of primary process equipment specific to CNS's demonstrated technology. Finally, Section 6.6 provides a generalized schedule for design, construction, start-up, and operation of the facility. This information is included to facilitate a more detailed evaluation, by the reviewer, of the CNS design concepts.

6.1 Scale Up

This section provides a summary of the pilot-scale test parameters which were measured and a discussion of any assumptions or areas of concern that were developed during the pilot-scale testing and the development of the full-scale facility design. Table 6.1-1 provides a summary of assumptions that were used for the full-scale facility. Table 6.1-2 provides a summary of the significant pilot-scale parameters that will be discussed individually in the following sub-sections.

The following requirements were provided by FDF for the development of the full-scale facility:

- Processing completed within three years;
- Facility operating with an availability factor of 70%;
- Maximum of 5900 lb/hr slurry feed from TTA (dry weight basis);
- Slurry received from TTA having 10 to 30 %wt solids;
- Treated waste meeting performance requirements of Contract (C.4.2.3.1);
- Process Off-gas sent to RCS meeting requirements of Contract (C.4.3.8); and,
- Wastewater to AWWT meeting requirements of Contract (C.4.3.3).

The basic approach for scale up to the final treatment facility involves a direct scaling of the slurry mass flow rates from 85-gallon drums to a final treated waste package weighing less then 21000 lbs. The full-scale facility utilizes a standard CNS container geometry and fillhead design.

Containers of treated waste are to be produced at a rate of one container per shift per process line. The facility is designed to operate two process lines, three shifts per day, seven days per week for 291 days a year. If necessary, the third process line can be run concurrently to generate 150% of the facility design capacity. This over-capacity capability, combined with the 74 non-operational days each year amply satisfy the 70% availability requirement and additionally, provide sufficient downtime for scheduled maintenance periods.

Dewatering of the received slurry is performed in the slurry settling/feed tank with decanted water recycled back to the TTA. Concentrated slurry is pumped to individual treatment containers. Dry additives are added to the containers from overhead silos in the same proportions (formulation) that were demonstrated during the pilot-scale test. Estimates of off-gas volumes and constituents are conservatively generated based on data taken during the pilot test. Other design parameters were developed using data taken during the pilot test.

The following table provides assumptions used in developing the full-scale facility/design:

Table 6.1-1 Full-Scale Facility Assumptions

Overall Assumptions	
Total slurry:	27,860,000 lb.
Waste (dry):	19,500,000 lb.
Moisture:	8,360,000 lb.
Process duration:	36 months
Plant availability:	70 %
Operational days/yr.:	291 days/year
Processing rate (dry):	22,800 lbs./operational day
Pre-Treatment	
Received slurry from TTA:	10 wt% solids
Slurry dewatered to:	37 wt% solids
Treatment	
Capacity (w/ 2 fill-heads operating)	6 containers/day
Total containers:	5,245
Waste formulation:	Demonstration Formulation
Waste loading:	25 wt% residue solids
Treated waste per container:	150 ft^3 **approx.**
Treated waste density:	105 lb/ft3

The basic approach for the mass and energy data collection was in accordance with Section 9.3 of the CNS POP Project Work Plan. Consistent with the stated approach, the information is presented as a mass and energy balance around the waste drum. The pilot-scale processing system lends itself to this approach in that the waste container around which the mass and energy are being balanced is the primary process vessel for mixing and treatment of the waste. The major exception is the decanting of water from the settled waste in the slurry feed tank. Figure 6.1-1 is a summation of the significant mass and energy flows that occur around the waste drum. This figure was originally presented as Figure 9-2 of the CNS POP Work Plan. In Figure 6.1-1, the decant water is shown on a per drum basis.

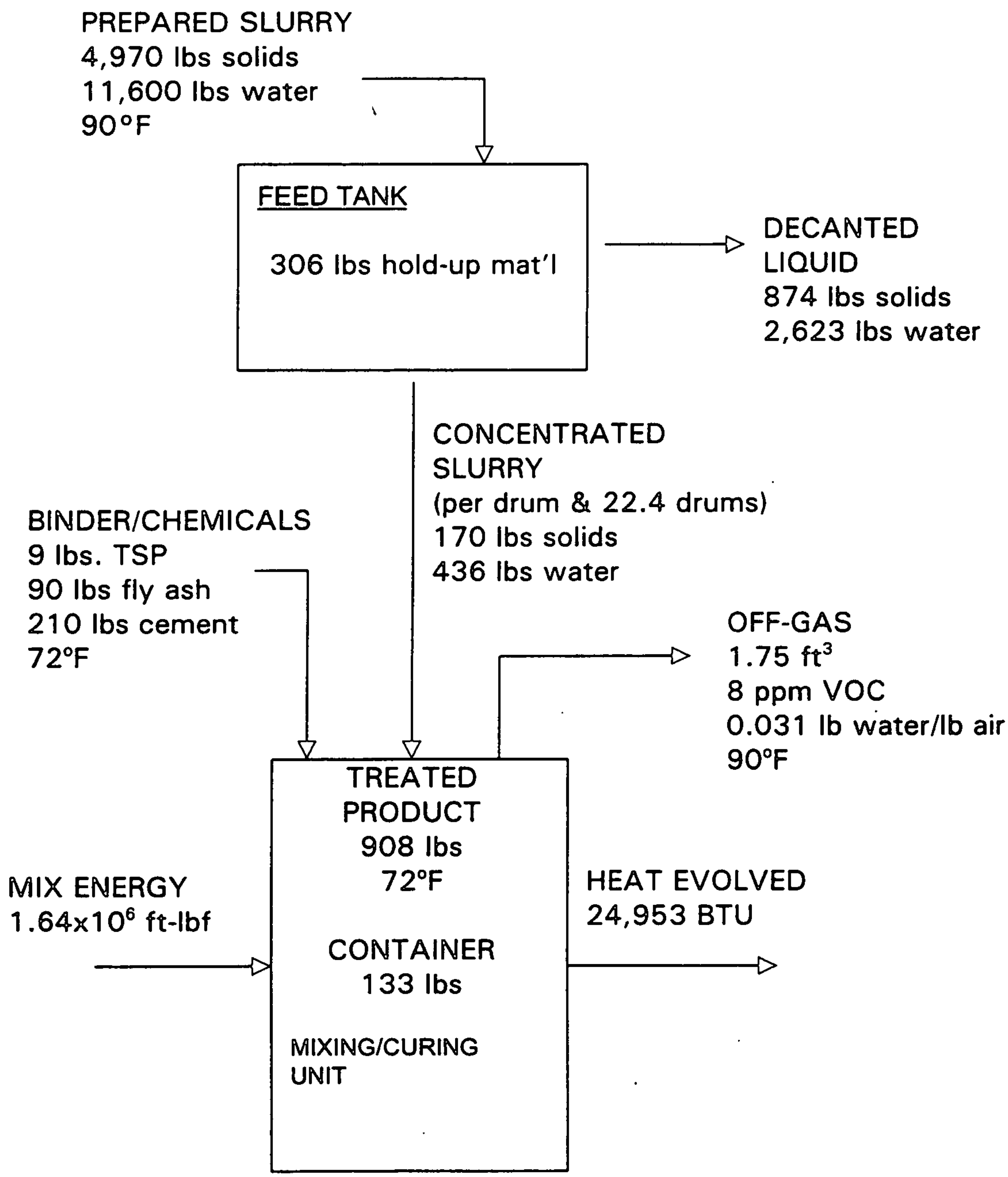

Figure 6.1-1 72-hour POP Pilot-scale Mass and Energy Balance

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Table 6.1-2 72-Hour POP-4224-R Pilot-Scale Mass and Energy Balance

POP-4224-R Demonstration		***input***					***out***				***remaining***	
Parameter	units	Surrogate Feed	TSP additive	Fly Ash additive	Cement	Mix Energy	Dewater Flow*	Off-Gas Mixer	Heat Evolved	Off-Gas Curing	Empty Container	Treated Waste
Solids	lbs/drum	170	9	90	210		39				133	908
Dry Air	cu.ft							12		1.75		
Water	lbs/drum	436					117					
Total	lbs/drum	606	9	90	210		156				133	908
Density	lb/ft3		88	55	94							89
Energy	Ft-lbf					1.64E+06						
Heat	BTU								24952			
VOCs	ppm							8		25		
Temperature	degrees F	91	72	72	72		91	90		82.4	72	72
Humidity	RH							99.9		99.9		
Notes												

* dewatering stream is listed on a per drum basis based on 22.4 drums

6.1.1 Surrogate Feed

Prior to beginning processing operations, decanting operations were performed on the surrogate slurry feed tank to simulate the decanting of the slurry settling/feed tank in the full-scale facility. For the full-scale facility a solids content of 10 to 30 percent by weight (%wt) solids will be received from the TTA. It has been demonstrated and documented that the Silo 1 and 2 residues will quickly settle out to provide a low solids content supernate and a high solids content underflow (Section 3.8 of the Final Florida International University Rheology Study [40700-RP-0005], October 1998).

To simulate a settling and decanting operation, the agitation system in the slurry storage tank was stopped and the surrogate was allowed to settle for approximately 48 hours. Approximately 3496 lbs. of liquid (supernate) were decanted from the surface of the storage tank by manually lowering a suction tube. Based on experience handling the surrogate slurry in the laboratory, this would normally yield an under flow of approximately 37 %wt solids.

The results and predictions of the pilot test and the full-scale dewatering results are provided in Table 6.1-3. For the full-scale facility the decanted liquid (at approximately 3.8 %-wt solids) will be recycled back to the TTA and reused for slurry preparation. The pilot-scale results indicate a slurry solids content of 25 %wt. The over-estimation of the settling in the slurry storage tank is attributed to the fact that the surrogate slurry had been agitating in the tank for approximately 40 days following preparation. The delay in decanting and the initiation of processing was due to the necessity of upgrading the Hydraulic Power Unit (HPU) as revealed in drum-scale testing. This, coupled with previously scheduled demonstrations of other vendors for FDF observers, required postponement of the CNS demonstration by approximately 40 days.

For the pilot-scale results, the mass balance around the tanker indicates a loss of approximately 306 lbs of solids. As noted previously in Section 3.2, this weight loss is attributed to the coarse silica material, which was held-up on the internal surfaces (structural bracing) of the tanker. The hold-up material was subsequently flushed out at the completion of processing operations. The slurry feed-settling tank for the full-scale facility will be a cone-bottomed tank without internal bracing and as such will not trap or "hold-up" material like the tanker truck.

Table 6.1-3 Slurry Dewatering

Flow	Units	Pilot-scale (tanker truck)	Full-scale (feed tank)
Initial prepared (received) Slurry	lbs solids	4,970	32,997
	lbs water	11,600	296,973
	%wt solids	30	10
Decanted Liquid	lbs solids	873	10,197
	lbs water	2,623	258,151
	%wt solids	25	3.8
Concentrated Slurry	lbs solids	3,791	22,800
	lbs water	9,748	38,822
	%wt solids	28	37
Approx. hold-up material in tanker	lbs solids	306	n/a

Following decanting, the agitation system was restarted and maintained for an additional 48 hours prior to the commencement of processing operations. The temperature of the surrogate in the feed tank remained at approximately 91°F due to the energy input from the agitation system. After one of the two agitation blades was stopped (due to the lower level of surrogate in the tank as processing progressed) the temperature decreased slightly and held at approximately 88°F.

6.1.2 Dry Additives (Tri-Sodium Phosphate, Fly ash, Portland Cement)

During the pilot-scale test, the three dry additives were weighed out individually on a calibrated scale in the quantities shown below. Use of the scale produced a high degree of accuracy and repeatability. Temperature of the dry additives was approximately 72° F and did not change significantly during the test. The basis for the additive quantities is discussed in Section 2.0 of this report.

Binder and additive quantities for the full-scale facility are scaled using the same formulation as developed for the pilot-scale test. The weights listed in Table 6.1-4 is based on 3,800 lbs. of dry waste per treatment container. Flow rates from the additive bins will be regulated to allow the addition of the TSP and fly ash in approximately 30 minutes and the Portland cement in another 30 minutes. This will allow the complete addition of dry additives within approximately 1-hour. The dry additives bins in the full scale facility are sized to provide a minimum of a two week supply of each additive between deliveries. The TSP bin significantly exceeds this requirement based on the small amount required by the formulation.

Table 6.1-4 Binder and Dry Chemical Additives

Dry Binder/Additive	Amount (%wt slurry)	units	Pilot-scale (per drum)	Full-scale (per container)
Tri-Sodium Phosphate	1.5	lbs	9	154
Type F Fly ash	15	lbs	90	1541
Type 1 Portland Cement	35	lbs	210	3595

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As discussed in Section 6.4, the full-scale plant will gravity feed binder and dry additives through a rotary air lock from overhead bins. The bins will be designed and equipped with vibrators and will have air pads in the bin cones. The air used to convey the dry additives into the storage bins when they are filled will be dried to minimize its moisture content. These two features will minimize the bridging problems encountered with the pilot-scale dry-additive feed system. Bulk powder storage and addition systems are a standard industry practice and bridging problems are unlikely with a properly designed full-scale system.

6.1.3 Mix Energy, Maximum Torque, and Maximum Power

Three parameters of interest in the scale-up process are the total mix energy imparted to the treated slurry during processing, and the maximum torque and power required during mixing. The mix energy is necessary for the overall mass and energy balance, and the maximum torque and power are necessary to scale-up the mixing equipment (both hydraulic motor and hydraulic power supply) for the full-scale facility.

Hydraulic supply pressure and mixer shaft revolutions were measured during mixing operations. Using engineering data from the hydraulic motor manufacturer these parameters were converted to shaft torque and mix energy imparted to the treated surrogate. Figure 6.1-2 provides torque and cumulative energy versus time curves for batch 1, drum 2 (B1/D2) mixing evolution. Mixer shaft speed was maintained between 70 and 80 revolutions per minute (rpm), with an average of 78.4 rpm, to ensure adequate mixing. Because shaft speed was kept relatively constant, and power is proportional to the torque-speed product, the power curve resembles a scaled version of the torque versus time curve in Figure 6.1-2.

Hydraulic supply pressure was adjusted, as required, to maintain the shaft speed. Initially 400 to 500 psi (about 30 ft-lb per foot torque) were required to maintain the mix rate from initial mixing through the addition of TSP and fly ash. The addition of the dry additives did not significantly increase the viscosity of the treated surrogate. As the cement was added to the drum, hydraulic pressure was increased to between 1,200 to 1,700 psi as the treated slurry thickened. The required hydraulic pressure was typically uniform through the final 15-minute mixing period following addition of the cement. A mean maximum torque value of 95.3 ft-lbf was calculated across all ten batches. Mean values of maximum power and total mix energy were found to be 1.423 hp and 1.64 X 10^6 ft-lbf, respectively. These values (different from Figure 6.1-2) will be used for estimating full-scale parameters.

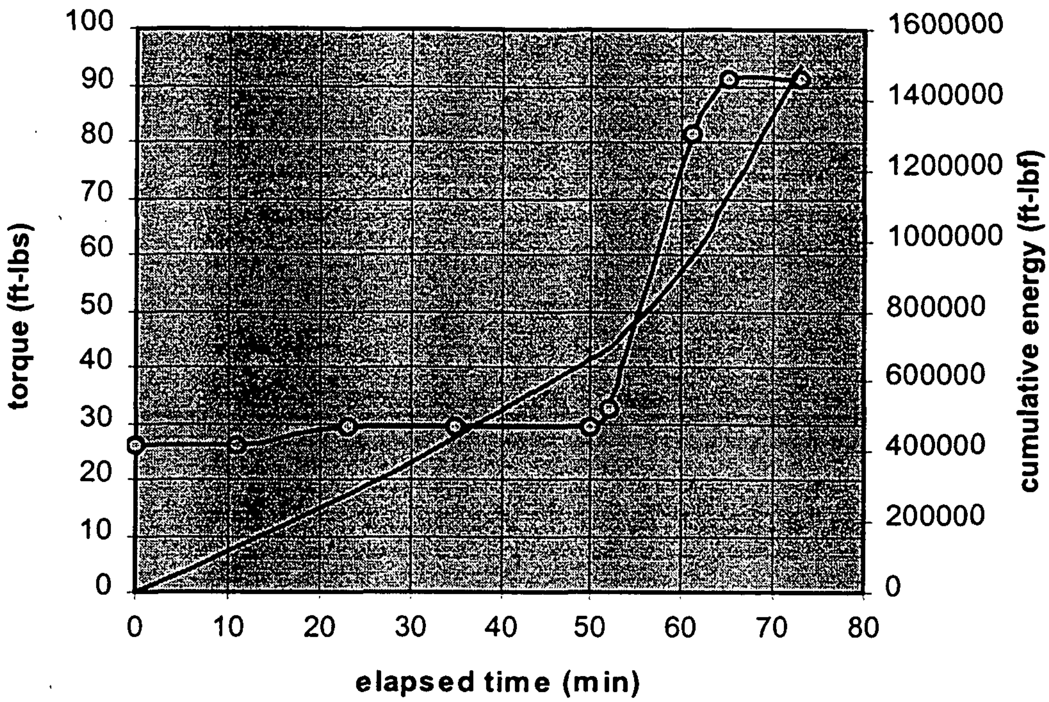

Figure 6.1-2 Mixer Torque and Energy Curves, B1/D2

Full-scale values of shaft speed and maximum torque and power were obtained by assuming that the power per unit volume should be the same for full-scale and pilot-scale operations. An expression for maximum torque, as a function of shaft speed and impeller geometry, was derived by analyzing impeller drag forces. The drag forces were expressed as a product of projected blade area, kinetic energy per unit volume, and a drag coefficient. This allowed determination of the full-scale shaft speed (64.5 rpm) that would maintain power per volume at the pilot-scale level. A maximum power for the full-scale process of 21.57 hp was obtained by multiplying pilot-scale maximum power by the ratio of liner volumes (= 15.165). A maximum torque of 1756 ft-lbf was then back-calculated from the known speed and power values.

In order to scale total mix energy, it was necessary to specify the duration of mixing. It was assumed that the full-scale process will follow approximately the same time schedule as the pilot-scale process, (30-minutes for TSP and flyash addition, 15-,minutes of mixing, 30-minutes for cement addition, and a 15-minute final mix period). This results in a 90-minute mixing period after the decanted slurry has been added. To maintain the power per volume scaling, total energy for the pilot-scale process was multiplied by the ratio of liner volumes to obtain full-scale energy imparted over the same time period yielding at total full-scale mixing energy of 2.34×10^7 ft-lbf.

Table 6.1-5 summarizes measurements and calculated results for both the pilot plant experimental data and the full-scale design. For the full-scale plant, the mixing speed (64.5 rpm) will be maintained automatically by controlling the hydraulic supply pressure. This analysis indicates that the full-scale mixing blade will impart 2.34 X 10^7 ft-lbf of energy, with a maximum torque of 1756 ft-lbf and requirement of a 21.57 hp full-scale hydraulic power unit.

Table 6.1-5 Mixer Torque and Mix Energy

Parameter	Unit	Pilot-scale	Full-scale
Average Shaft Speed	Rpm	78.4	64.5
Maximum Torque	ft-lbf	95.3	1756
Maximum Power	Hp	1.423	21.57
Total Mix Energy	ft-lbf	1.64 X 10^6	2.34 X 10^7

6.1.4 Decant Water

During the pilot-scale test, 3497 lbs of liquid were decanted from the surrogate storage tank prior to processing operations. The quantities decanted for the full-scale facility are based on settling of the received slurry to allow decanting of a 3.8 %wt supernate. This value is based on results from the bench scale testing which is consistent with the conclusions of the Final FIU Rheology Study.

As discussed previously, the settling results experienced during the pilot-scale testing are considered atypical of the normal settling characteristics of the surrogate and actual K-65 slurry. Results of the pilot-scale decant water evolution and predicted values for the full-scale facility are provided in Table 6.1-6.

Table 6.1-6 Decant Water Solids

Decant Water	Unit	Pilot-scale (per tanker)	Full-scale (settling/feed tank)
Decanted volume	Gal	398	30,622
weight of solids	Lbs	874	10,197
weight of water	Lbs	2623	258,151
Solids content of decant	%wt	25	3.8

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6.1.5 Vessel Vent System (VVS) Inputs

Additional parameters of interest for the full-scale facility are the volume and composition of the gas collected from the slurry settling/feed tank and treatment containers during operations. As each vessel is filled, a volume of gas (approximately equal to the volume of slurry added) is displaced. This gas is captured by the VVS, which maintains a slight negative pressure in the headspace in these vessels. Because the process components used for the full-scale facility are relatively airtight (use of rotary air locks for dry additives), the only significant volume of off-gas during mixing occurs during filling. The VVS collects additional off-gas when the headspace of the containers are purged prior to lifting the fillhead after mixing, and prior to removing the temporary lid following the initial cure period. Since flow from the VVS is discharged to the Radon Control System (RCS), the pilot-scale test data was evaluated to determine whether anticipated flows to the VVS during full-scale operations will exceed the limitations of the RCS.

There are four main sources that account for the majority of the contaminated (elevated radon concentrations) off-gas that must be controlled in the full-scale facility and treated by the RCS via the VVS. The major sources are listed below:

1. Off-gas displaced from slurry feed/settling tanks during filling with raw slurry from the TTA.

2. Off-gas displaced from containers during filling with decanted slurry through the fillhead.

3. Off-gas purged from container headspace prior to lifting the fillhead after mixing.

4. Off-gas purged from container headspace prior to lifting temporary lid following 14-day initial cure.

It was not possible to monitor the pilot-scale feed tank (tanker truck) during a fill operation since the slurry was created (mixed from dry additives) directly in the feed tank. The slurry feed tank headspace, however, was monitored after it had been in recirculation with both agitators running continuously for a sustained period. This generated readings of 100% relative humidity (@ 90° F) and VOC (kerosene) concentration of 50 ppm. While these conditions are considered to be typical of the average headspace conditions during the filling operation, they are assumed to approximate the maximum in the treatment container headspace at the completion of mixing, when the headspace is swept and the fillhead is removed.

During operation of the full-scale facility, the vessel ventilation system will run continuously to maintain a slightly negative pressure in the process vessels. It is assumed that some inleakage will occur in the process system. Additionally, overpurging of the container headspaces will be necessary to insure that radon concentrations have been adequately reduced in the container headspace prior to opening it up to the process room environment. When these factors are combined it can be reasonably assumed that an average of approximately 250 cubic feet per minute (cfm) of air will be drawn from the process room and combined with the four major contaminant sources listed above. This "inleakage" air flow is not anticipated to contain significant concentrations of VOCs or high humidity levels.

In order to estimate the volumetric flow rate, temperature, water content, and VOC concentration of the full-scale off-gas stream after dilution with the baseline "inleakage" stream, pilot-scale measurements were applied to the full-scale process. For a conservative estimate, it was assumed that, during filling, the full-scale slurry settling/feed tank and treatment containers would generate VOC gas concentrations equal to the maximum measured levels (8 ppm) for the pilot-scale filling operations. It was further assumed that, after mixing and before lifting the fillhead , the treatment container headspace would reach the 50 ppm maximum observed in the pilot-scale feed tank.

Estimates of radon concentrations in the four major contaminated (radon) off-gas sources were calculated based on radon emanation rate estimates (OU4FS for treated slurry, K-65 Silo, pre-bentonite emanation rates for untreated slurry).

Table 6.1-7 provides a summary of the estimated full-scale output stream conditions (VVS output stream). When the output stream values are compared to the RCS limits, it is clearly evident that even with very conservative assumptions, the VVS will not exceed the RCS limits.

Table 6.1-7 Vessel Vent System Parameters

Gas Stream (frequency at 150% design capacity)	Flow Rate (cfm)	Displaced Volume (ft^3)	VOC Conc. (ppm)	Temp. (°F)	Water/Air Mass Fraction	Radon Conc. (pCi/m^3)
Assumed inleakage to process components	250		0	70	0.0078	0
Displaced – Filling slurry feed tank (1.5 times/day)	3.184	2946	8	90	0.031	1.09×10^{10}
Displaced – Filling container w/ slurry (9 times/day)	0.955	150	8	80	0.022	2.39×10^{8}
Purged – Container after mixing (9 times/day)	0.011	1.7	50	90	0.031	1.13×10^{11}
Purged – Container after 14-day cure period (9 times/day)	0.011	1.7	50	80	0.031	1.64×10^{8}
VVS Output Stream	254.15		0.13	70.29	0.008	1.43×10^{8}
RCS Limits	<500		<40	<90	<0.022	n/a

6.1.6 Heat of Hydration

During the curing process, the heat of hydration liberated from the treated waste causes the drum internal temperature to increase significantly. This is a valuable method for monitoring the curing process. Generation of a typical peak internal temperature is a strong indication that curing is proceeding normally and that acceptable treatment performance will be achieved.

For pilot-scale tests, drums were monitored internally using a thermocouple inserted approximately 12 inches below the waste surface near the centerline of the drum. In addition, the external skin temperature of three of the drums was monitored during the curing process by an additional thermocouple taped to the outside of the drum. A numerical heat transfer model was used to estimate heat transfer parameters by matching the internal and skin temperature profiles. Figure 6.1-3 shows the comparison of modeled versus measured temperatures for Batch 3, Drum 2 and Batch 6, Drum 2. During full-scale activities TCLP Analysis on collected samples from processing containers will be performed following a 24-48 hours at ambient temperature followed by 4 to 5 days of oven cure time.

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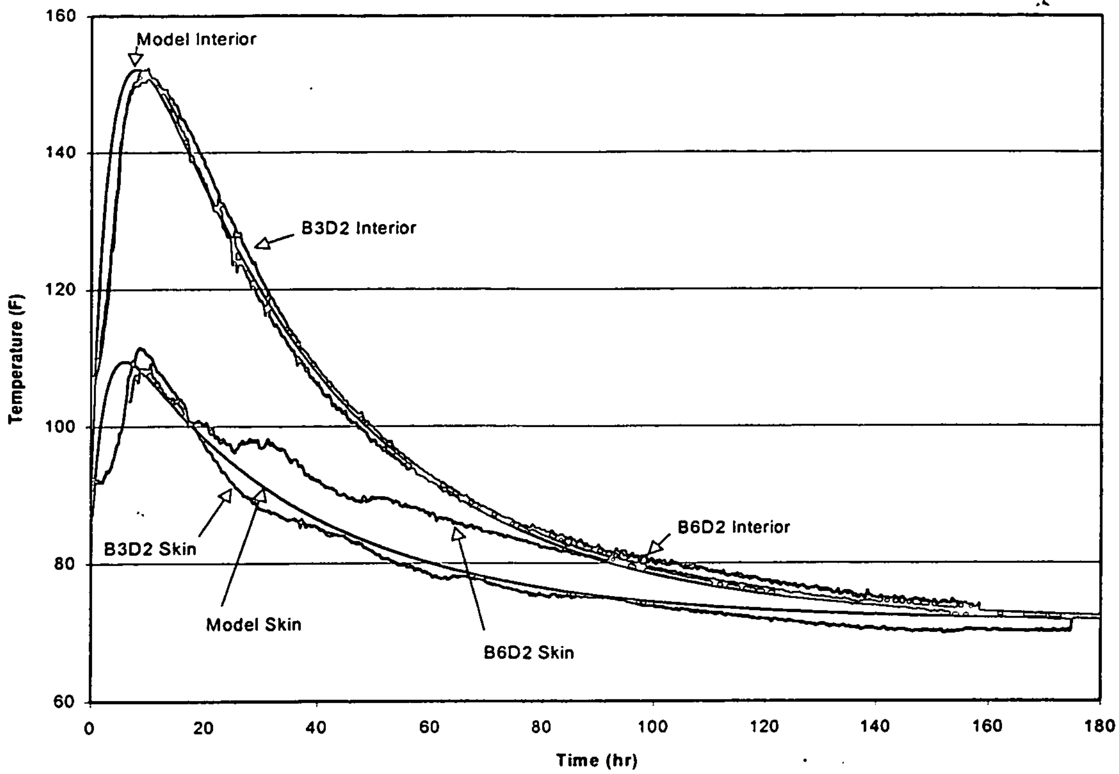

Figure 6.1-3 Modeled vs. Pilot-Scale Drum Temperatures

This heat transfer model was used to predict the heat evolved from a full-scale container and the internal temperatures for a full-scale container. Table 6.1-8 provides the energy and temperature values for full- and pilot-scale model predictions. A relatively small amount of initial enthalpy is available for dissipation over the curing period. The "enthalpy dissipated" entry in the table reflects the estimated portion of the initial enthalpy that is released by the end of the curing period, and the remainder is reported under "enthalpy remaining".

Table 6.1-8 Temperature and Energy Values during Curing Periods

Parameter	Units	Pilot-scale	Full-scale
Peak internal temperature	°F	152	158
Enthalpy Remaining	BTU	496	28,000
Enthalpy Dissipated	BTU	5,210	58,600
Heat of Hydration	BTU	19,740	299,300
Total heat evolved	BTU	24,950	357,900

Figure 6.1-4 shows the predicted curing temperatures for a full-scale liner at points in the center and on the skin of the cylinder. Due to the greatly increased thermal mass and reduced surface-to-volume ratio, the temperature reaches higher levels and remains elevated longer than the pilot-scale drums.

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The 14-day initial cure period for the treated containers is based on preventing major temperature cycles (freezing) until the majority of the curing reaction is complete. Although the curing reaction (hydration) for cement continues over an extended period of time, it can be seen in Figure 6.4-4 that the significant portion of the reaction is complete with approximately 330 hours (14 days) of initial treatment. This is evidenced by a return to near-ambient temperature in the curing container.

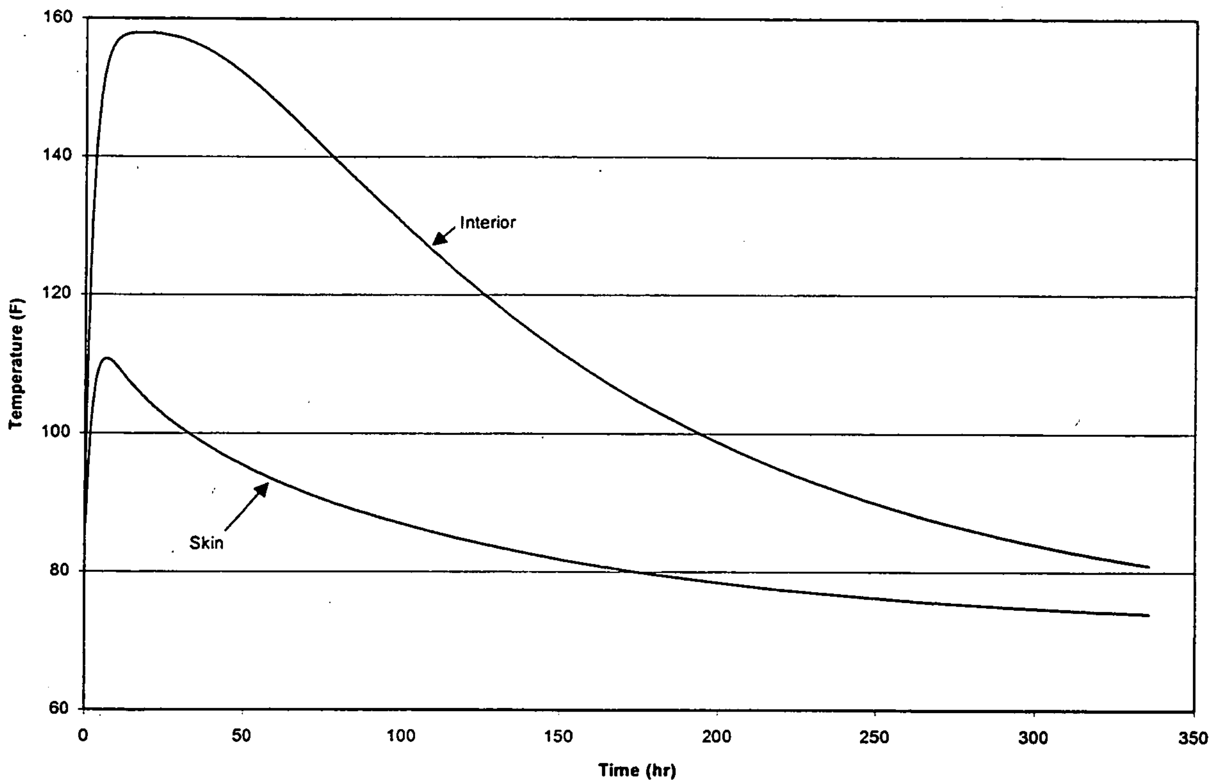

Figure 6.1-4 Predicted Curing Temperatures for Full-Scale Container

6.1.7 Curing Off-Gas

During the curing process, the gasses within the drum/container headspace expand due to the increasing internal temperature caused by the heat of hydration of the cement. During full-scale operations, a small volume of these expanding gasses will be released by the temporary container lid into the curing room atmosphere.

During the pilot-scale test, measurements from the headspace of the treated drums were monitored to gain an indication of the quantity of VOCs that might be released to the full-scale curing room. The modeled temperature profile of the full-scale container was also used to estimate the volume of gas which would be released and the time period (and rates) over which it would be released. An estimate of the radon concentration of this gas was calculated by taking into account the build-up, decay, and release mechanisms in the container headspace during this time. These calculations are included in Appendix E. The results are presented in Table 6.1-9 and are discussed below.

The quantity of radon released from the full-scale containers is dependent on the degree of expansion of the headspace gases. Because the radon concentration builds over time due to radon release from the stabilized waste, the quantity of radon released from the container is also dependent on length of time that the expansion takes place. As shown in Figure 6.1-4 the skin (headspace) temperature of the container will reach a predicted maximum temperature of 110° F within approximately 7 hours of being filled with treated waste. During this time approximately 1.3 cu. ft. of gas containing 5.18×10^5 pCi of radon will be released, through the temporary container lid into the curing room, as the headspace gas expands. Based on 6 containers being added to the curing room per 24 hours, a total of 3.11×10^{-6} Ci of radon will be released to the curing room on a daily basis.

This release rate will result in radon concentration levels in the curing room substantially less than 4 pCi/L. These radon concentrations pose no threat to human health and require no additional controls (either engineered or administrative) to be placed on personnel entering the curing room. The curing room air can be discharged through the HEPA-filtered building ventilation system without additional treatment and will have an insignificant impact on radon concentration limits at the site fenceline (0.5 pCi/L yearly average). VOC content and humidity released to the curing room are also insignificant concerns.

Table 6.1-9 Curing Room Off-Gas

Parameter	units	Pilot-scale (per drum)	Full-scale (per container)
Headspace Volume	ft^3	1.75	17.7
Volume released *	ft^3	0.13	1.3
Humidity	lb. H_2O/lb dry air	.031	.031
Total VOC	ppm kerosene	200	200
Radon**	Ci	N/A	5.18×10^{-7}

*Predicted based on headspace expansion due to temperature increase
** Based on a source term of 1300 pCi/m^2/sec (FEMP-OU4FS, Feb 94, Fig. H.3-15)

6.1.8 Empty Containers

The treatment containers used for the pilot-scale testing were standard 85-gallon waste drums. Each drum had an internal mixing blade mounted on a simple bearing (see description in Section 6.1.3 above) in the bottom of the drum. The mixing blades are a scaled version of commercial mixing blade which Chem-Nuclear Services uses during standard stabilization operations. The hydraulic motor mounted on the fillhead provides the upper bearing surface for the mixing blade. After treatment and mixing operations, the mixing blade is left in place and disposed of along with the treated waste. All drums were weighed prior to filling for input to the mass and energy balance data. Including the drum, mixing blade, lid, and bolt ring, the median empty drum weight was 133 lb.

A description of the full-scale container is provided in Section 6.4. Drawing L150-FS provides a sketch typical of the full-scale container and mixing blade arrangement. Dimensions and volumes of both the pilot- and full-scale containers are provided in Table 6.1-10.

Table 6.1-10 Container Dimensions

Parameter	Units	Pilot-scale	Full-scale
Total Volume	ft^3	11.7	167
Usable Waste Volume	ft^3	10.5	150
Inside Diameter	inches	26	74.5
Height	inches	38	66
Container Wall Thickness	Gauge/inch	16 GA	¾"
Total Weight (w/ blade)	lbs	133	5,350

6.1.9 Treated Waste

Analytical data and performance results for the treated surrogate were presented and discussed previously in Sections 4.0 and 5.0. For the purposes of the mass and energy balance data, the weights and density of the cured treated surrogate are presented in Table 6.1-11 below.

Table 6.1-11 Treated Waste Density

Parameter	Units	Pilot-scale	Full-scale
Volume	ft^3	10.2	150
Weight	lbs	908	15,560
Density	lbs/ft^3	89.4	105

6.2 Process Flow Diagrams (PFD) Heat/Energy and Material Balances

The PFDs are provided in Appendix A. PFDs are provided for the six main process systems developed for the conceptual full-scale facility. Additionally, a Mechanical Flow Diagram is provided in Appendix A to illustrate the container handling and movement process. 53

PF-001	Slurry Feed System
PF-002	Binder/Additives System
PF-003	Treatment System
PF-004	Ventilation System
MF-001	Product Process and Handling

6.3 Facility Arrangement Drawings

The arrangement of the full-scale facility is presented on four arrangement drawings listed below and attached in this section. Drawing GA-001 presents the layout of the overall facility and an overview of the major facility areas. Within that facility, two arrangement drawings (GA-002 and 003) are provided of the process area (plan and elevation views) and plan views are provided of the curing area, inspection/rework area, and staging area (GA-004, 005, 006). General Arrangement drawings of the full-scale facility are provided in Appendix A. This section provides details on the process layout design and general information on other portions of the facility.

GA-001	Facility Layout
GA-002	Process Area – Plan
GA-003	Process Area – Elevation
GA-004	Curing Area
GA-005	Inspection / Rework Area
GA-006	Staging Area

Facility Layout
The overall facility is shown on drawing GA-001; the facility will be located at the FEMP east of the proposed TTA and South of the Vitrification Pilot Plant on the south side of the K-65 Pipe Trench. Major areas within the facility include the Main Process Building, Curing Area, Inspection Area, and Staging Area. The main process room is located adjacent to the TTA in order to minimize piping runs for slurry transfer. The remaining areas are arranged to optimize container handling within in the facility.

Main Process Building
The major processing activities are accomplished in the main process building. The building is shown on GA-002, GA-003 and GA-005. The building is comprised of six main rooms described below. The inspection area is discussed in later subsections.

Tank Room
The tank room is shown in plan view on GA-002 and in elevation on GA-003. The tank room is approximately 26' wide and 102' long and contains four slurry settling/feed tanks and the decant water tank. These tanks comprise the major process vessels of the full-scale facility. The tops of the settling/feed tanks extend to the ceiling of the tank room such that the top opening and agitator motor can be accessed from an external room located on, and shielded by, the roof of the tank room. Isolation valves to the connections at the tank's upper nozzles are operated from the external

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room using long stem actuators. The tank room is curbed to provide secondary containment and has an integral sump which is pumped to the decant water tank. Access to the tank room is through an airlock located on the southern wall of the room above curb height. The tank room will be a high radiation area (RAZ 5) during operations when the feed tanks are full. The tank room is maintained at a slightly negative pressure and ventilated by the building ventilation system and can be ventilated by the emergency radon control system if necessary.

Pump Room

The pump room is approximately 15' wide and 90' long. It contains the four slurry pumps, two recycle water pumps, and the four hydraulic power supplies that power the hydraulic motors in the fillheads and the decontamination booth pump.

The slurry and recycle pumps are located in pump pits (niches) that consist of a reinforced concrete enclosure with a removable top section. The pump pits provide shielding for the pumps and valves during operation. This arrangement minimizes personnel exposure during operations and maintenance. In addition to the slurry pump, each pump pit contains manual isolation valves that are operated by using long stem actuators. Slurry piping within the pump room is located in shielded concrete pipe runs.

An overhead bridge crane provides access to the pump pits by lifting the top section of the containment. The bridge crane is also used to lift and position equipment to be removed from the pump room using equipment dollies. Personnel access to the pump room is provided by an airlock located on the southern wall. Personnel entrances to the process room are elevated to allow the process room foundations and sump system to serve as secondary containment in the event to spill or pipe failure.

The shielded pump pits and shielded pipe runs in the tank room allow it to be maintained as a RAZ 2 radiation area during operations and RAZ 1 or 2 following system shutdown and flushing. The room will generally be maintained radiologically "clean" although it will be posted as a surface contamination control area. Individual contamination control areas would be established at each pump pit during any required maintenance. The pump pits are designed to facilitate decontamination following maintenance with each pit draining to the tank room sump. The pump room is maintained at a slightly negative pressure and ventilated by the building ventilation system. If necessary, the pump room can be ventilated by the emergency radon control system.

Process Room

The processing room is approximately 26' wide and 100' long and contains three process lines. Full-scale design capacity (100%) is based on operation of two (out of three) process lines with the third line maintained in a stand-by condition. If necessary, all three-process lines

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can be operated simultaneously. In this case the facility will be operating at 150% of design capacity. Each process line is comprised of a filling station and a lidding station located along one of the three indexing conveyors. A transfer conveyor runs the length of the room and provides the main throughput of waste containers. The fillhead and the lidding equipment are mounted on an upper "mezzanine" level over the index conveyors. The heads are lowered through openings in the mezzanine floor to engage the containers. The mezzanine provides shielding to personnel entering the process room to access the fill and lidding equipment.

Empty waste containers are placed on the transfer conveyor and conveyed into process room through the south container air lock. Each container is moved onto an indexing conveyor that positions the container under the fill and lidding stations. Mechanical stops are provided to position the container properly under the fill-head and lidding station. The filled, mixed, sampled, and lidded container is returned to the transfer conveyor and exits the room through the northern container air lock after passing through the decontamination booth.

A bridge crane located near the ceiling in the process room can be used for removing and installing equipment for maintenance or repair and has sufficient capacity to lift a full waste container. Personnel access to the process room is provided by an elevated airlock located on the southern wall.

The process room will be a radiation area (RAZ 4) during operations when filled containers are present. The process room is maintained at a slightly negative pressure and ventilated by the building ventilation system. It can also be ventilated by the emergency radon control system if necessary.

Control Room

The control room, located adjacent to the process room, houses the control systems for both waste treatment operations and container handling systems. Major component operations and evolutions for the facility are supervised and controlled from the control room. Critical process and control systems have an uninterruptable power supply. In addition to the video monitoring and systems instrumentation, the control room has windows looking into the process room.

Responsibility in the control room is split between a waste treatment operator and a container management operator. The waste treatment operator is responsible for operation of the slurry feed, dry additives, fill and mixing stations, and air cleaning systems. The container management operator is responsible for supervising the movement and control of waste containers, including inspection, monitoring, and rework activities.

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<u>HVAC Room</u>
The mechanical equipment room is located in the main process building. Ventilation of the main process building and curing room will be controlled by HVAC supply systems and a HEPA-filtered exhaust system. The HVAC supply systems provide a conditioned source of fresh air to the facility and is comprised of standard components. The supply systems are not discussed in this report. The building exhaust system draws air from the process building rooms, passes it through HEPA filters and discharges it through a monitored stack. A basic diagram of the exhaust system is presented in Drawing PF-004. The building exhaust system includes back-up HEPA filter housings and fans for system redundancy and flexibility. Based on the conceptual nature of the process facility, specific equipment size and flow data is not provided for this equipment and it is shown on PF-004 to illustrate it's interrelationship with the Emergency Radon Control System.

The Emergency Radon Control System (ERCS) is normally maintained in a stand-by condition and has no function during normal operating conditions. During upset or casualty conditions that may release high concentrations of radon gasses to a process room, that process room will be isolated from the regular building exhaust system and the ERCS will be placed on service to provide an alternate discharge path for that area.

The ERCS consists of a HEPA filter housing, two carbon adsorption beds and a discharge blower. These components are shown on Drawing PF-004. Either or both carbon beds can be placed on service for a total of 4,000 cfm of HEPA-filtered and radon treated exhaust. The carbon beds are located behind shield walls next to the inspection area. The ERCS discharges to the regular building monitored exhaust stack.

<u>Electrical Room</u>
The electrical room is located in the main process building and houses the main electrical switch gear, motor control centers for the facility, and the uninterruptable power supply for the control room and key process components. Electrical power (480V, 3-phase) is provided from a pad mounted transformer (13.2 Kv/480V) located outside and adjacent to the stabilization facility. The facility would also require a back-up source of electrical power (e.g. diesel generator located outside) to allow a safe shutdown of the facility following an extended loss of site power.

<u>Curing Area</u>
Filled disposal containers are transported to, and held in, the curing area during the first 14 days of the curing process. The curing area provides a controlled environment that prevents the containers from experiencing freeze cycles, which could disrupt the curing process. As shown in Figure 6.1-4, the curing process is largely complete following initial 330 hours or approximately 14 days. The curing area (shown on Drawing GA-004) has overall dimensions of approximately 166' long and 123' wide and is constructed of 2-foot thick concrete walls to provide shielding for the waste containers.

The curing area provides 130 spaces for storage in a 10 by 13, single container height, block arrangement. The containers are positioned with one foot of clearance on all four sides. Although the curing room will normally only hold approximately 84 containers (6 containers x 14 days), sufficient area is provided to allow extended operations with all three process lines operating which would require 126 spaces (9 containers x 14 days). Inspection and viewing of the curing area is conducted through the use of a closed circuit TV camera and lighting mounted on the bridge crane.

An overhead bridge crane runs the length of the curing area. The crane has a standard CNS container grapple device that allows the crane to reliably and safety lift and position the containers. The grapple is currently being used on several other CNS stabilization projects that use this type of disposal container. The grapple/crane picks up each treated waste container from the process room conveyor at the start of the 14-day cycle and then moves it to the inspection area conveyor at the completion of the 14-day cycle. The curing room grapple is operated remotely from the control room or locally in the curing room if necessary. CNS Drawing C-121-D-0041 provides details on the CNS container grapple.

A 25-foot aisle is provided between the shield walls and the outside of the container block to maintain radiation requirements outside the shield wall. Although all container movement is normally by crane, labyrinth entrances are provided to allow forklift and personnel entrance and access to the containers, in an emergency, via the 25-foot aisles.

Radon detectors and monitors within the facility will provide real-time alarm of radon levels in the curing room. The curing room will be a high radiation area (RAZ 5) during operations when filled containers are present. The curing room is maintained at a slightly negative pressure and ventilated by the building ventilation system. It can also be ventilated by the emergency radon control system if necessary.

<u>Overpacking Area</u>

As shown on GA-004, a dedicated area within the curing room is reserved to handle treated waste that fails TCLP performance or compressive strength requirements. The failed containers (FDF requires an assumed 1% failure rate) will be over-packed and macro-encapsulated prior to shipment from the site. Macro-encapsulation is regulatory compliant under the debris rule (40 CFR 268). This process generates a final package that is safe for handling and protective of the environment. Additionally, macro-encapsulation significantly reduces the radiological and mechanical complexities that would be associated with size-reduction and reprocessing. Size reduction would involve complex expensive remotely controlled systems that generate significant air quality control challenges (particulate dust and radon releases as well as ALARA considerations for maintenance and up-keep of the equipment.

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In the overpacking area, a failed container is placed into an over-pack container (standard CNS 210 cu ft concrete liner) and the annulus between the containers is filled with grout. The grout is mixed and pumped using standard commercial cement equipment located in the crane maintenance area. The overpacked container is then relocated to the staging area for eventual loading and shipment.

Inspection and Monitoring Area

After performance test results are received for a particular batch of treated waste and after the initial 14-day cure cycle, the containers are moved to the inspection area. In the inspection area, each container is purged to remove the radon laden gas that has built-up in the headspace during curing. This is accomplished by drawing the headspace gasses through the HEPA cartridge while opening the inlet port to allow clean air to enter the headspace and displace the built-up radon gas. The radon gas is captured by the VVS.

After purging, the temporary lid is removed. The temporary lids are collected and reused in the process. The surface of the treated waste is then inspected via closed circuit camera for uniformity and the presence of free liquid. An absorbent material (binder consisting of dry Portland cement powder and flyash) is added to the interior of the container and the container is sealed (air-tight) by crimping a permanent lid in place. These activities are conducted remotely.

After the lid is sealed, the container is moved into the final monitoring and decontamination position. Here, the exterior of the container is again monitored for radioactive contamination and, if necessary, the exterior is cleaned. The cleaned, sealed, treated waste container is then moved through an airlock and along a conveyor into the staging area.

The inspection area will be a radiation area (RAZ 4) during operations when filled containers are present. The inspection area is maintained at a slightly negative pressure and ventilated by the building ventilation system. It can also be ventilated by the emergency radon control system if necessary.

Staging Area

Once a container is inspected and sealed for final disposal, it is placed in the staging area for approximately 20 days to complete curing and await final shipment. The staging area (shown on Drawing GA-006) has overall dimensions of approximately 217' long and 136' wide and is located on a prepared pad with roof and weather protection (rubb building or equivalent). The staging area is located immediately south of the curing room (shown on drawing GA-001) such that the east curing room wall eliminates the need for movable concrete shield walls along the northern side of the staging area.

The staging area provides 140 storage spaces in a 10 by 14, single container height, block arrangement. The containers are positioned with

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one foot of clearance on all four sides. Inspection and viewing of the staging area is conducted through the use of a closed circuit TV camera mounted on a bridge crane. The staging pad is shielded by 2-foot thick movable concrete partitions. Although all container movement is normally by crane, labyrinth entrances are provided to allow forklift and personnel entrance and access to the containers, in an emergency, via the 25-foot aisles. The 25-foot aisle space between the containers and the shield walls also contributes to a shielding geometry, which will maintain exterior radiation levels consistent with continuous occupancy.

The crane has a standard CNS container grapple device that allows the crane to reliably and safely lift and position the containers. The grapple/crane picks up the treated waste containers from the inspection room conveyor and positions them on the storage pad.

The truck loading area is located on the north end of the staging area. Two disposal containers, approximately 21000 lbs each, will be loaded by crane/grapple and secured onto a transporter for final shipment. The average shipment rate will be six containers per day to maintain facility throughput. Six containers could be handled/loaded during a single shift with additional shipments loaded during a second shift if necessary to support a more dynamic shipping schedule. The bridge crane/grapple is operated remotely from the control room or locally from the truck loading area. The truck loading area also serves as a crane maintenance or repair area.

6.4 System Design Descriptions

Slurry Feed System

The Slurry Feed System (shown on PF-001) receives slurry from the TTA and dewaters it prior to feeding it through one of the fillheads and into waste containers for treatment.

For the full-scale facility, a total of four feed tanks will be available to dewater the slurry and feed concentrated slurry to the fillheads. During normal operations two of these tanks will be providing concentrated slurry to the two operational process lines (fillheads) to support processing operations. A third feed tank will be filled, settled, and decanted over a 24-hour period in preparation for being placed on service. The fourth feed tank is maintained in a stand-by condition.

A single slurry settling/feed tank will supply concentrated slurry to a fill-head process line in operation. Handling and transport of high solids slurries requires design specialized equipment to insure that settling of solids will not shutdown the process. Shutdowns are costly in terms of the time and effort necessary to clear clogs and restart the system. The cost of a specialized tank to perform these functions is less expensive than a more complex system with multiple process vessels and much higher risks with regard to unplanned shutdowns. Since Silos 1 and 2 residues settle quickly, and because the decant water will be recycled to

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the Tank Transfer Area (TTA) for additional processing, dewatering will occur in a settling/feed tank. "Bento Grout ™" retained in the decant water will not significantly degrade the use of that water for further slurrying operations at the TTA.

The four slurry settling/feed tanks are located in the tank room. Each tank is a 22,000-gallon cylindrical cone-bottomed tank with an internal agitator. Slurry from the TTA, is received into one settling/feed tank at a time. After filling, the settling/feed tank is agitated and sampled. Tank agitation is suspended for approximately 24 hours to allow the slurry to settle. The supernate is decanted from the settling/feed tank to the decant water tank in order to achieve a desired increase in solids content of the remaining slurry. Supernate will be removed from the slurry tank using one of several decant ports located at various heights near the top of the tank. Decant port selection is based on an analysis of the actual received slurry content in the tank prior to settling. The selected port is placed on line remotely from the control room.

The settling/feed tanks are sized to hold sufficient slurry for a single process line (fillhead) for a 24-hour period (6 containers) based on 10%wt solids slurry from the TTA. During actual operations it is expected that a higher solids content slurry will be received, allowing each slurry settling/feed tank to be on service for approximately four days (12 containers from one process line). Each tank is maintained at a slight negative pressure by the VVS. The negative pressure insures the collection of any off-gas displaced from the tank during filling. Vented air is removed through the vessel vent header to the RCS.

The decant tank is a large cylindrical tank with a sloped bottom. It has a capacity of 32,000 gallons and is provided with two recycle water pumps which allow recirculation through the decant tank and discharge back to the TTA. AT the completion of the project, excess recycle water will be stabilized per this process or pre-treated and sent to the wastewater treatment system.

Following dewatering, the settling/feed tank contents are re-agitated and sampled to verify the increased solids content. In addition to the agitation system, slurry pumps are used to provide additional mixing through the recirculation line. The slurry recirculation line runs from the bottom of each settling/feed tank through the slurry pump and is returned to the tank through a nozzle located near the top of the settling/feed tank.

There are four slurry pumps located in individual pump pits in the pump room. The slurry pumps are air-operated double diaphragm pumps with a capacity of 110 gpm. One pump is provided for each settling/feed tank with redundant piping that allows each slurry pump to pump from either of two-slurry feed/settling tanks.

The slurry piping is made of carbon steel and utilizes large radius bends to minimize pressure drops during slurry transport. The piping runs will be designed to minimize hold-up points and low flow or low pressure disturbances. The piping run diameters are sizing to maintain adequate slurry velocity during both recirculation and container filling operations such that solids do not settle out of the slurry. Alternate recirculation line connections for settling/feed tanks allow them to be recirculated and supplied to either of two fillheads for additional flexibility.

Each recirculation line passes through the wall into the adjoining processing room. Inside the processing room, a discharge line taps off the recirculation line to provide slurry flow to its respective fillhead. The discharge line is controlled via a remotely operated discharge valve that directs flow from the recirculation line into the fillhead when it is opened. After a fill operation, residue slurry in the discharge line is blown out of the discharge line (into the fillhead) with air from a compressed air connection on the downstream side of the discharge valve.

Once it has been started, following a dewatering operation, the slurry pump continues to recirculate slurry until the settling/feed tank is taken off line for refilling. Prior to stopping the slurry pump, the recirculation line is flushed with recycle water.

Binder and Additives System

The binder and additives system (shown on PF-002) provides for the receipt, storage, and metering of cement and additives into the fillhead.

Portland cement, tri-sodium phosphate and flyash are stored in a three-compartment silo with double wall partitions. Material is pneumatically transported into these bins from a truck loading station located at grade outside the facility. The bins themselves are located on the roof of the processing area. Each bin is sized for approximately two weeks of processing operations. The bins are industry standard carbon steel silos equipped with vibrators and air pads.

Each bin feeds its respective material to the additive manifold through a remotely operated slide gate and a rotary air lock. The rotary air lock is interlocked to the load cells under the waste containers to allow precise metering of additives. For the TSP bin, a loss-of-weight feeder is located between the TSP rotary airlock and the additive manifold. The feeder, consists of a small intermediate, bin with a screw feeder mounted on a load cell that is used to precisely measure the smaller weights of TSP required for the treatment formulation. The additive manifold combines the metered flow individually (and sequentially) from each of the three separate material bins and allows the paths to be directed to any of the three dry additives feed lines by selecting and opening the appropriate slide gate. The three dry material feed lines enter the process room and empty into their respective fillheads.

Without the need for batching equipment (other than the separate feeder for TSP), the dry material bins can be located directly over the fillheads. With the use of load cells under the treatment vessel, the dry materials 62 can be metered with adequate precision and controlled directly into the treatment vessel. A simplified dry bulk material handling system greatly reduces capital costs, enhances reliability, and reduces the physical size of the facility.

Waste Container

The waste container is a cylindrical container fabricated of 3/4-inch carbon steel. Drawing L150-FS provides a typical CNS steel container design of the type and dimensions that would be used for the full-scale plant. The container will be designed and constructed to meet DOT 7A, Type A requirements. The container will also meet the Nevada Test Site burial requirements. The container has an internal diameter of 74.5" and an internal height of 66". The top of the container is accessed through a lipped opening, similar to and identical in size to the top of a standard 55-gallon drum. The container has an internal mixing blade that is optimized to maximize the mixing effect when the hydraulic motor is engaged. The full-scale blade is mounted on a bottom-bearing surface that has an integral blade-retaining device that prevents the blade from being lifted from the container when the fillhead is removed. The container (with blade) has an empty weight of approximately 5350 lbs and a usable volume of 150 Ft^3. When the container is full, it will have a gross weight of just less than 21000 lbs. Radiation levels external to a filled container will be less than 70 millirem per hour.

Fill Station

The main component of the treatment system is the fillhead. The fillhead allows a controlled and monitored interface with the waste container during filling and processing operations. A standard CNS fillhead of the type envisioned for the full-scale plant is shown on CNS Drawing C-313-E-0041. The fillheads are mounted above each of the fill stations on the mezzanine level in the process room.

Once a container has been moved into the proper position on the index conveyor, the fillhead is hydraulically lowered (remote, semi-automatic) onto the empty container. The fillhead provides a positive seal to the waste container and mates the hydraulic motor with the container mixing blade. These and the subsequent operations can be viewed remotely through the fillhead camera. The container is then filled with slurry from the slurry discharge line, which is operated automatically and interlocked with the load cells located under the waste container. The discharge line is blown down with compressed air (into the container) and the hydraulic motor is engaged to begin mixing the slurry.

After an initial mixing period, dry additives are added via the dry additives feed line. First TSP, then Fly ash, and finally Portland cement is metered into the container. These additions are measured and controlled using load cells mounted under the indexing conveyor (loss-of-weight feeder for TSP). The hydraulic power unit is operated and adjusted automatically by the control system to maintain the mixing rate during and following the addition of dry additives. Flush nozzles in the fillhead provide for flushing and cleaning of the fillhead skirt, camera, and light lens.

During filling and mixing operations, a vent line attached to the vessel vent header maintains the container headspace at a slightly negative pressure. A sampling probe collects a small volume of wet treated waste for performance and quality assurance testing. When mixing is complete, a bleed valve in the fillhead is remotely operated to allow air to be pulled through the head space of the container. This removes (or sweeps) any radon gas that has built-up during the mixing process. Once the headspace has been flushed, the fillhead is lifted from the container and the container is indexed to the lidding and sampling station. Preventive maintenance on the fillheads (replace lightbulbs, cameras, etc.) can be performed at times when there are no filled containers in the process room. In the event that a fillhead needs to be replaced, the module can be quickly replaced by a new unit and the old unit is removed from the process room for repair.

Lidding Station

The lidding station is located immediately adjacent to the filling station on the indexing conveyor. The remotely operated lidding head is mounted above the mezzanine floor in a manner similar to the fillhead. The lidding head is hydraulically lowered over the top of the container and a temporary curing lid is placed over the top of the container.

The temporary lid is constructed of ¾-inch steel plate. A small lip (skirt) on the under side of the lid centers it over the container opening and a latching device provide positive restraint on the container. A rubber gasket on the lid provides a sealing surface with the container. A relief port on the top of the lid prevents the pressurization of the container during the heating cycling of the curing process by releasing headspace gases through a HEPA filter cartridge. An additional inlet port (with integral check valve) on the top of the lid allows external air to enter the container during purging prior to inspection and removal of the temporary lid.

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Decontamination Booth

The full container is then passed back onto the transfer conveyor where it is transported to the decontamination booth. Although not considered part of the primary process-line. The decontamination booth provides a valuable house keeping and radiological control capability. It is used, as necessary, to remove any gross surface contamination, which may have resulted from the filling, mixing, and temporary lidding operation. Additionally, the spray booth provides a means to perform preliminary decontamination on equipment or materials removed from the process area for repair or disposal.

The decontamination booth is a standard commercial cleaning booth which uses high pressure water jets to clean and rinse the exterior of the container and ensures that the containers do not retain any radioactive material on their external surfaces. The decontamination system consists of a high-pressure spray booth through which the containers or equipment are passed. The inside of the spray booth has a series of high-pressure spray nozzles that direct decontamination fluid across all surfaces of the container. Decontamination fluid is collected in the bottom of the spray enclosure and recycled back to a decontamination tank for storage. A decontamination pump (located in the pump room) provides the high-pressure water supply. The decontamination solution will be primarily water (available on-site). Water used for decontamination will be treated using ion exchange beds (commercially available), then recycled to be used again for decontamination.

Vessel Vent System

The Vessel Vent System is comprised of process ventilation ductwork that allows the collection and control of specific process off-gasses within the full-scale facility that contain high concentrations of radon. Drawing PF-004 shows the basic inputs to the VVS. The four major source types are listed and described in Section 6.1.5. The VVS discharges to the RCS and relies on the RCS fans for the negative pressure to insure containment and initiate off-gas flow. The major process vessels (slurry feed/settling tanks) will be continuously connected to the VVS while the lines specific to the fillheads and inspection area will be placed on-line (through the actuation of remotely operated dampers) at selected intervals during operations. Continued operation of the VVS system is a critical to the safe operations of the facility and the monitoring and system controls are powered through the uninterruptable control room power supply.

6.5 Priced Equipment List

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Table 6.5-1 provides a priced equipment list of the major pieces of equipment for the systems described by this report, which are unique to the full-scale facility presented by this report.

6.6 Schedule for Full-scale Facility

Appendix D provides a top level schedule for design, construction, operation, and shutdown of the full-scale facility developed in this report.

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Table 6.5-1 Chemical Stabilization – Other Equipment List

QTY	NAME	EQUIP_ID	CAPACITY	PHYSICAL SIZE	MAT'L	POWER	COMMENT
4	Slurry Settling/Feed Tank	15-TK-001-4	22,000 gal	15 ' dia. by 24 ' OAL high	CS	25 Hp	45° Cone bottom w/ agitator & level alarms
4	Slurry Feed Pump	15-PM-001-4	110 gpm, 45 psi		SST	5 Hp	Air operated, Double Diaphragm
1	Decant Water Tank	15-TK-005	32,000 gal	16 ' dia by 24 ' OAL high	CS		Flat Bottomed.
2	Recycle Water Pump	15-PM-005A&B	100gpm, 70feet		Cast iron	5 Hp	Centrifugal, water flush seals, 1000 ppm
4	Slurry Tank Agitator	15-AG-001-4	45 RPM	219" shaft	SS	15 Hp	219" long, 4-inch diam. 316SS shaft with two impellers.
1	Process Control System	N/A	N/A	N/A	N/A	N/A	PLC system with video mimic process and parameter display
1	Dry Additives Storage Bin and Additive Manifold	44-BN-001	6,422 cf	11 by 33 ' wide by 45 ' high	CS	5 Hp	Bag house, level alarms, vibrator, and air pad in cone section.
1	TSP Loss-of Weight Feeder	44-BN-002	5 cf	15 by 15 by 15 inches tall	SST	½ Hp	Loss-of weight feeder with 5 cf hopper and platform scale.
100	Temporary Lids	N/A	N/A	¾' thick, 22 ½" diameter	CS	N/A	
5245	Waste Container	82-VE-001	150 cf	6' dia by 5'6" high	CS	N/A	Steel vessel with integral mixing blade and lid.
2	Container Grapple	N/A	24,000 lbs.	71" x 38" x 36" (Lxwxh)	CS	24 Volts	Used to pick up waste containers
55	Overpack Container	N/A	210 cf	100" OD x 107" H	Concrete	N/A	Concrete Cylandrical Container
2	Adsorpant Addition and Container Lid Crimping Tool	N/A	N/A	Not Available	CS	N/A	Used to add adsorption material and crimp the lid on the container permanently
3	Solidification Fillhead	82-ME-001-3	N/A	3' dia by 4' high	various	NA	Includes camera, lights, hydraulic motor, tach, and level ind.
3	Lidding Station	82-LE-001-3		3' dia by 4' high	various	NA	Attaches 55 gal lid to filled container.
3	Hydraulic Power Unit – Fillhead	82-HP-001-3	3,000 psi	5ft x 3ft x 4ft (LxWxH)	NA	40 Hp	

NA = Not Applicable

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TABLE 6.6-1 - START-UP COST COMPONENTS

TYPE	COMPONENT	QUANTITIY	COST INFO
Consumables	Portland Cement	9.2 tons	$ 80 per ton plus trans.
	Flyash	4.0 tons	$ 22 per ton plus trans.
	TSP	0.4 tons	$325 per ton plus trans.
	HEPA Filters	4 months, 12 filters/month	use FDF cost
Technical Support	Project Manager	1 FTE for 6 months	$ 82/hr.
	Shift Supervisor	4 FTE for 4 months	$ 56/hr.
	Quality Assurance	1 FTE for 4 months	$ 48/hr.
	Engineers	2 FTE for 6 months	$ 80/hr.
	Operator	1 FTE for 6 months (including class & field training)	$ 51/hr.
Energy Usage (Utilities)	Electrical	1,000 KVA feed, 10,800 kW-hr/day	use FDF cost
	Potable Water	400 gpd	use FDF cost
Other Costs	PPE		$1,000 per day
	Trailer Rental	(2) 12' by 60' trailers	$ 1,200 installation each $ 350 per month each
Labor	Operator	2 per shift, 3 shifts/24 hrs.	Use labor union rates
	Laborer	6 for the day shift 3 for the other two shifts	Use labor union rates
	Radiological Tech	1 per shift, 3 shifts/24 hrs.	Use labor union rates
	Maintenance	1 per shift, 3 shifts/24 hrs.	Use labor union rates

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TABLE 6.6-2 - OPERATING COST COMPONENTS

TYPE	COMPONENT	QUANTITY	COST INFO
Consumables	Portland Cement	2,370 tons	$ 80 per ton plus trans.
	Flyash	1,015 tons	$ 22 per ton plus trans.
	TSP	102 tons	$325 per ton plus trans.
	HEPA Filters	12 Filters per month	use FDF cost
Equipment (expected lifetime)	Slurry Pump	1 spare	Provided in the Report
	Fillhead Assy	1 spare	Provided in the Report
	Feed Tank Agitator	1 spare	Provided in the Report
	Container Grapple	1 spare	Provided in the Report
	Hydraulic Power Unit	1 spare	Provided in Report
Spare Parts and Special Tools	Slurry Pump Internals	6 per year	$75
	Fill Head Camera	1 per year	$1,500
	Fillhead Lights	1 per month	$5
	Fillhead Level Detector	1 per year	$1,200
Technical Support	Project Manager	1 FTE for 30 months	$ 82/hr.
	Shift Supervisor	4 FTE for 30 months	$ 56/hr.
	Quality Assurance	1 FTE for 30 months	$ 48/hr.
Energy Usage (Utilities)	Electrical	1,000 KVA feed, 10,800 kW-hr/day	use FDF cost
	Potable Water	400 gpd	use FDF cost
Other Costs	PPE		$ 1,000 per day
	Trailer Rental	(2) 12' by 60' trailers	$ 350 per month each
Labor	Operator	2 per shift, 3 shifts/24 hrs.	Use labor union rates
	Laborer	6 for the day shift 3 for the other two shifts	Use labor union rates
	Radiological Tech	1 per shift, 3 shifts/24 hrs.	Use labor union rates
	Maintenance	1 per shift, 3 shifts/24 hrs.	Use labor union rates

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7.0 Conclusions

This demonstration proved the ability of the CNS stabilization/solidification chemistry and process equipment in treating the Fernald Silos 1 and 2 surrogate materials to meet all regulatory, processing, storage, transportation, and disposal requirements. Bench-scale testing was used to develop six recommended treatment formulae. The pilot-scale testing proved the reliability of CNS's unique full-scale processes and equipment. This testing also generated the data required for scale-up and costing for key components of a full-scale treatment facility. The following sections present the conclusions drawn from this testing program.

Bench-Scale Formula Development

Bench-scale tests were used to optimize treatment recipes to meet ½ RCRA TC and the RCRA UTS for metals. Recipes were optimized considering factors such as workability, waste loading, leach performance, and compressive strength. As a result of the testing, the six recommended treatment recipes were developed. The treatment recipes and data relative to their performance are provided in Table 7-1.

Table 7 - 1 Recommended Treatment Formulas

Formula/Description	SO-D /Demo ½ RCRA	SO-U /Demo UTS	S1-T /Silo #1 ½ RCRA	S1-U /Silo #1 UTS	S2-T /Silo #2 ½ RCRA	S2-U /Silo #2 UTS
Developmental Designation	SO-D-7B (Pilot-Scale)	SO-U-6A	S1-T-5B	S1-T-3B	S2-T-4B	S2-T-3B
Initial surrogate (parts)	100	100	100	100	100	100
Dry solids (parts)	30	30	30	30	30	30
Decant Liquid (parts)	21	21	19	19	0	0
Residue Solidified (parts)	79	79	81	81	100	100
TSP(parts)	1.17	1.96	2.43	2.43	3.0	3.0
Flyash (parts)	11.9	21.7	0	9.5	0	9.6
Portland Cement (parts)	27.6	50.7	28.6	22.3	28.6	22.5
Solid Surrogate Form (parts)	119.7	153.4	112.0	115.2	131.6	135.1
Waste Loading, %	25.1	19.6	26.8	26.0	22.8	22.2
Compressive strength (psi)	816	2310	408	212	408	87
TCLP results:						
Hg, ppm	ND	ND	ND	ND	ND	ND
Ag, ppm	ND	ND	ND	0.002	-	-
As, ppm	0.070	ND	ND	ND	0.016	0.038
Ba, ppm	0.160	0.159	0.06	0.061	0.068	0.066
Be, ppm	ND	ND	ND	ND	ND	0.0006
Cd, ppm	ND	ND	ND	ND	ND	ND
Cr, ppm	1.710	0.377	0.296	0.196	0.563	0.360
Ni, ppm	0.003	ND	ND	ND	ND	ND
Pb, ppm	0.043	ND	0.0107	0.014	ND	0.072
Sb, ppm	0.026	ND	ND	ND	ND	0.0143
Se, ppm	0.247	0.138	0.164	0.232	0.187	0.304
Tl, ppm	0.019	0.017	0.0066	0.007	ND	0.0074
V, ppm	0.059	0.067	-	0.017	-	-
Zn, ppm	0.004	ND	-	0.005	-	-
Dusting/ Particulate	ND	ND	ND	ND	ND	ND
RCRA characteristics:						
Cyanide, Reactive, ppm	ND	ND	ND	ND	ND	ND
Sulfide, Reactive, ppm	ND	0.0450	ND	ND	ND	ND
Flash Point, closed cup, °F	>145	>145	>145	>145	145	145
Corrosivity, pH (from leachate TCLP)	12.4	12.3	13.0	12.9	12.8	12.6

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Pilot-Scale Testing

In accordance with the CNS workplan, a 72-hour pilot-scale demonstration test was performed. The test began at 10:00 am on January 25, 1999, and was completed at 10:00 am on January 28, 1999. During that period, CNS processed twenty-two 85-gallon drums (13,070 lbs.) of surrogate slurry in ten total batches. The results of that processing indicate that the CNS technology for stabilization/solidification may be successfully applied to treat the Fernald Silos 1 and 2 wastes. Analytical results for samples taken from treated product of the pilot-scale test unequivocally proved that all regulatory, processing, storage, transportation, and disposal requirements for the final waste forms were satisfied by the CNS method of treatment.

The pilot-scale test also allowed CNS to demonstrate the application of the key processing components that are unique to CNS's standard solidification processing methodology; specifically, the use of a single vessel for both treatment and disposal of waste. This concept allows a significant simplification of the more standard batch-oriented processing arrangement. The fillhead, which is the central treatment component in the processing system, is comprised of standard industrial grade components in a package that is easily replaced for repair or extended maintenance. The integral mixing blade in the treatment/disposal container is optimally designed for the container and its one-time use eliminates potentially costly delays for maintenance which could be expected with a batch plant.

Table 7-2 provides a tabular summary of the performance obtained during the pilot-scale testing:

Table 7-2 Pilot-scale Solidification Performance

Parameter	Result
Equipment operation duration	72 hours
CNS equipment down time	0 hours
Availability of CNS equipment	100%
Amount of Surrogate Slurry Treated	13,070 lbs.
Number of 85-gallon Drums Processed	22
Median net weight of processed drums	862 lbs
Median net waste loading of drums	23.4%
Median compressive strength	1256 psi
Median TCLP result for Lead	0.0073 ppm
Median TCLP result for Chromium	0.703 ppm

Design Data for a full-scale Treatment Facility

Pilot-scale testing simulated operation of key processes and equipment central to the CNS technology. Data collected during the pilot-scale test was used to support preliminary design of a full-scale facility. This information is provided in Section 6.1. Specifically, the pilot-scale data was used to evaluate the following:

- Mix energy, maximum torque and maximum power requirements for a full-scale fillhead/mixing container arrangement.

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- Heat evolved during the curing of the treated product to evaluate HVAC requirements on the full-scale plant.
- Off-gas treatment requirements associated with a full-scale facility and the potential impact to the RCS due to off-gas temperature, VOCs, and humidity.

Data developed during the pilot-scale test was combined with design criteria and site requirements to generate conceptual design elements for a full-scale facility at the FEMP.

Process Flow Diagrams and system descriptions (Section 6.4) were developed for the main process line to allow a complete understanding of the proposed process. Equipment data sheets with cost data have been developed for unique primary process equipment. This work concluded that the full-scale facility could be designed with significantly less process equipment than a more typical batch plant. The required process equipment is of a relatively simple design and amenable to remote monitoring, control, and handling of containers.

The most complex piece of equipment, the fillhead, is still relatively simple in comparison with other processes; and, it is small enough to be quickly replaced for repair or extended maintenance outside of radiation fields with a minimum disruption to processing operations. Other simplifications in the process equipment include a dry additives system, which feeds directly to the fillheads, eliminating the need for batching stations, intermediate bins, and other complex material transfer systems. The slurry settling and feed system also utilizes a single vessel for both settling and feed operations, thus reducing the number of times which slurry must be moved and handled. The process system is provided with sufficient redundancy and flexibility that when repairs are required, they are accomplished with minimal impact on facility operations.

General Arrangement drawings and descriptive text (Section 6.3) of the processing and material handling areas were also developed to provide perspective to the overall size and arrangement of a functional full-scale facility. The main processing area is divided into three separate rooms to provide greater control over contamination, air quality, and the radiation fields resulting from multiple sources. The slurry feed pumps are located in individual pump pits to provide additional shielding and allow maintenance personnel to enter the room during processing operations. The slurry settling/feed tank agitators are also accessible from outside radiation shielded areas to allow maintenance on them without disrupting processing operations.

The overall facility arrangement allows for the smooth transfer of containers from one functional area to the next. Once an empty container is loaded into the processing room, it is handled remotely until it leaves the facility. This allows a significant reduction in the amount of personnel exposure required to operate the facility. The use of bridge cranes and a standard CNS grapple device allows the secure and safe positioning of treated waste containers.
Operations are controlled from a central control room using monitoring equipment, closed circuit TVs, and direct observation through viewing windows. Finally, an overall schedule for design, construction, and operation of the full-scale facility was developed (Section 6.5) which shows that the facility can be 73

designed and constructed within the constraints of the existing site remediation schedule.

Reliability and safety aspects of the process are enhanced by operating at ambient temperatures and pressure. Wear and degradation of mechanical subsystems and electrically powered monitoring instrumentation is minimized by a low temperature operating environment. Additionally, due to the simplicity and the inherently safe operational characteristics of the system, personnel do not require a high level of expertise or extraordinary vigilance to guarantee the safe and successful solidification of silo waste material.

The conceptual design elements developed in this report will allow FDF to generate a detailed cost estimate for the "Chemical Treatment – Other" option which (with the use of common auxiliary facilities and equipment) can be compared and evaluated as a complete package against the other treatment options being evaluated for remediation of the Silos 1 and 2 residues.

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APPENDIX A

DRAWINGS

(23 PAGES)
(These documents are not available electronically. Please go to Document Control for a hard copy.)

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List of drawings associated with this section

L150-FS	full-scale Container (modified L14-195)
C-313-D-2792	85 Gallon Solidification Fillhead
C-313-B-2791	POP Drum Mixer Blade
C-121-D-0041	Battery Powered Remote Controlled Liner Grapple
GA-001	Facility Layout
GA-002	Process Area – Plan
GA-003	Process Area – Elevation
GA-004	Curing Area
GA-005	Inspection / Rework Area
GA-006	Staging Area
MF-001	Container Handling/Processing
PF-001	Slurry Feed System
PF-002	Binder/Additives System
PF-003	Treatment System
PF-004	Ventilation Systems

PROCESSING/DISPOSAL CONTAINER

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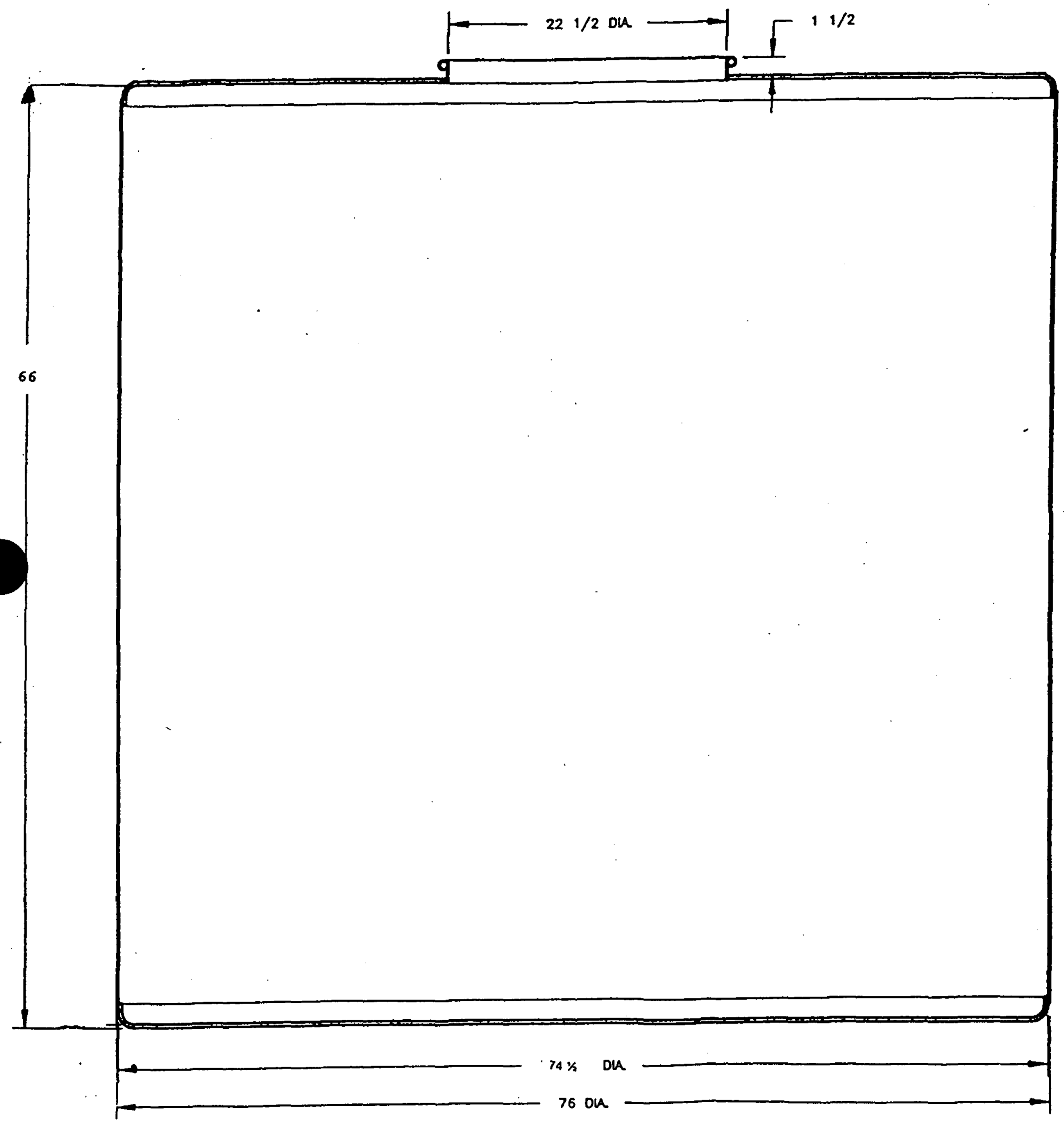
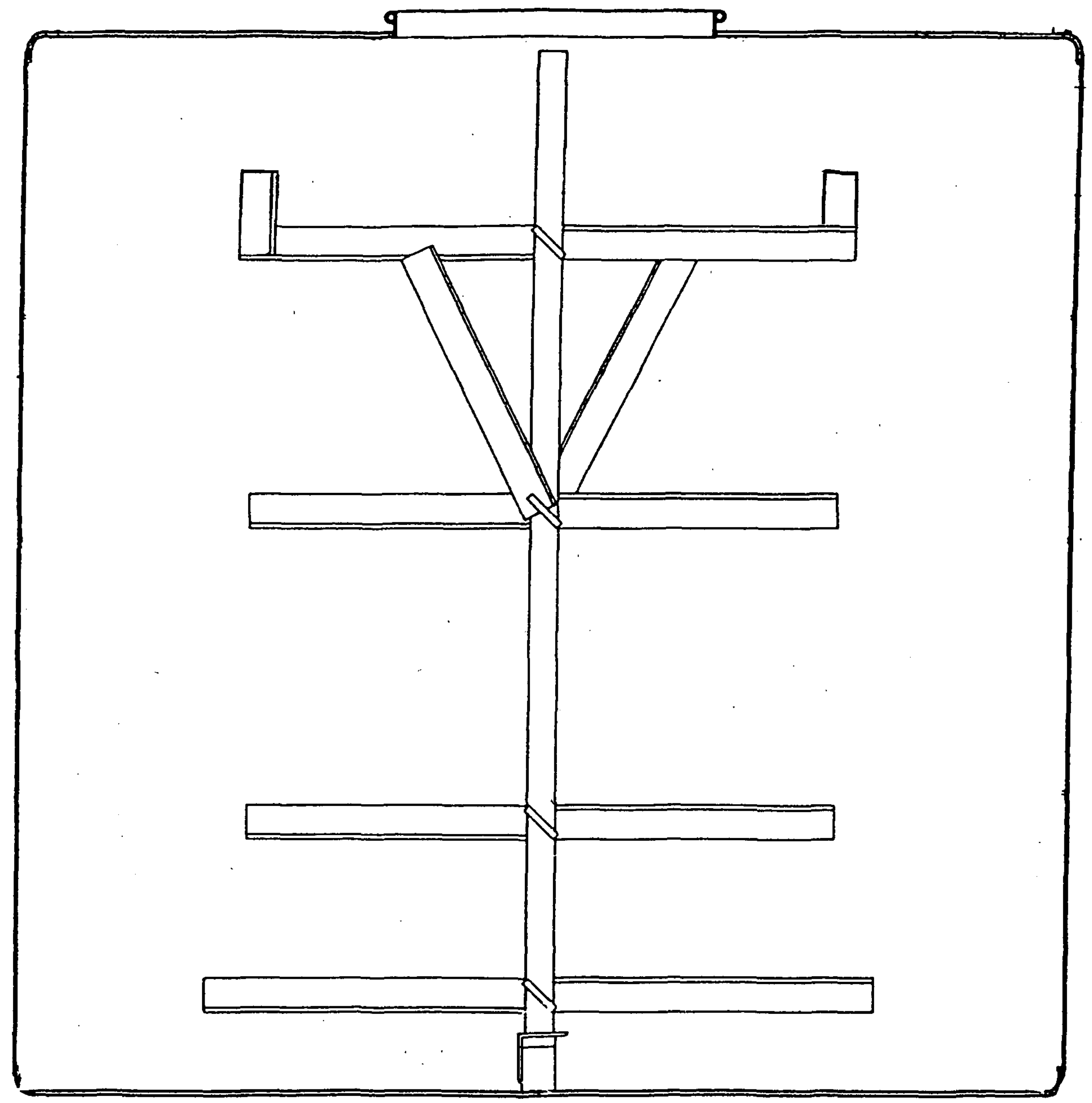


LINER (#C-120-D-0095)



LINER (#C-120-D-0095)
MIXER BLADE (#C-313-D-1000)

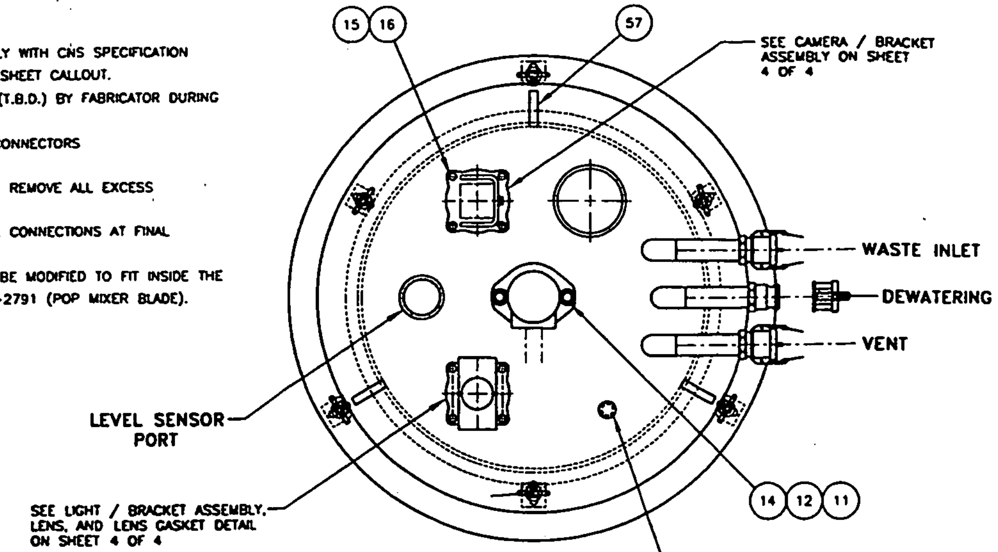
Note: Not to scale

L150-FS

NOTE:

1. FABRICATION, INSPECTION, TESTING AND ACCEPTANCE SHALL COMPLY WITH CNS SPECIFICATION ES-E-031 AND ITS RELATED DATA SHEET. SEE P. O. FOR DATA SHEET CALLOUT.
2. ATTACHMENT OF ITEM 3 AND 7 INSIDE DRUM TO BE DETERMINED (T.B.D.) BY FABRICATOR DURING ASSEMBLY.

   CAM-TYPE CONNECTORS SHALL PROPERLY MATE AND SEAL WITH CONNECTORS MANUFACTURED TO MIL C-27487.
4. USE PIPE THREAD SEALANT ON ALL THREADED PIPE CONNECTIONS, REMOVE ALL EXCESS SEALANT AFTER FINAL ASSEMBLY.
   USE PVC. CLEANER/PRIMER AND TRANSITION CEMENT ON ALL PVC. CONNECTIONS AT FINAL ASSEMBLY.
5. ITEM 45 (MIXER BLADE DRIVE SHAFT) SQUARE END OF SHAFT TO BE MODIFIED TO FIT INSIDE THE 2" SQUARE TUBING WITH 1/4" WALL ON CNS DRAWING C-313-B-2791 (POP MIXER BLADE).
6. REMOVE HEX HEAD PRIOR TO ASSEMBLY.



PLAN VIEW

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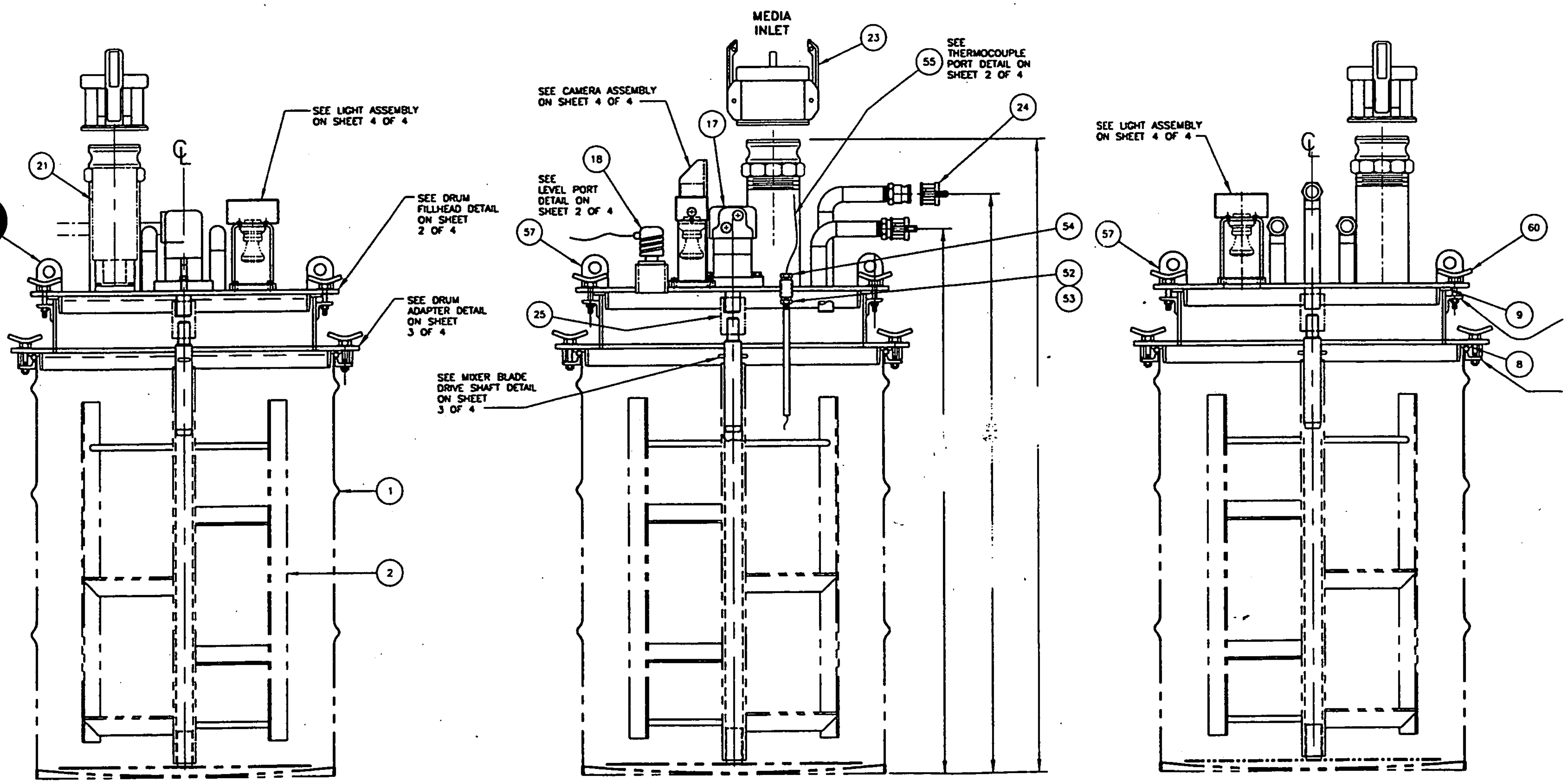

REAR ELEVATION
SOME ITEMS NOT SHOWN FOR CLARITY

SIDE ELEVATION

ASSEMBLY CUTAWAY

FRONT ELEVATION
SOME ITEMS NOT SHOWN FOR CLARITY

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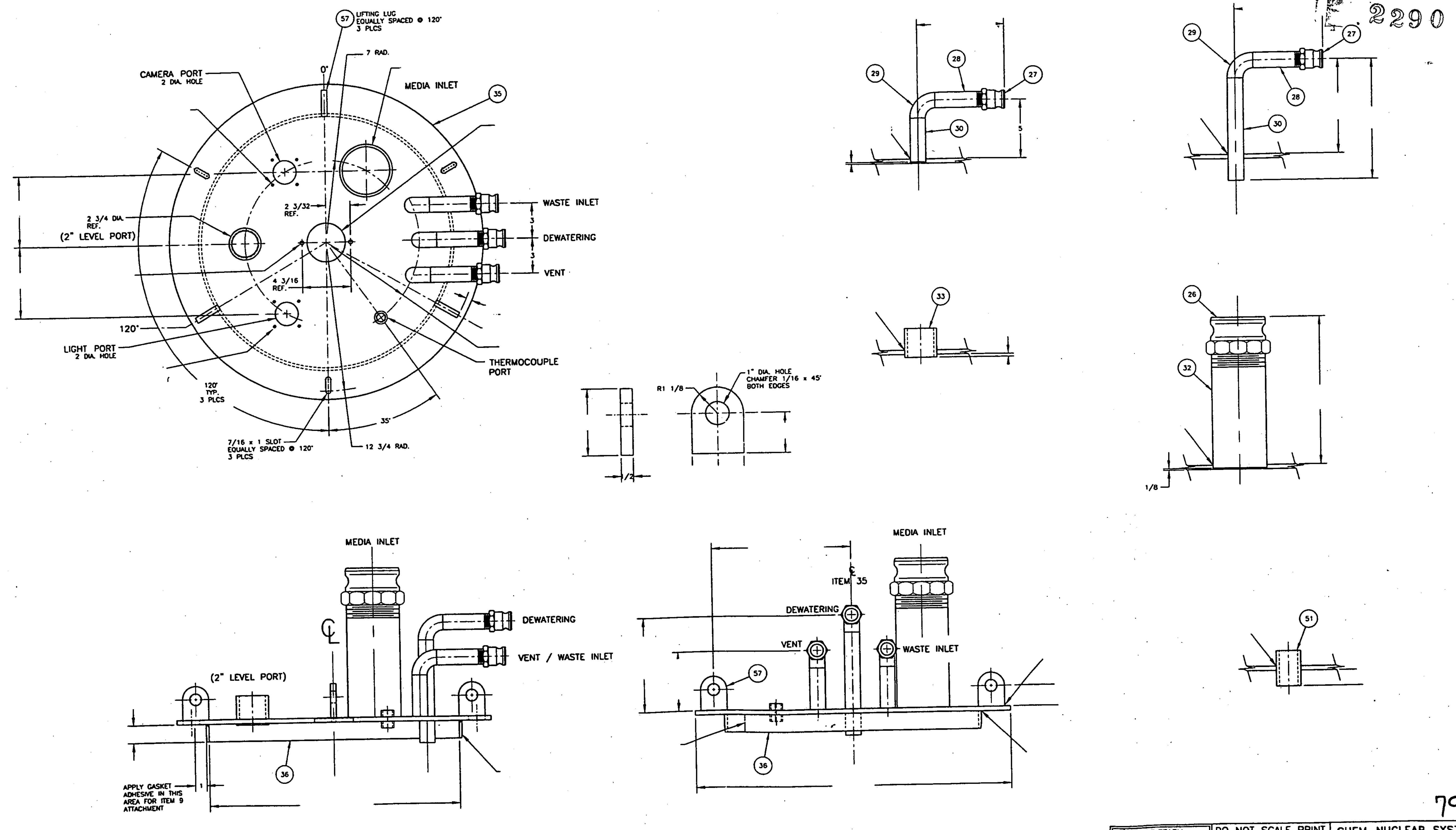
BILL OF MATERIALS

☐ PROPRIETARY ☒ NON-PROPRIETARY	DO NOT SCALE PRINT DIMENSIONS ARE IN INCHES UNLESS NOTED	CHEM-NUCLEAR SYSTEMS
FSCM No. 54643	PROJECT No. 46692 / FILE ID. 10890102 REVIEWERS OF ORIGINAL (REV. 0)	85 GALLON SOLIDIFICATION FILLHEAD
THIS DRAWING IS THE PROPERTY OF CHEM-NUCLEAR SYSTEMS IT IS LOANED UPON THE CONDITION THAT IT IS NOT TO BE REPRODUCED, COPIED OR LOANED TO OTHERS WITHOUT WRITTEN PERMISSION OF CHEM-NUCLEAR SYSTEMS AND IS TO BE RETURNED UPON REQUEST.	DRAWN BY P. PREVATTE 9/1/98 CHECKED BY L. KEAN 9/2/98 ENGINEER CARL MCGOVERN 9/2/98	SIZE D / DRAWING NUMBER C-313-D-2792 / REV. 2 SCALE 1:8 / WT. N / A / SHEET 1 OF 4



FILLHEAD DETAILS

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PROPRIETARY / ☒ NON-PROPRIETARY	DO NOT SCALE PRINT — DIMENSIONS ARE IN INCHES UNLESS NOTED	CHEM-NUCLEAR SYSTEMS
FSCM No. 54643	REVIEWERS OF ORIGINAL (REV. 0)	85 GALLON SOLIDIFICATION FILLHEAD
THIS DRAWING IS THE PROPERTY OF CHEM-NUCLEAR SYSTEMS ... CHEM-NUCLEAR SYSTEMS	DRAWN BY P. PREVATTE 9/1/98; CHECKED BY L. KEAN 9/2/98; ENGINEER CARL MCGOVERN 9/2/98	SIZE D — C-313-D-2792 — REV. 2

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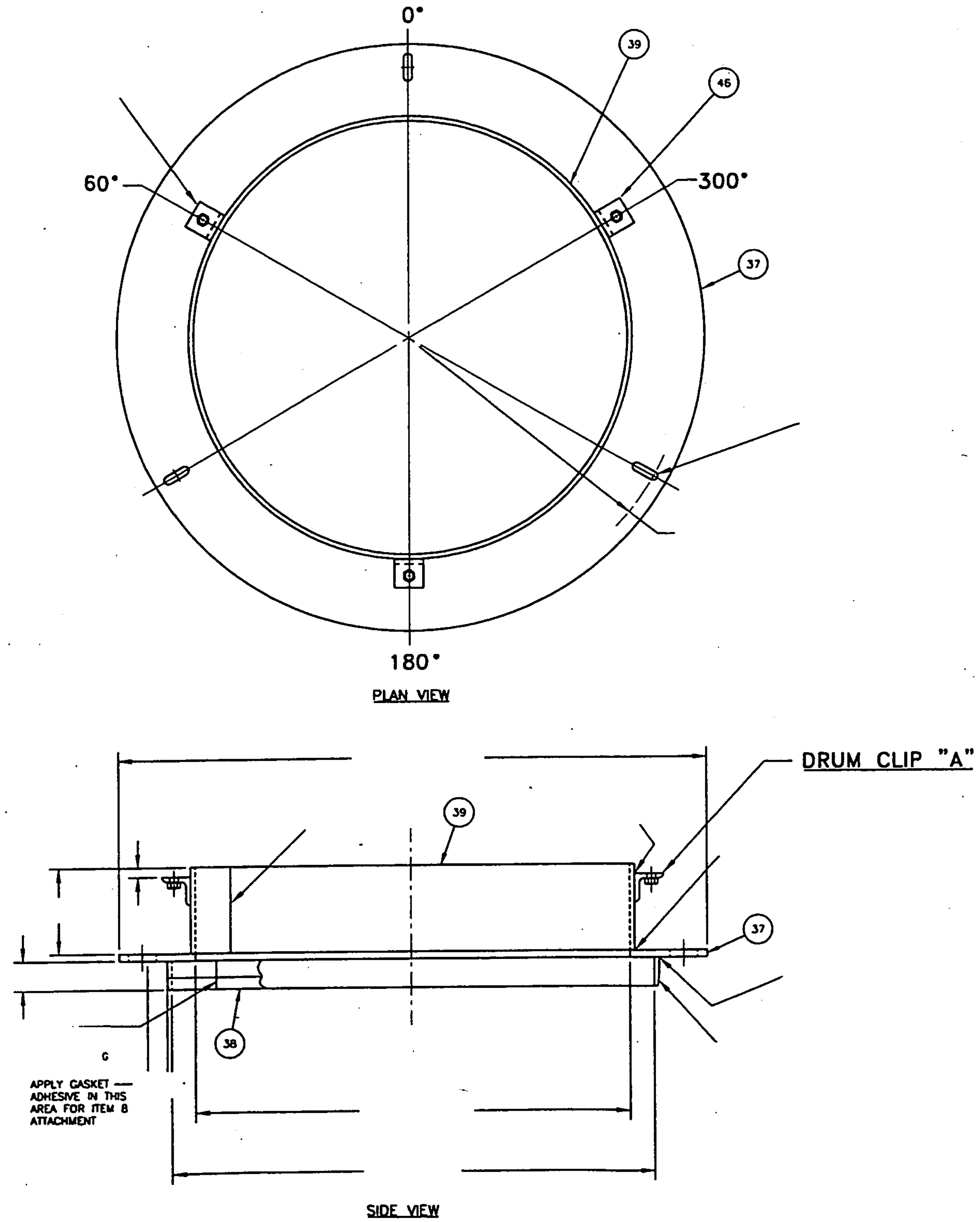
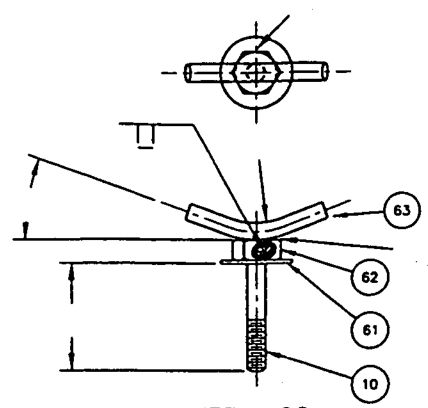
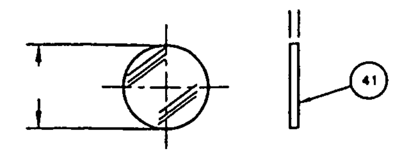


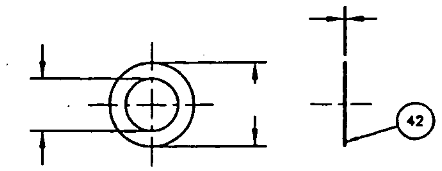
DRUM ADAPTOR DETAIL



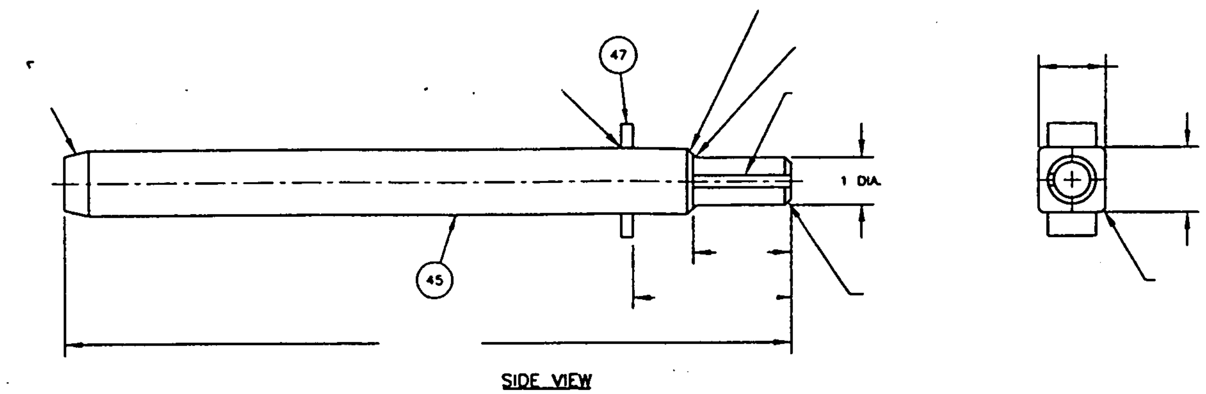
ITEM 60
WING BOLT ASSEMBLY
SCALE 1:2



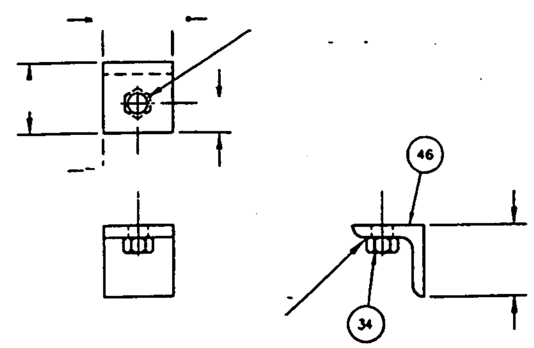
LENS DETAIL



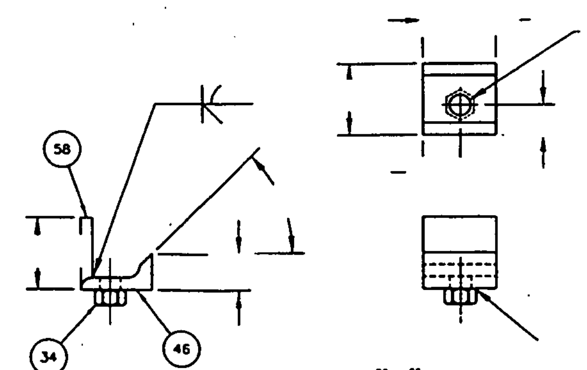
LENS GASKET DETAIL



MIXER BLADE DRIVE SHAFT DETAIL
SCALE 1:2



DRUM CLIP "A" DETAIL
SCALE 1:2



DRUM CLIP "B" DETAIL
SCALE 1:2

80

PROPRIETARY
☒ NON-PROPRIETARY
FSCM No. 54643
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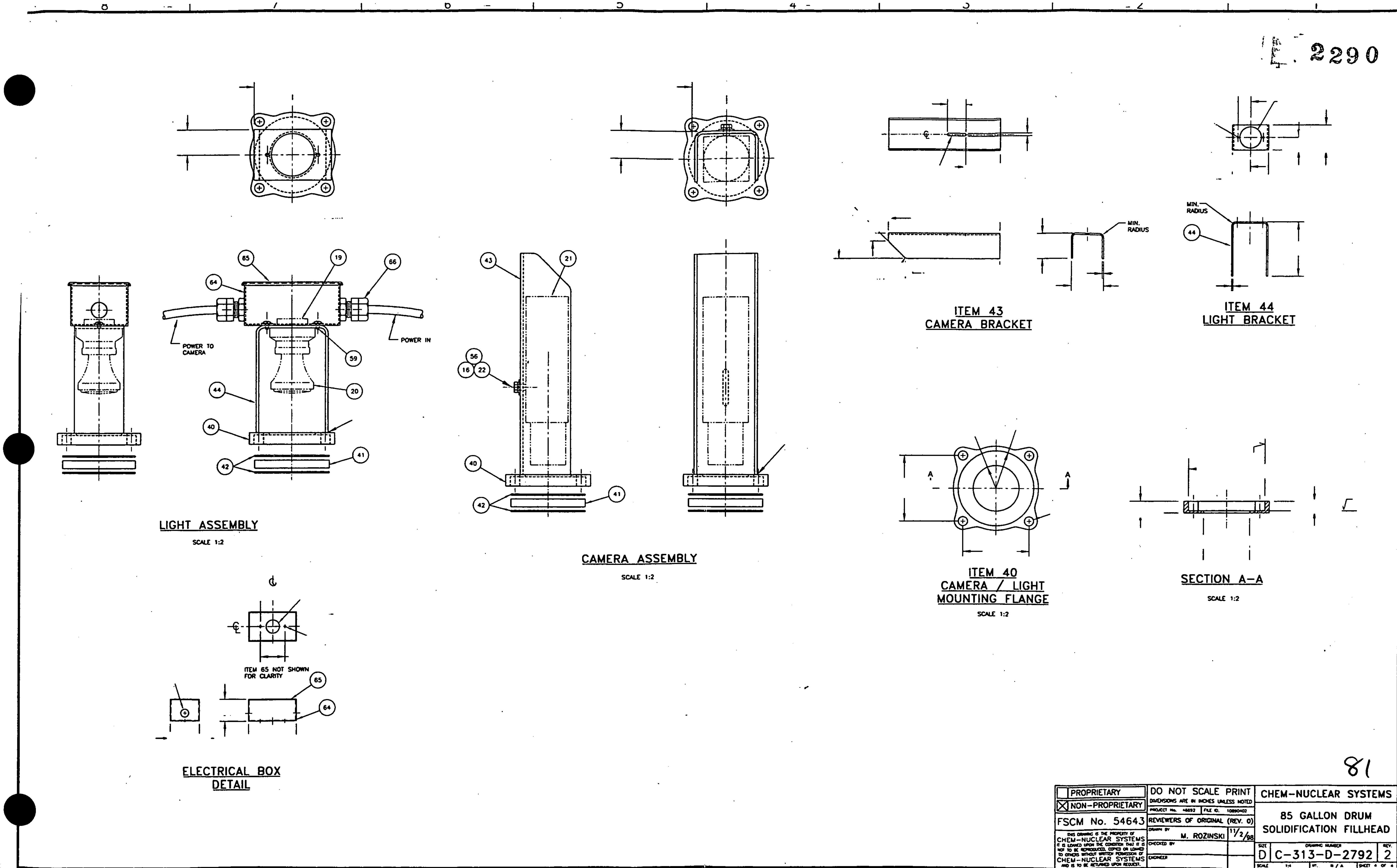
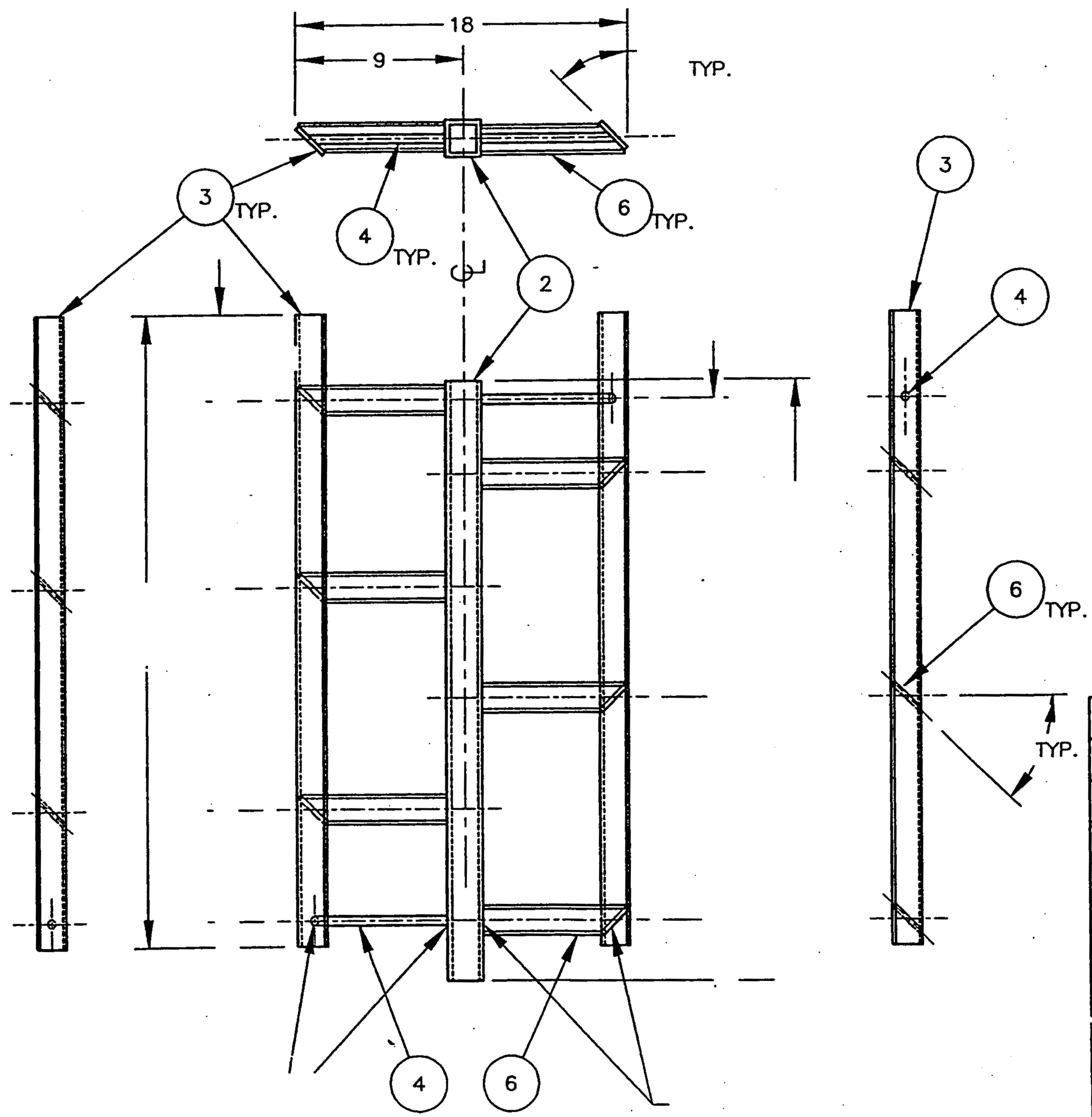
DO NOT SCALE PRINT
DIMENSIONS ARE IN INCHES UNLESS NOTED
PROJECT No. 46693 FILE NO. 10890302
REVIEWERS OF ORIGINAL (REV. 0)
DRAWN BY P. PREVATTE 9/1/98
CHECKED BY L. KEAN 9/2/98
ENGINEER KARL MCGOVERN 9/2/98

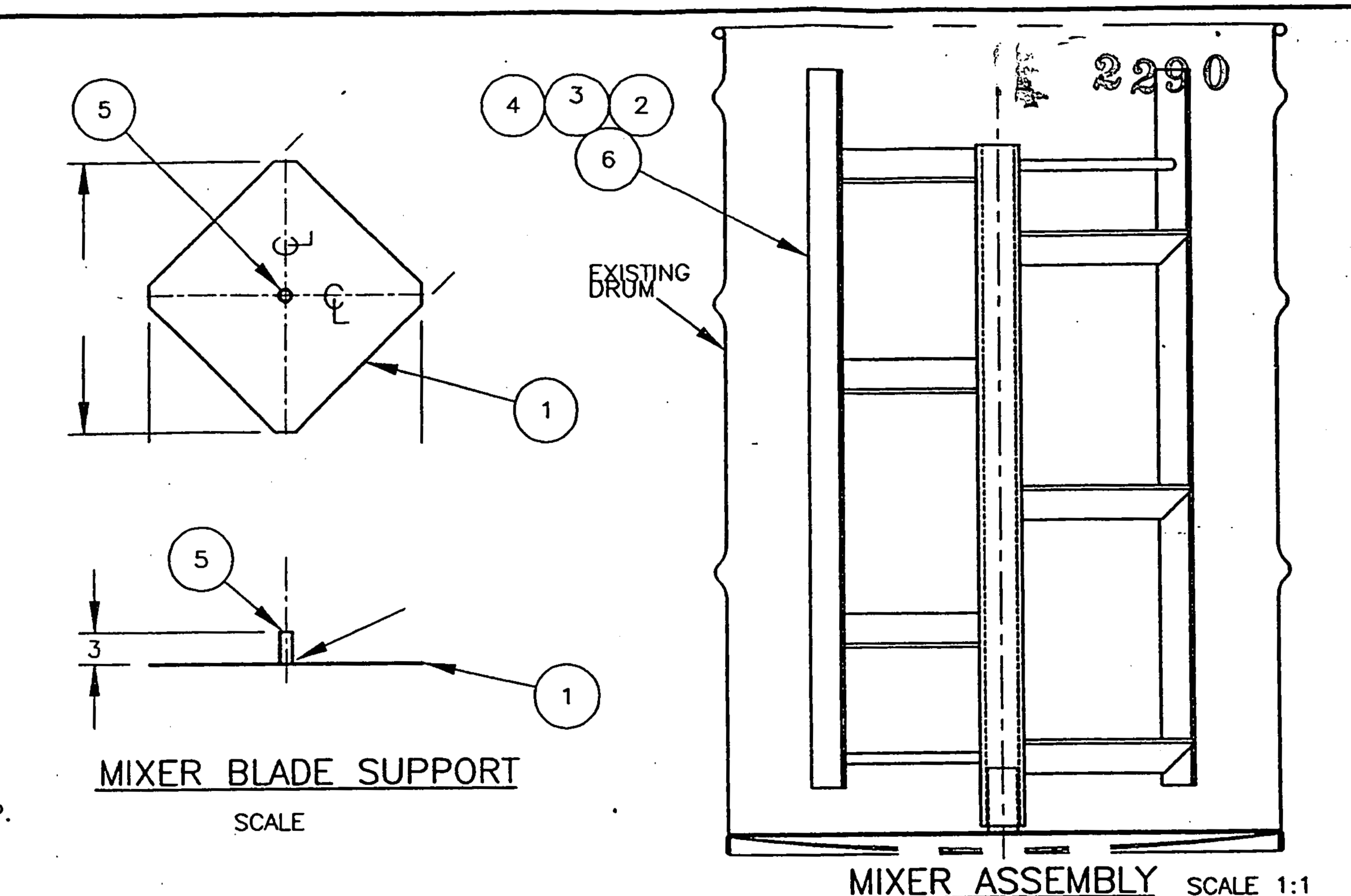
CHEM-NUCLEAR SYSTEMS
85 GALLON DRUM SOLIDIFICATION FILLHEAD
SIZE D DRAWING NUMBER C-313-D-2792 REV. 2
SCALE 1:4 WT. N/A SHEET 3 OF 4


2290
LIGHT ASSEMBLY
SCALE 1:2
POWER TO CAMERA
POWER IN
CAMERA ASSEMBLY
SCALE 1:2
ITEM 43
CAMERA BRACKET
MIN. RADIUS
ITEM 44
LIGHT BRACKET
ITEM 40
CAMERA / LIGHT
MOUNTING FLANGE
SCALE 1:2
SECTION A-A
SCALE 1:2
ITEM 65 NOT SHOWN FOR CLARITY
ELECTRICAL BOX
DETAIL
81
PROPRIETARY
NON-PROPRIETARY
FSCM No. 54643
DO NOT SCALE PRINT
DIMENSIONS ARE IN INCHES UNLESS NOTED
REVIEWERS OF ORIGINAL (REV. 0)
M. ROZINSKI 11/2/98
CHEM-NUCLEAR SYSTEMS
85 GALLON DRUM
SOLIDIFICATION FILLHEAD
D
C-313-D-2792
2



MIXER BLADE

SCALE 1:1



MIXER BLADE SUPPORT

SCALE

MIXER ASSEMBLY SCALE 1:1

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
6	6		ASTM A-36
5	1		ASTM A-53
4	2		ASTM A-36
3	2		ASTM A-36
2	1		ASTM A-500 GR.B
1	1		ASTM A-569

BILL OF MATERIALS

☐ PROPRIETARY
☒ NON-PROPRIETARY

FSCM No. 54643

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DO NOT SCALE PRINT

DIMENSIONS ARE IN INCHES UNLESS NOTED

PROJECT No. 46692 FILE ID. 10870101

REVIEWERS OF ORIGINAL (REV. 0)

DRAWN BY	M. ROZINSKI	08/06/98
CHECKED BY	P. PREVATTE	08/10/98
ENGINEER	C. McGOVERN	08/10/98

CHEM-NUCLEAR SYSTEMS

POP
DRUM MIXER BLADE

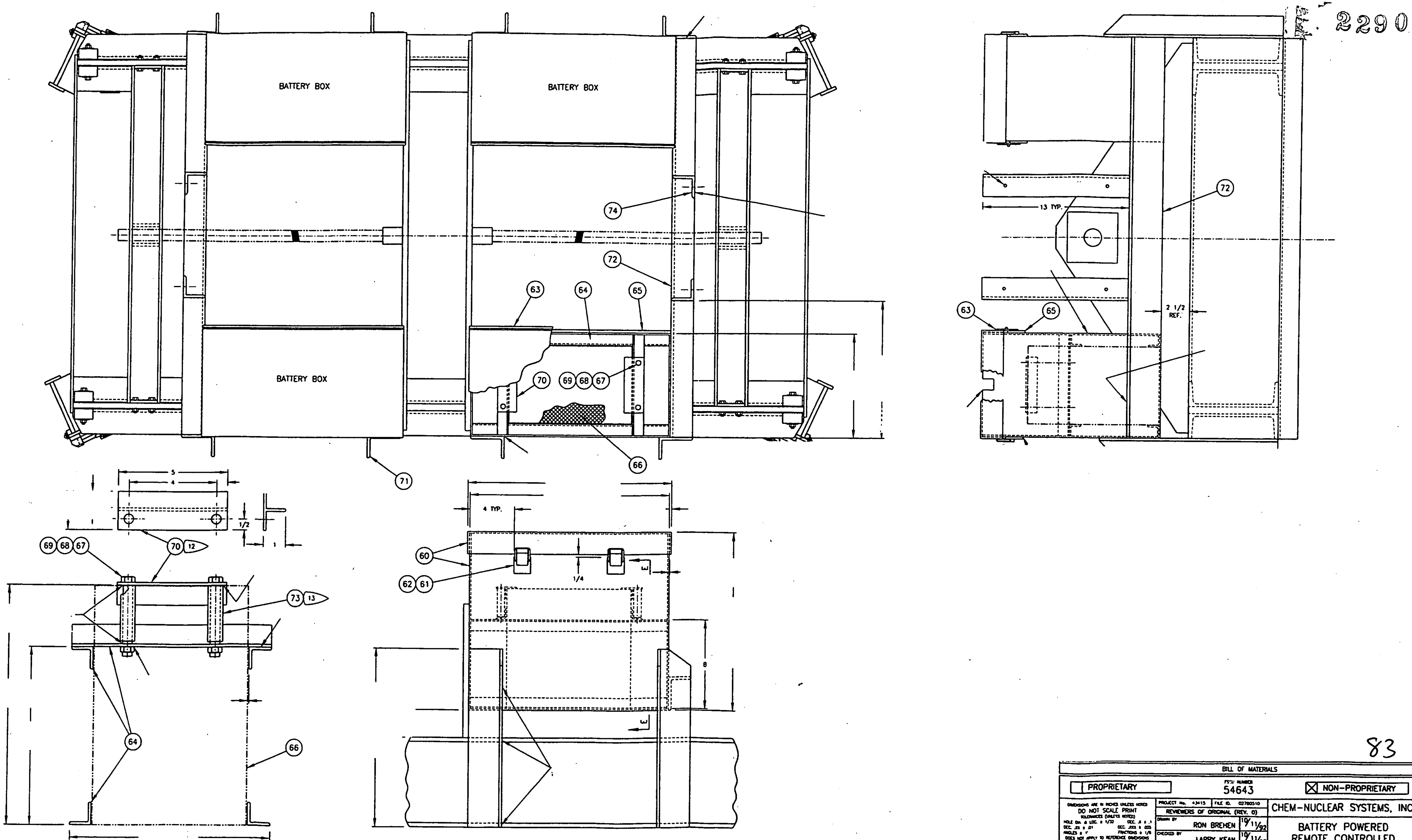
82

SIZE B DRAWING NUMBER C-313-B-2791 REV. 1

SCALE 1:8 WT. N / A SHEET 1 OF 1

NOTES:

1. MATERIALS, FABRICATION, INSPECTION, ACCEPTANCE AND RECORDS SHALL COMPLY WITH ES-E-031-67 AND ITS RELATED DATA SHEETS.
2. ITEMS 1 THROUGH 5 MAY BE FABRICATED FROM CARBON STEEL OF EQUAL STRENGTH.



83

BILL OF MATERIALS

☐ PROPRIETARY	FSCM NUMBER 54643	☒ NON-PROPRIETARY

DIMENSIONS ARE IN INCHES UNLESS NOTED
DO NOT SCALE PRINT
TOLERANCES (UNLESS NOTED)
HOLE DIA. & LOC. ± 1/32 DEC. .X ± .1
DEC. .XX ± .01 DEC. .XXX ± .005
ANGLES ± 1° FRACTIONS ± 1/8
DOES NOT APPLY TO REFERENCE DIMENSIONS

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PROJECT No. 43415 | FILE ID. 02780510

REVIEWERS OF ORIGINAL (REV. 0)

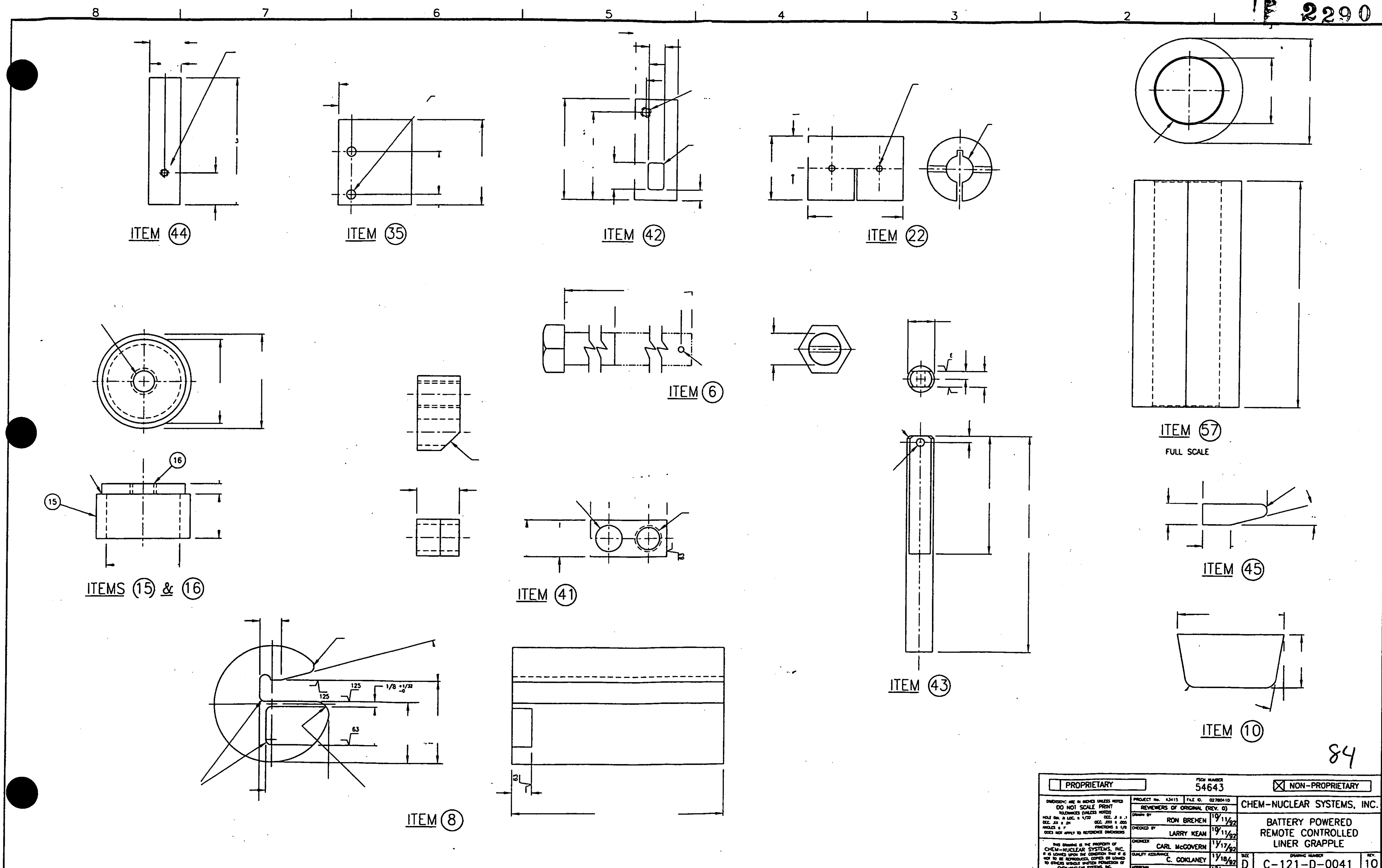
Role	Name	Date
DRAWN BY	RON BREHEN	10/11/92
CHECKED BY	LARRY KEAN	10/11/92
ENGINEER	CARL McGOVERN	11/17/92
QUALITY ASSURANCE	C. GOKLANEY	11/18/92
APPROVAL	PATRICK PAQUIN	12/4/92

CHEM-NUCLEAR SYSTEMS, INC.

BATTERY POWERED REMOTE CONTROLLED LINER GRAPPLE

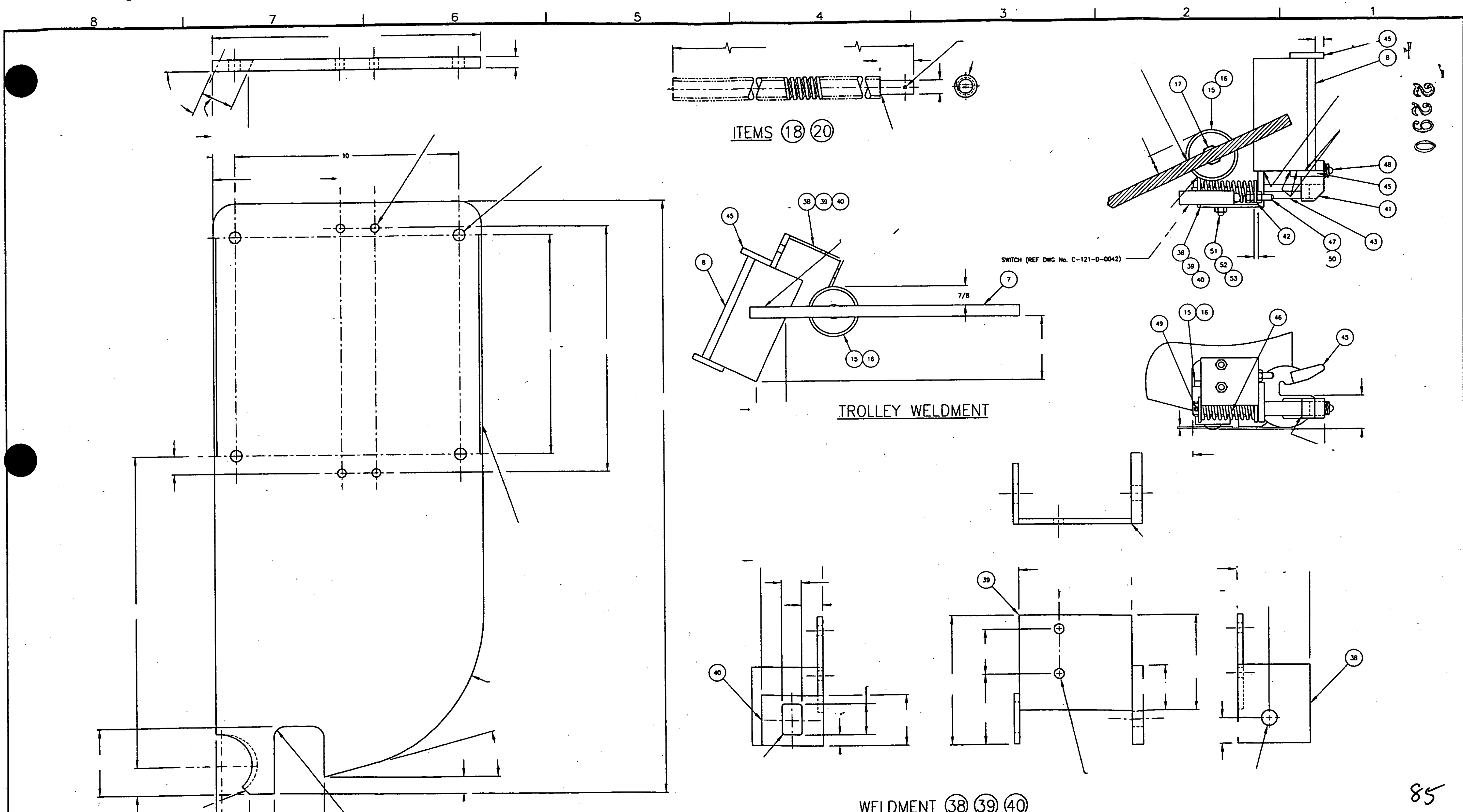
SIZE D | DRAWING NUMBER C-121-D-0041 | REV. 10

SCALE 1:4 | WT. N/A | SHEET 5 OF 5



ITEM 44
ITEM 35
ITEM 42
ITEM 22
ITEM 57
FULL SCALE
ITEM 6
ITEMS 15 & 16
ITEM 41
ITEM 43
ITEM 45
ITEM 10
ITEM 8
125
1/8 +1/32 -0
63
PROPRIETARY
FSCM NUMBER 54643
NON-PROPRIETARY
DIMENSIONS ARE IN INCHES UNLESS NOTED
DO NOT SCALE PRINT
PROJECT No. 43415
REVIEWERS OF ORIGINAL (REV. 0)
CHEM-NUCLEAR SYSTEMS, INC.
DRAWN BY RON BREHEN 10/11/92
CHECKED BY LARRY KEAN 10/11/92
ENGINEER CARL McGOVERN 11/17/92
QUALITY ASSURANCE C. GOKLANEY 11/18/92
APPROVAL PATRICK PAQUIN 12/4/92
BATTERY POWERED
REMOTE CONTROLLED
LINER GRAPPLE
SIZE D
DRAWING NUMBER C-121-D-0041
REV. 10

84



85

PROPRIETARY	FSCM NUMBER 54643	☒ NON-PROPRIETARY
DIMENSIONS ARE IN INCHES UNLESS NOTED DO NOT SCALE PRINT TOLERANCES (UNLESS NOTED) HOLE DIA. & LOC. ± 1/32 DEC. .X ± .1 DEC. .XX ± .01 DEC. .XXX ± .005 ANGLES ± 1° FRACTIONS ± 1/8 DOES NOT APPLY TO REFERENCE DIMENSIONS	PROJECT No. 43415 FILE ID. 02780310 REVIEWERS OF ORIGINAL (REV. 0) DRAWN BY RON BREHEN 10/11/92 CHECKED BY LARRY KEAN 10/11/92	CHEM-NUCLEAR SYSTEMS, INC. BATTERY POWERED REMOTE CONTROLLED LINER GRAPPLE
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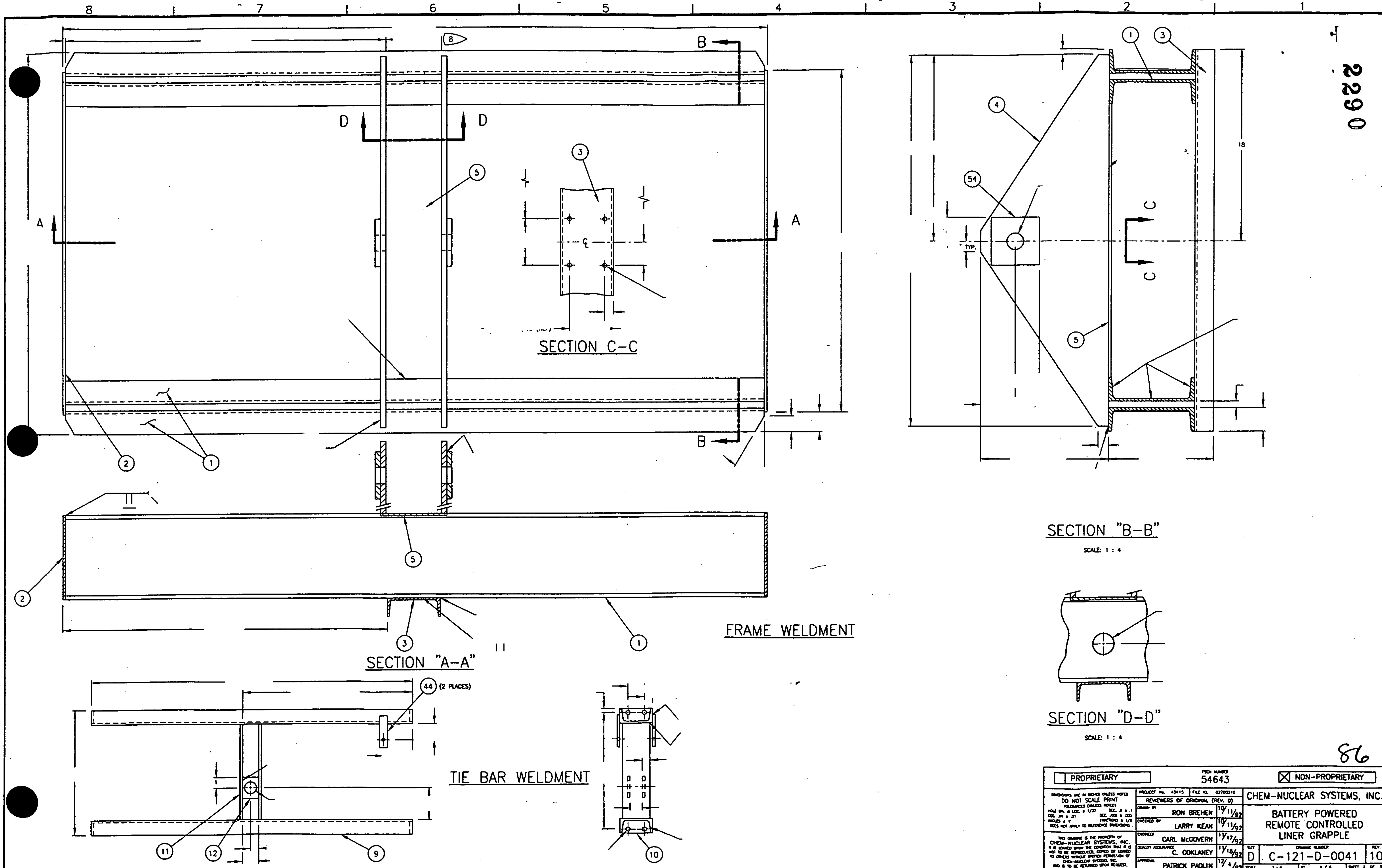
SECTION C-C
SECTION "B-B"
SCALE: 1 : 4
FRAME WELDMENT
SECTION "A-A"
SECTION "D-D"
SCALE: 1 : 4
TIE BAR WELDMENT
(2 PLACES)
TYP.
PROPRIETARY
54643
NON-PROPRIETARY
DIMENSIONS ARE IN INCHES UNLESS NOTED
DO NOT SCALE PRINT
PROJECT No. 43415
FILE ID. 02780210
REVIEWERS OF ORIGINAL (REV. 0)
DRAWN BY RON BREHEN 10/11/92
CHECKED BY LARRY KEAN 10/11/92
ENGINEER CARL McGOVERN 11/17/92
QUALITY ASSURANCE C. GOKLANEY 11/18/92
APPROVAL PATRICK PAQUIN 12/4/92
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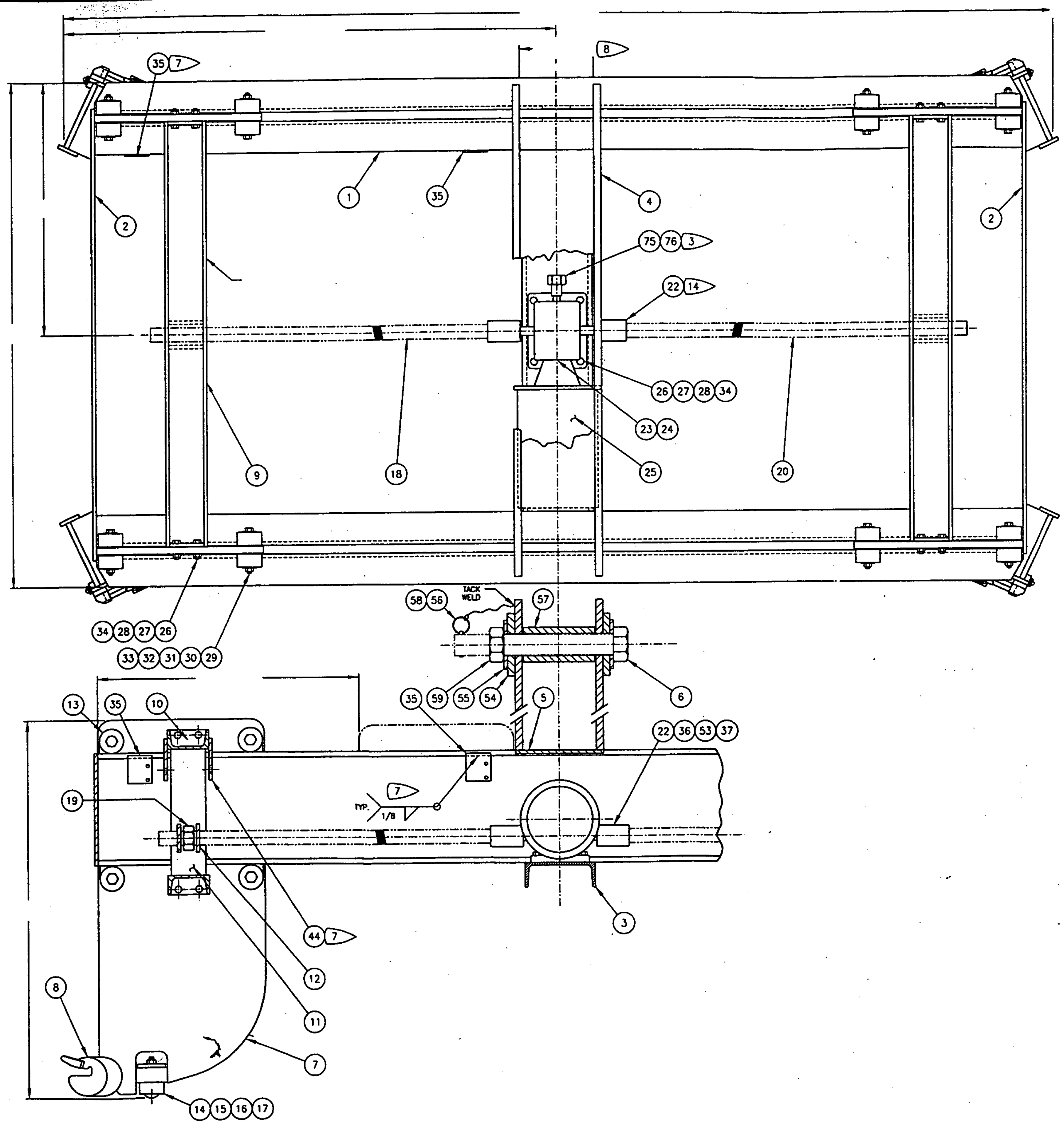
CHEM-NUCLEAR SYSTEMS, INC.
BATTERY POWERED
REMOTE CONTROLLED
LINER GRAPPLE
SIZE D
DRAWING NUMBER C-121-D-0041
REV. 10
SCALE 1:4

2290

86



2290

87

BILL OF MATERIALS

☐ PROPRIETARY	FSCM NUMBER 54643	☒ NON-PROPRIETARY

DIMENSIONS ARE IN INCHES UNLESS NOTED
DO NOT SCALE PRINT
TOLERANCES (UNLESS NOTED)
HOLE DIA. & LOC. ± 1/32 DEC. .X ± .1
DEC. .XX ± .01 DEC. .XXX ± .005
ANGLES ± 1° FRACTIONS ± 1/8
DOES NOT APPLY TO REFERENCE DIMENSIONS

PROJECT No. 43415 | FILE ID. 02780110

REVIEWERS OF ORIGINAL (REV. 0)

Role	Name	Date
DRAWN BY	RON BREHEN	10/11/92
CHECKED BY	LARRY KEAN	10/11/92
ENGINEER	CARL McGOVERN	11/17/92
QUALITY ASSURANCE	C. GOKLANEY	11/18/92
APPROVAL	PATRICK PAQUIN	12/4/92

CHEM-NUCLEAR SYSTEMS, INC.

BATTERY POWERED
REMOTE CONTROLLED
LINER GRAPPLE

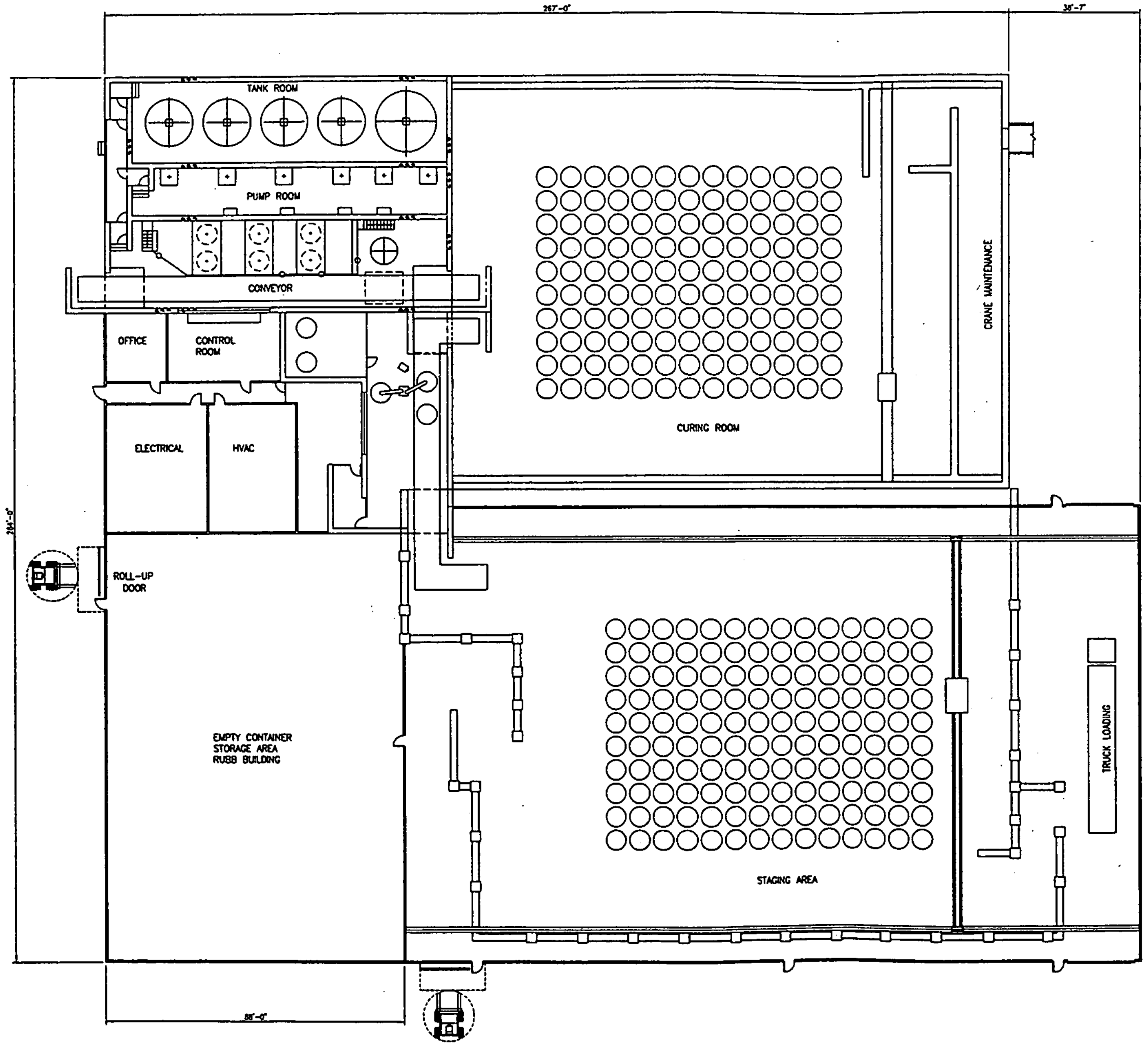
SIZE	DRAWING NUMBER	REV.
D	C-121-D-0041	10

SCALE 1:4 | WT. N/A | SHEET 1 OF 3

GENERAL NOTES

1. THIS GENERAL ARRANGEMENT PROVIDES THE MAIN ELEMENTS FOR THE PROCESS AREA LAYOUT AS DESCRIBED BY THE REPORT TEXT. SECONDARILY OR AUXILLARY FACILITIES SUCH AS ON-SITE LABORATORY. WAREHOUSING REPAIR AND MAINTENANCE AREAS ARE NOT SHOWN.

E 2290



PLAN

0' 16' 32'

SYM	NO.	DESCRIPTION	APP/DATE
	0		P. FRINK/ 5/20/99

REVISIONS

DESIGN CONTRACTOR

PARSONS

GENERAL ARRANGEMENT

CHEMICAL STABILIZATION - OTHER FACILITY LAYOUT - PLAN

SCALE: 1/16"=1'-0"

REFERENCE

GA-001

MECHANICAL

DATE: 20 MAY 1999

88

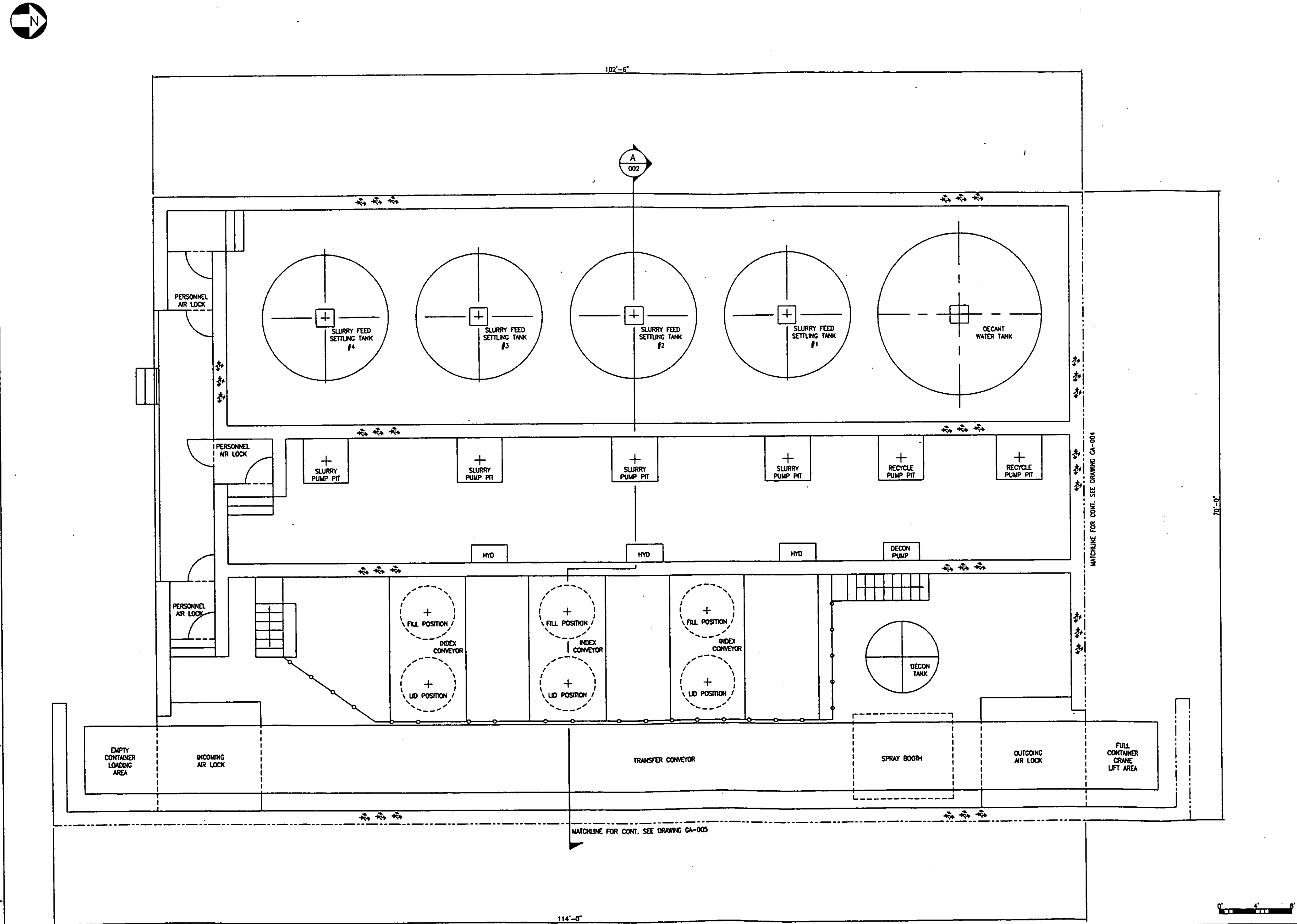
GENERAL NOTES

1. ALL SHIELD WALLS 18" TYPICAL.

LEGEND

- - - - - REPRESENTS AIR LOCK DOORS
—o—o— OUTLINE OF MEZZANINE

2290



89

SYM	NO.	DESCRIPTION	APP/DATE
	0		P. FRINK/ 5/20/99

REVISIONS

DESIGN CONTRACTOR

PARSONS

DR.	CK.	D.ENG.
PROJ. MGR. P. FRINK	F. BR. CH.	F. DIV. CH.
FAC/SYS.MGR.	E. BR. CH.	E. DIV. CH.
R. ENG.	R. BR. CH.	R. DIV. CH.

GENERAL ARRANGEMENT

CHEMICAL STABILIZATION - OTHER PROCESS AREA - PLAN

SCALE: 1/4" = 1'-0"

REFERENCE

GA-002

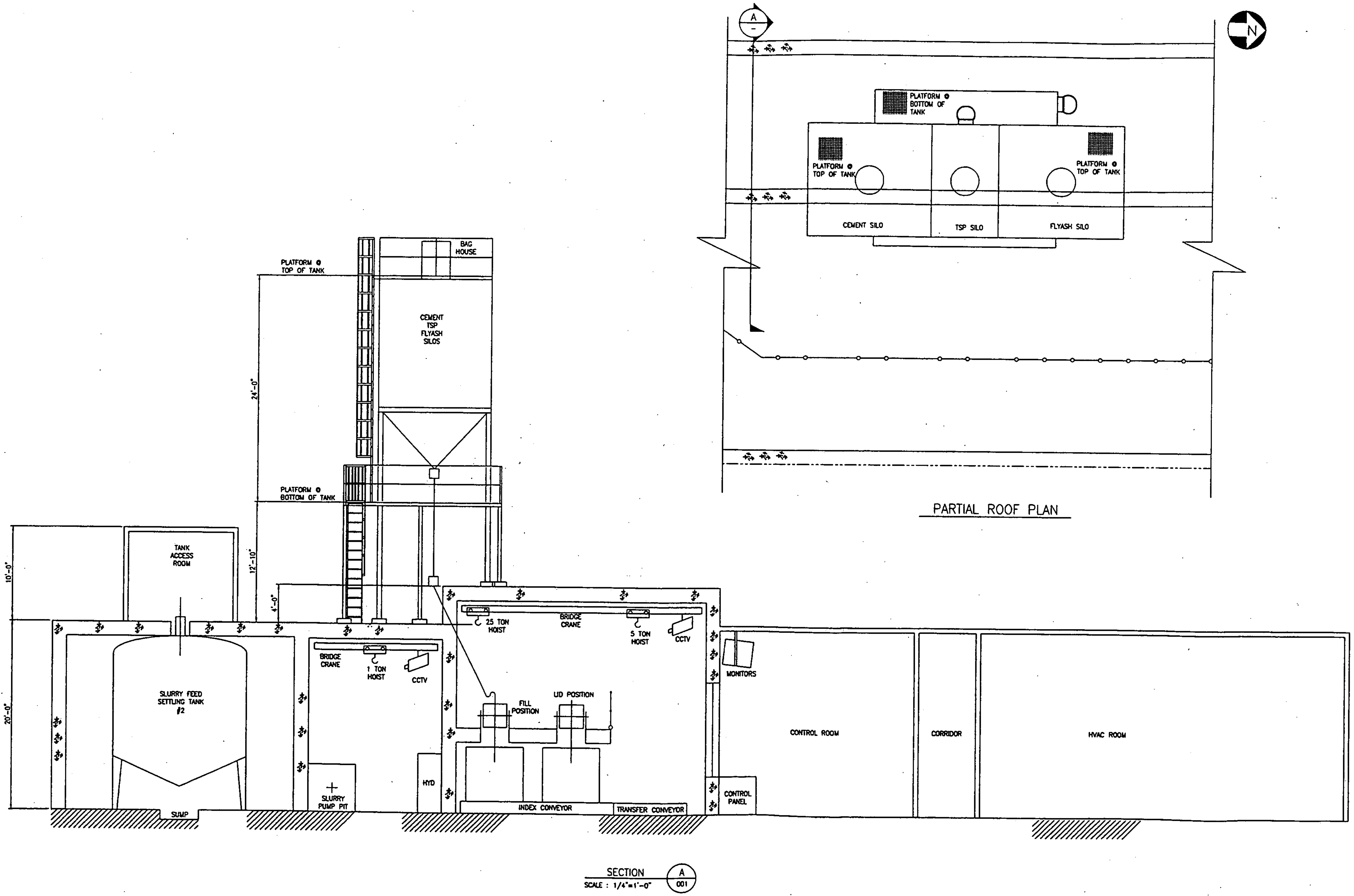
MECHANICAL

DATE: 20 MAY 1999

GENERAL NOTES

1. ALL SHIELD WALLS 18" TYPICAL.
2. FOUNDATION DETAILS NOT SHOWN FOR CLARITY.

E 2290



SECTION A 001
SCALE : 1/4"=1'-0"

90

SYM	NO.	DESCRIPTION	APP/DATE
	0		P. FRINK/ 5/20/99

REVISIONS

DESIGN CONTRACTOR
PARSONS

DR.	CK.	D.ENG.
PROJ. MGR. P. FRINK	F. BR. CH.	F. DIV. CH.
FAC/SYS.MGR.	E. BR. CH.	E. DIV. CH.
R. ENG.	R. BR. CH.	R. DIV. CH.

GENERAL ARRANGEMENT

CHEMICAL STABILIZATION – OTHER PROCESS AREA – ELEVATION

SCALE: 1/4" = 1'-0"

REFERENCE

GA-003

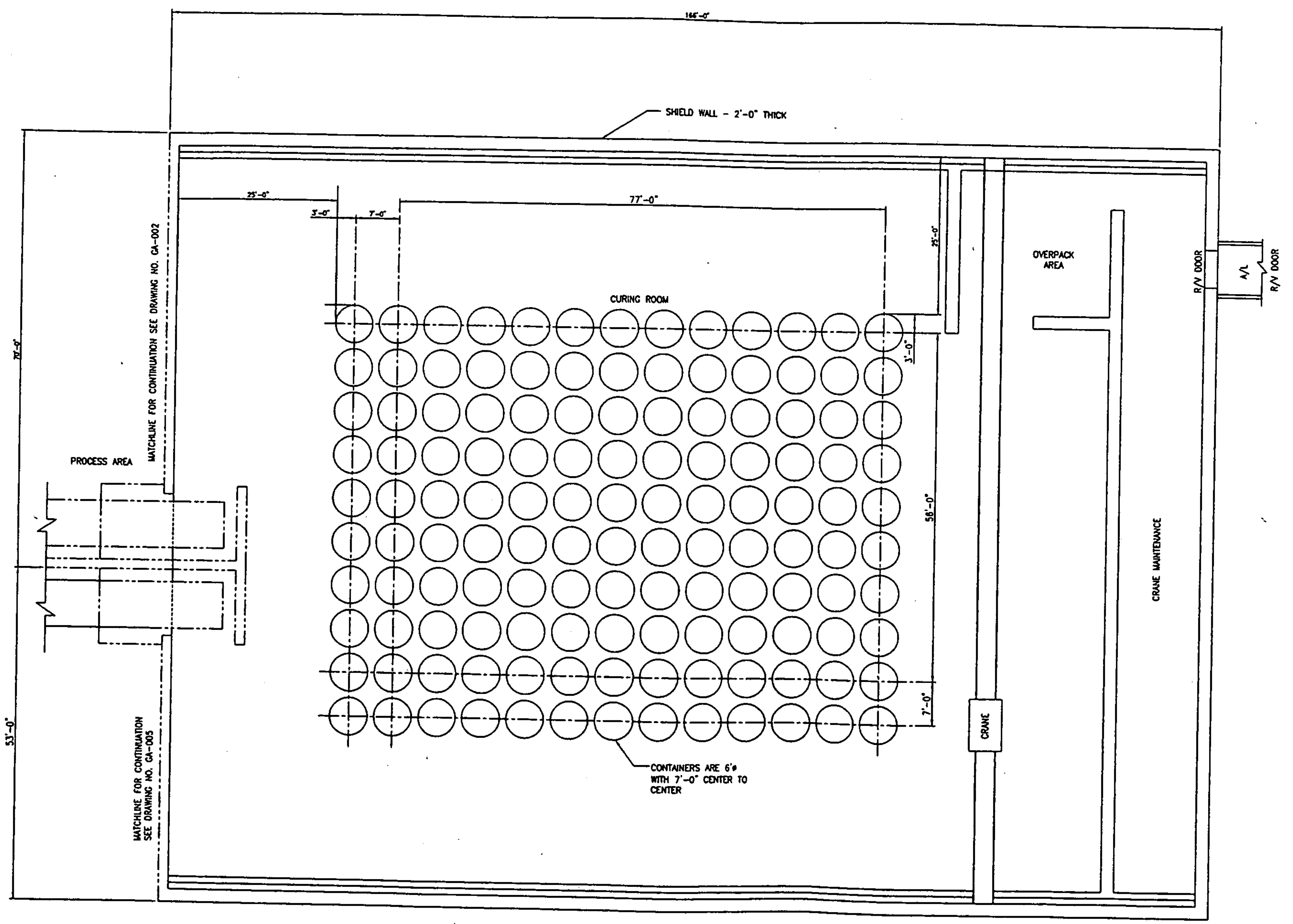
MECHANICAL

DATE: 20 MAY 1999

GENERAL NOTES

1. CURING ROOM SHEILD WALLS 2' TYPICAL

2290



PLAN

91

0' 8' 16'

SYM	NO.	DESCRIPTION	APP/DATE
	0		P. FRINK/ 5/20/99

REVISIONS

DESIGN CONTRACTOR

PARSONS

DR.	CK.	D.ENG.
PROJ. MGR. P. FRINK	F. BR. CK.	F. DIV. CK.
FAC/SYS.MGR.	C. BR. CK.	C. DIV. CK.
R. ENG.	R. BR. CK.	R. DIV. CK.

GENERAL ARRANGEMENT

CHEMICAL STABILIZER-OHTER
CURING ROOM - PLAN

SCALE: 1/8"=1'-0"

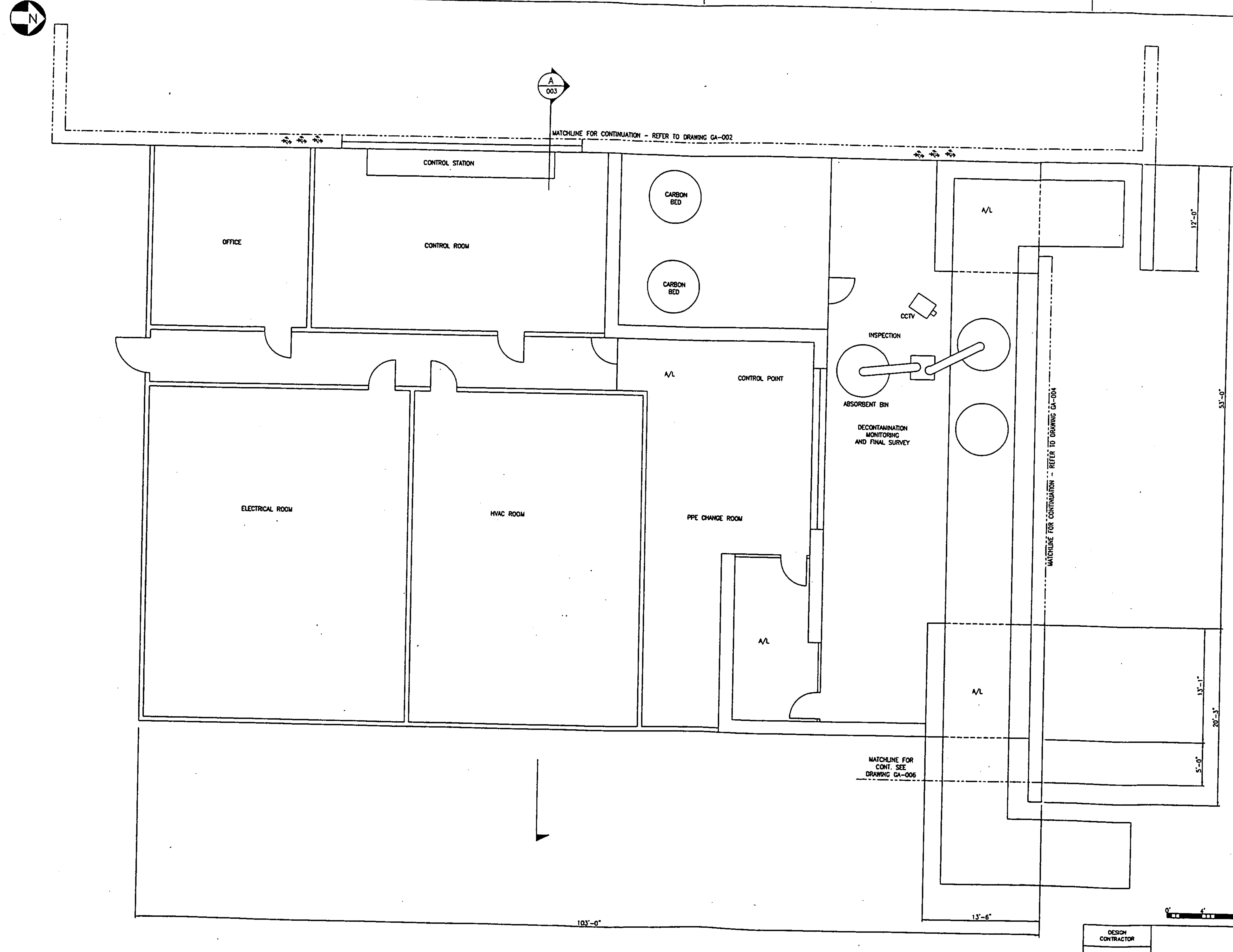
REFERENCE

GA-004

MECHANICAL

DATE: 20 MAY 1999

2290



PLAN

92

SYM	NO.	DESCRIPTION	APP/DATE
	0		P. FRINK/ 5/20/99

REVISIONS

DESIGN CONTRACTOR

PARSONS

PROJ. MGR. P. FRINK

GENERAL ARRANGEMENT

CHEMICAL STABILIZATION - OTHER
INSPECTION / REWORK AREA - PLAN

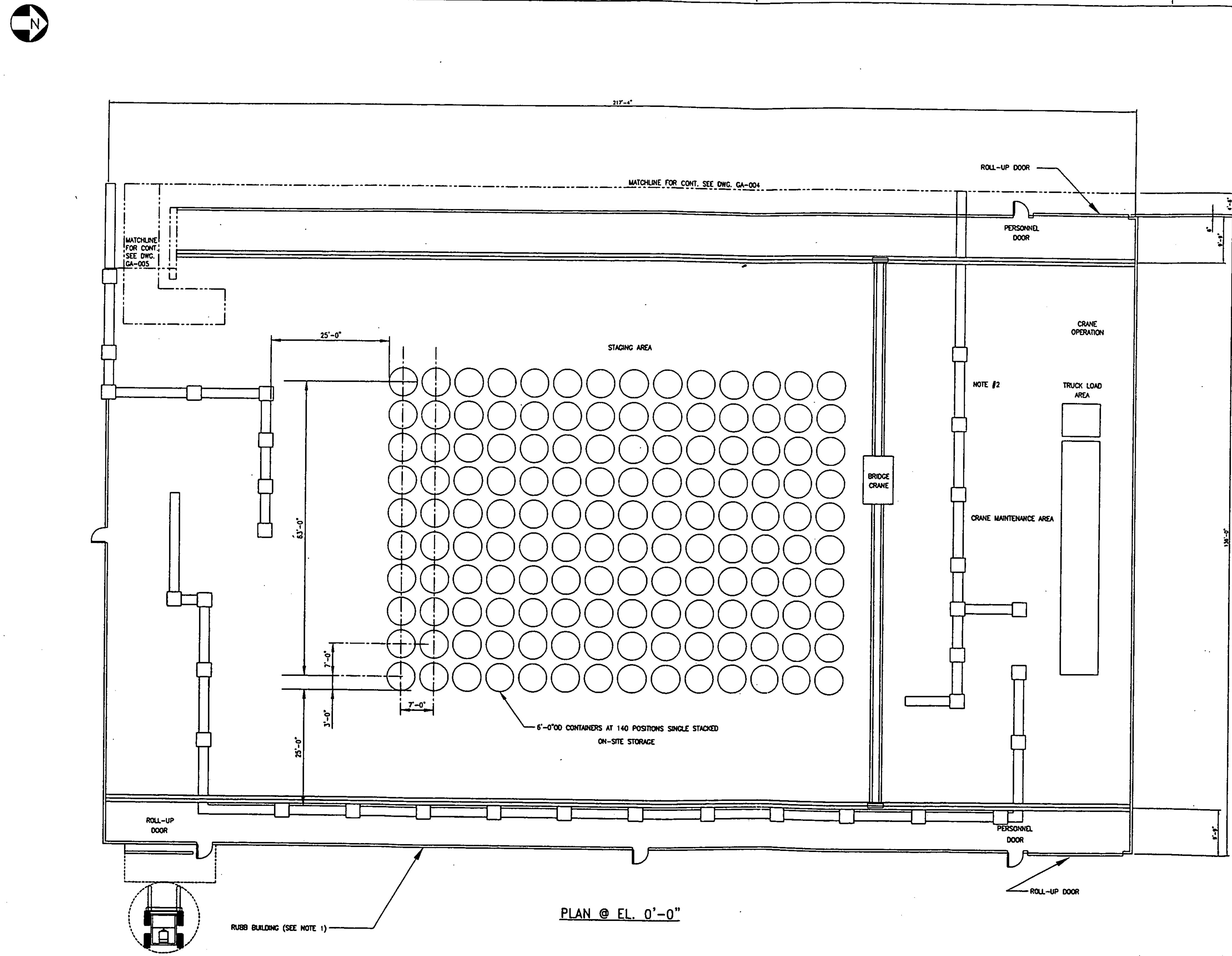
SCALE: 1/4" = 1'-0"

REFERENCE

GA-005

MECHANICAL

DATE: 20 MAY 1999



PLAN @ EL. 0'-0"

GENERAL NOTES

1. STAGING AREA IS COVERED BY RUBB BUILDING OR OTHER SUITABLE STRUCTURE.
2. MOVABLE CONCRETE SHEILD PORTIONS APPROXIMATELY 7'-0" HIGH.

2290

93

SYM	NO.	DESCRIPTION	APP/DATE
	0		P. FRINK/ 5/20/99

REVISIONS

DESIGN CONTRACTOR: PARSONS

PROJ. MGR. P. FRINK

GENERAL ARRANGEMENT

CHEMICAL STABILIZATION – OTHER
STAGING AREA – PLAN

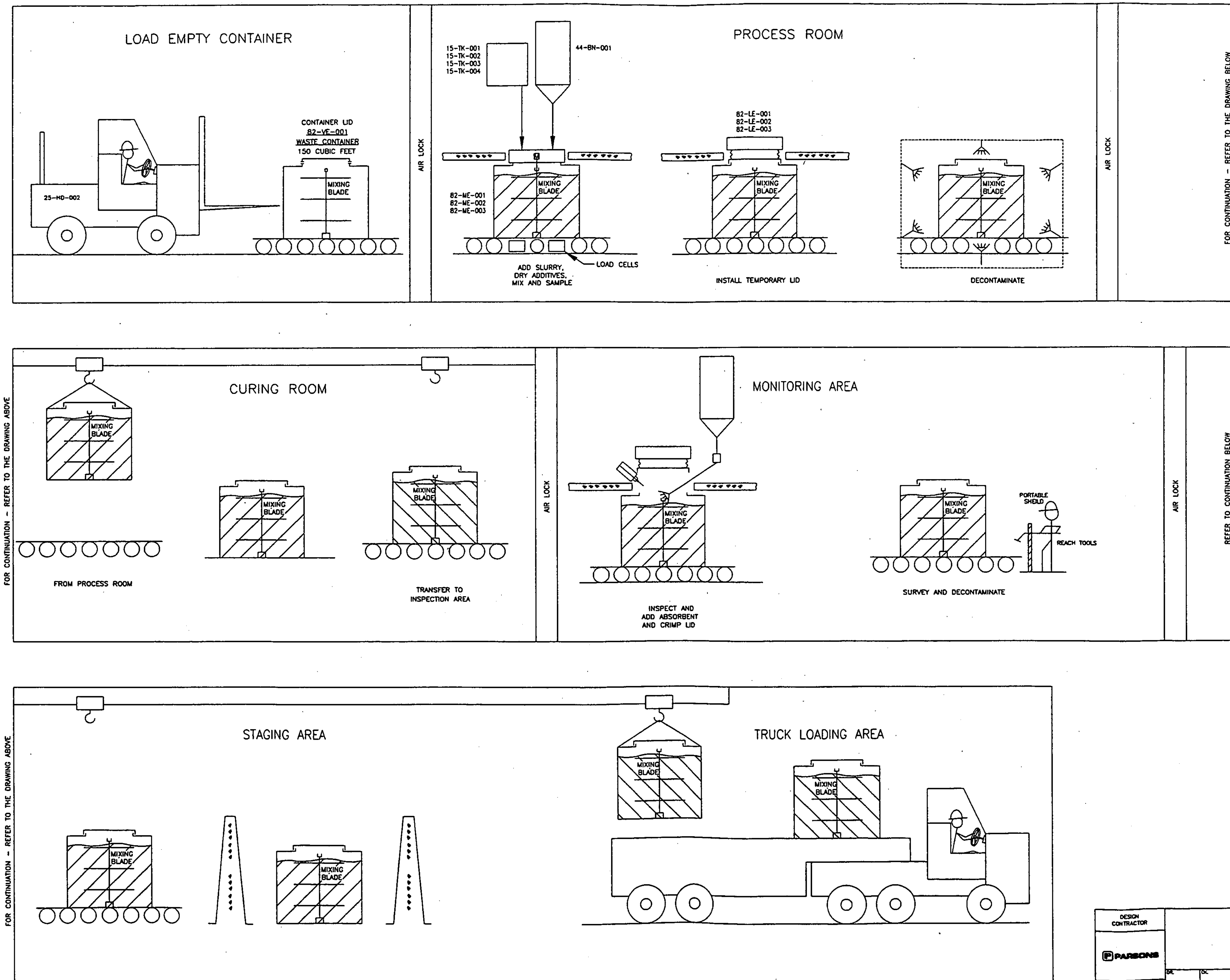
SCALE: 1/8"=1'-0"

REFERENCE

GA-006

MECHANICAL

DATE: 20 MAY 1999



P 2290

94

SYM	NO.	DESCRIPTION	APP/DATE
	0		P. FRINK/ 5/20/99

REVISIONS

DESIGN CONTRACTOR

PARSONS

DR. | CK. | D.ENG.
PROJ. MGR. P. FRINK | F. BR. CH. | F. DIV. CH.
FAC/SYS.MGR. | E. BR. CH. | E. DIV. CH.
R. ENG. | R. BR. CH. | R. DIV. CH.

MECHANICAL FLOW DIAGRAM

CHEMICAL STABILIZATION - OTHER PRODUCT PROCESS AND HANDLING

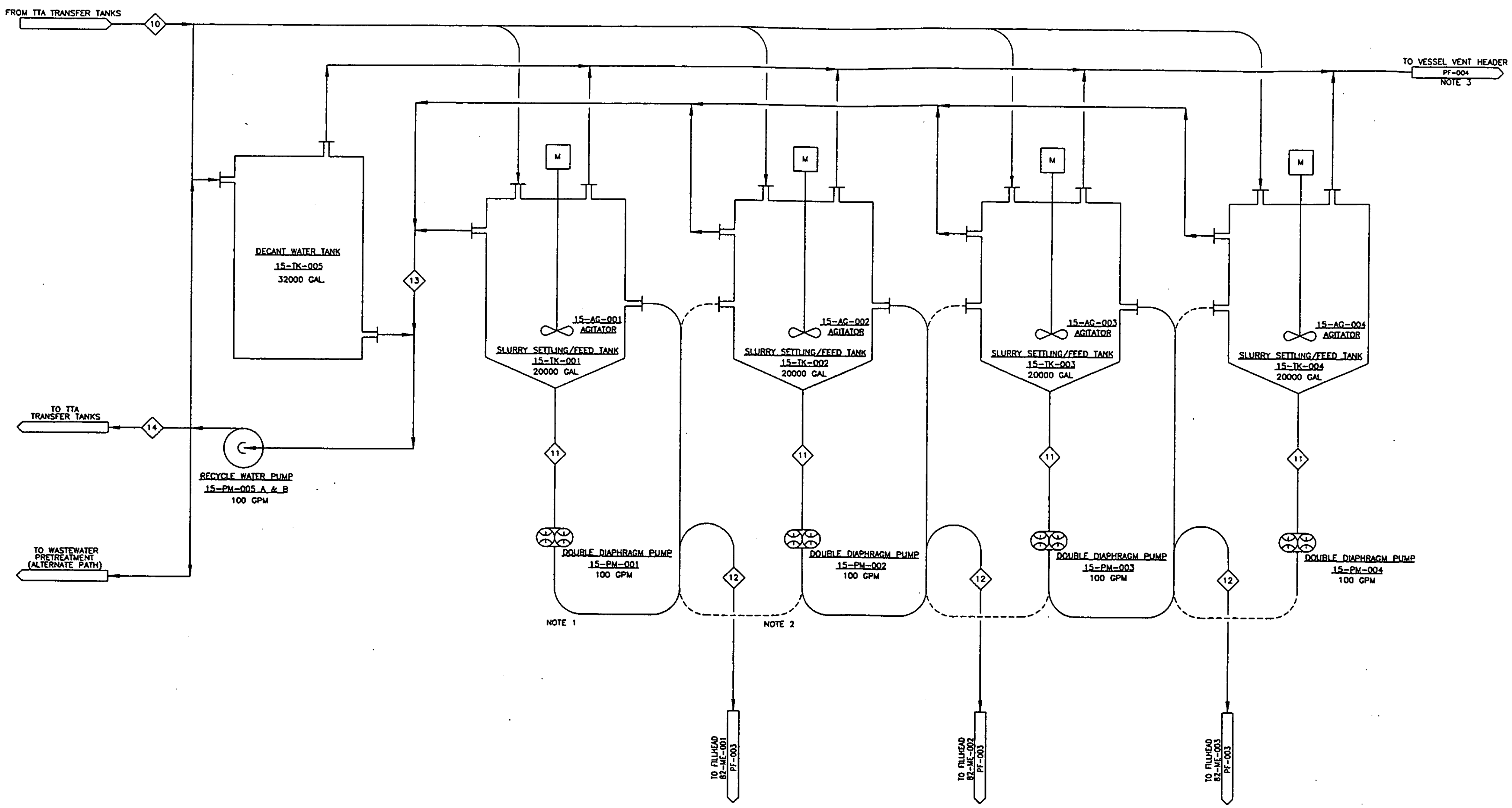
SCALE: NONE

REFERENCE

MF-001

SHEET 1 OF 1

DATE: 20 MAY 1999



GENERAL NOTES

1. SLURRY PIPING HAS 5 PIPE DIAMETER RADIUS BENDS.
2. CROSS CONNECT PIPING ALLOWS SLURRY SETTLING TANKS 2 & 3 TO PUMP TO EITHER OF TWO FILL HEADS.
3. TANK VENTS ARE INTERMITTANT FLOWS. SEE PF-004 FOR COMBINED VVS FLOW STREAM.

E 2290

95

SYM	NO.	DESCRIPTION	APP/DATE
	0		P. FRINK/ 5/20/99

REVISIONS

DESIGN CONTRACTOR

PARSONS

DR.	CK.	D.ENG.
PROJ. MGR. P. FRINK	F. BR. CH.	F. DIV. CH.
FAC/SYS.MGR.	E. BR. CH.	E. DIV. CH.
R. ENG.	R. BR. CH.	R. DIV. CH.

PROCESS FLOW DIAGRAM

CHEMICAL STABILIZATION - OTHER
SLURRY FEED SYSTEM

SCALE: NONE

REFERENCE

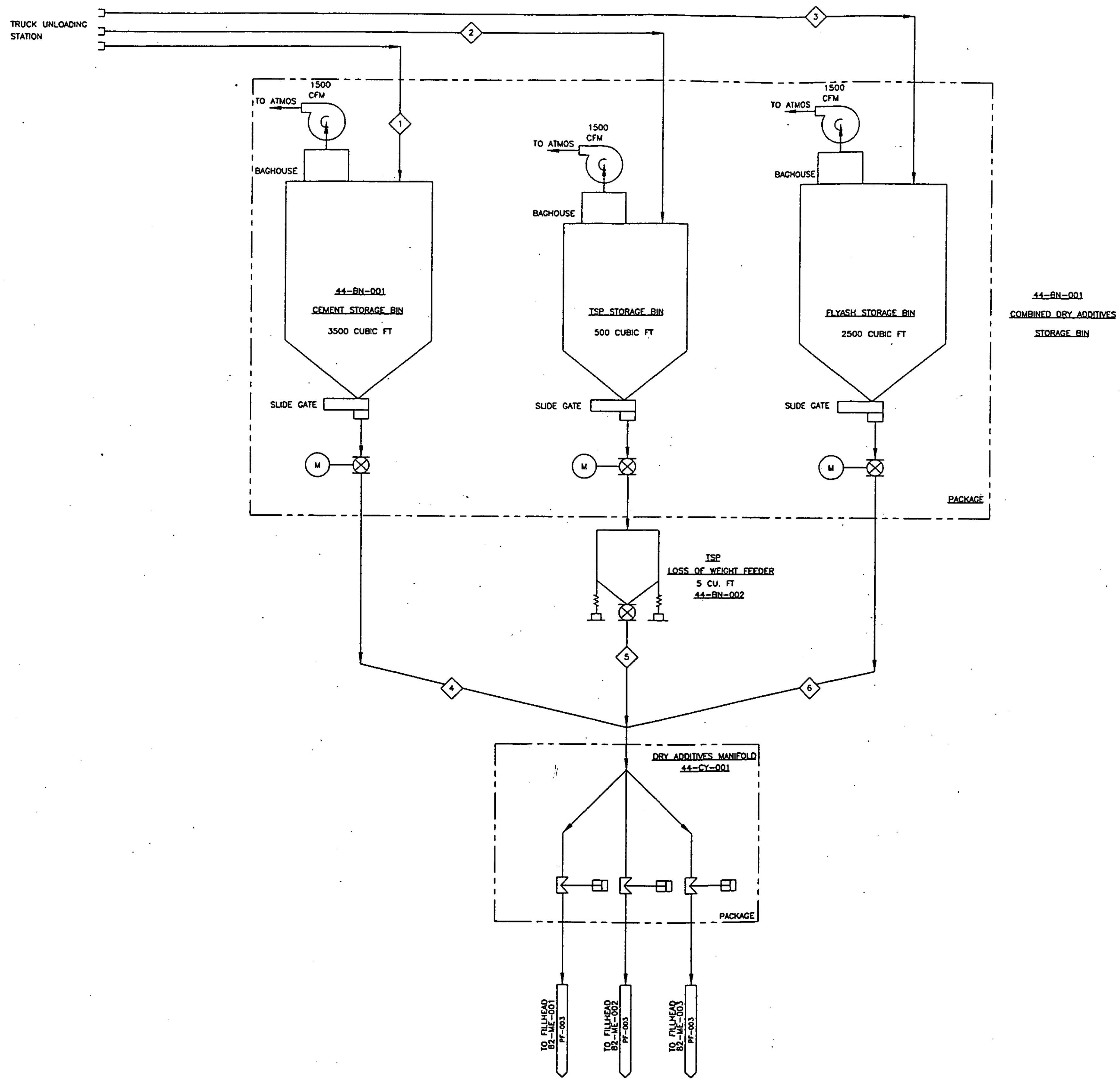
PF-001

MECHANICAL

DATE: 20 MAY 1999

PF001.DWG
LWY 05/20/99 13:51:
733903.01000

4 3 2 1



GENERAL NOTES

1. SEE PF-003 FOR FLOW STREAM DATA.

2290

96

SYM	NO.	DESCRIPTION	APP/DATE
	0		P. FRINK/ 5/20/99

REVISIONS

DESIGN CONTRACTOR

PARSONS

PROCESS FLOW DIAGRAM

CHEMICAL STABILIZATION - OTHER
BINDER / ADDITIVES SYSTEM

PROJ. MGR. P. FRINK

SCALE: NONE

REFERENCE

PF-002

MECHANICAL

DATE: 20 MAY 1999

PF002.DWG
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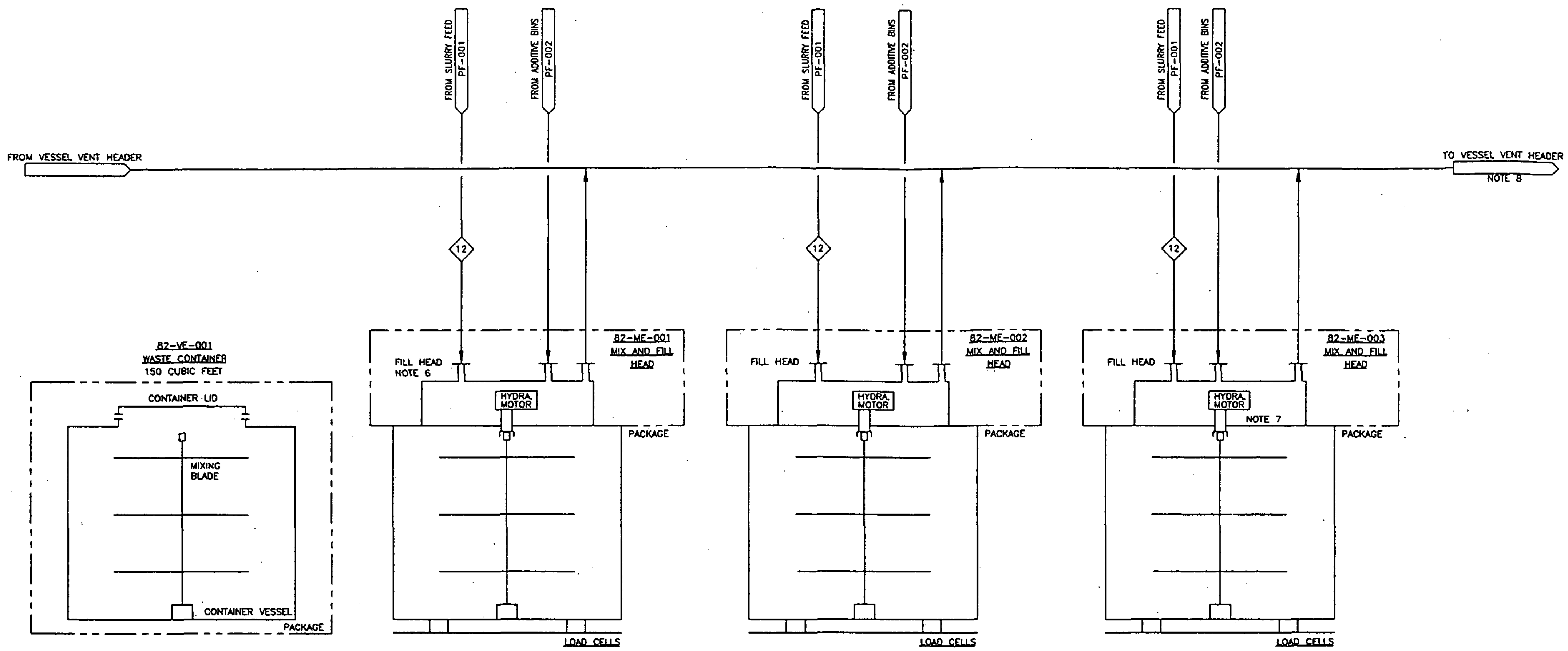
733903.01000



PROCESS FLOW STREAM DATA

	UNITS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
FLOW		CEMENT	TSP	FLYASH	CEMENT	TSP	FLYASH				SLURRY	SLURRY	SLURRY	DECANT	DECANT			OFFGAS	EMERG. OFFGAS
FROM		TRUCK	TRUCK	TRUCK	CEMENT BIN	TSP BIN	FLYASH BIN				TTA	SLURRY TK	RECIRC	SLURRY TK	DECANT TK			VENT HDR	BLDG. VENT
TO		CEMENT BIN	TSP BIN	FLYASH BIN	FILL HEAD	FILL HEAD	FILL HEAD				SLURRY TK	RECIRC	FILL HEAD	DECANT TK	TTA			RCS	STACK
OPERATIONS	HR/DAY				2.7	0.46	2.3				5.5	24		5.1	5.1			24	*
SOLIDS	LBS/HR				8000	2000	4000				6000	25272		2000	2000				
WATER - GAS	LBS/HR																	9.2	80.5
WATER - LIQUID	LBS/HR										53995	43032		50618	50618				
DRY AIR	LBS/HR																	1126	8753
TOTAL	LBS/HR				8000	2000	4000				59995	68304		52618	52618			1135	8833
SPECIFIC GRAVITY											1.2	1.24	1.24	1.05	1.05				
DENSITY	LBS/CU FT	65	42	35														0.1	0.1
VOLUMETRIC FLOW	CFM																	254	2000
VOLUMETRIC FLOW	GPM											110		100	100				
BATCH OPERATION	HR/BATCH				0.45	0.077	0.385				5.5		0.41	5.1	5.1				
SOLIDS	LB/BATCH				3595	154	1541				32997		3800	10197	10197				
WATER - GAS	LB/BATCH																		
WATER - LIQUID	LB/BATCH										296973		6470	258151	258151				
DRY AIR	LB/BATCH																		
TOTAL	LB/BATCH	269000	8400	115300	3595	154	1541				329970		10270	268348	268348				
VOLUMETRIC FLOW	GPM										100		40						
TEMPERATURE	DEGREES F				AMB.	AMB.	AMB.				80	90	90	80	80			70.3	75
HUMIDITY	LBS/LB DRY AIR																	0.008	0.0092
NOTES					4	4	4				2		3	2	2			1	5

FLOW STREAM NOTES

1. FLOW STREAM 17, VVS COMBINED DISCHARGE, PARAMETERS ARE APPROXIMATE AND CONSERVATIVELY ESTIMATED.
2. FLOW STREAMS 10, 13, & 14 ARE BASED ON A SETTLING /FEED TANK BATCH AND ONE BATCH PER DAY.
3. FLOW STREAM 12 IS BASED ON ON A CONTAINER BATCH.
4. FLOWSTREAMS 4, 5, & 6 ARE BASED ON A CONTAINER BATCH AND FOUR CONTAINERS PER DAY.
5. ERCS SYSTEM OPERATES ON AN AS-NEEDED BASIS ONLY.

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GENERAL NOTES

6. FILLHEAD PACKAGE INCLUDES CAMERA, LIGHTS, ULTRASOUNIC LEVEL DETECTION, TACHOMETER.
7. HYDRAULIC FLUID LINES NOT SHOWN FOR CLARITY.
8. CONTAINER VENTS ARE INTERMITTANT FLOWS. SEE PF-004 FOR COMBINED V.V.S. FLOW DATA.

97

SYM	NO.	DESCRIPTION	APP/DATE
	0		P. FRINK/ 5/20/99

REVISIONS

DESIGN CONTRACTOR
PARSONS

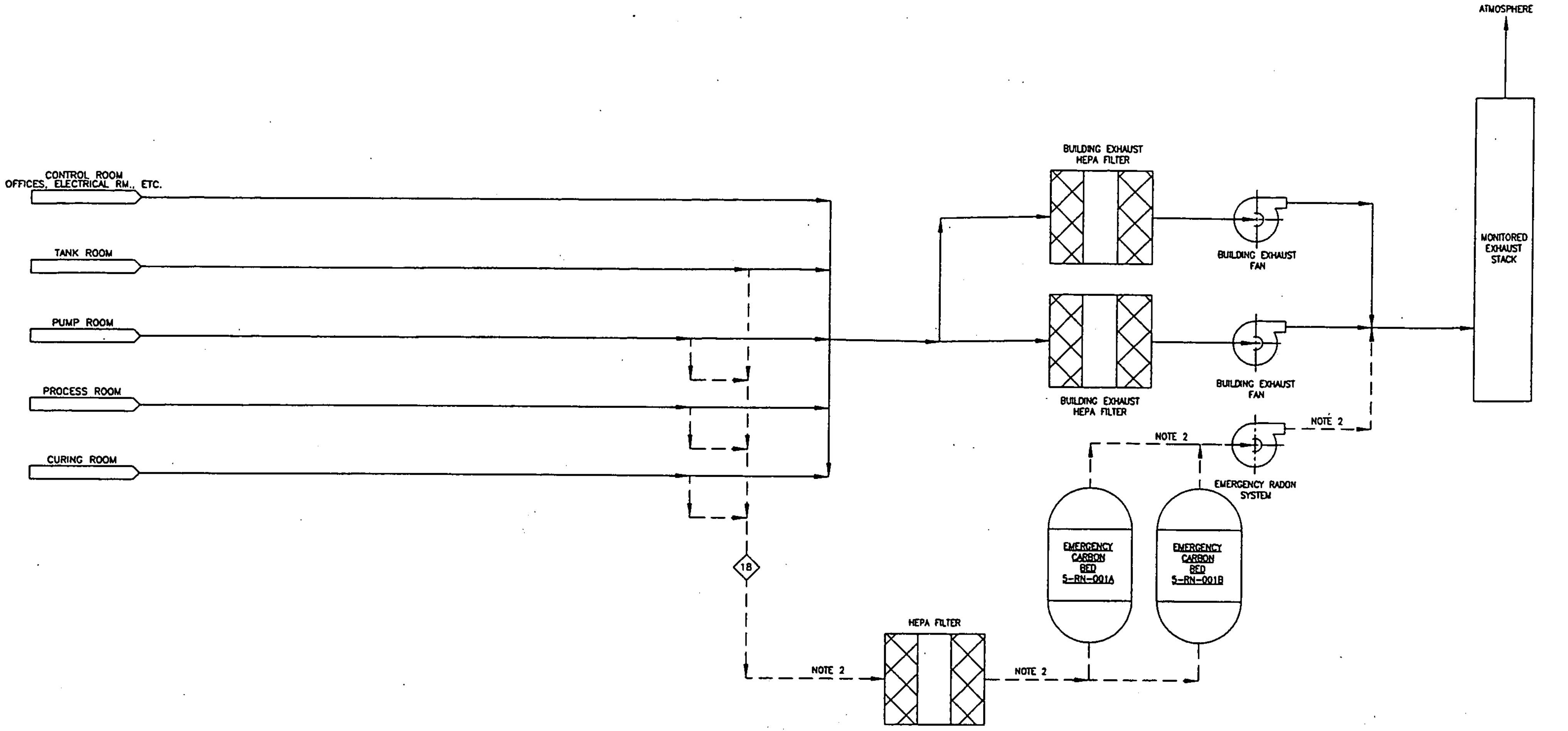
DR. | CK. | D.ENG.
PROJ. MGR. P. FRINK | F. BR. CH. | F. DIV. CH.
FAC/SYS.MGR. | E. BR. CH. | E. DIV. CH.
R. ENG. | R. BR. CH. | R. DIV. CH.

PROCESS FLOW DIAGRAM

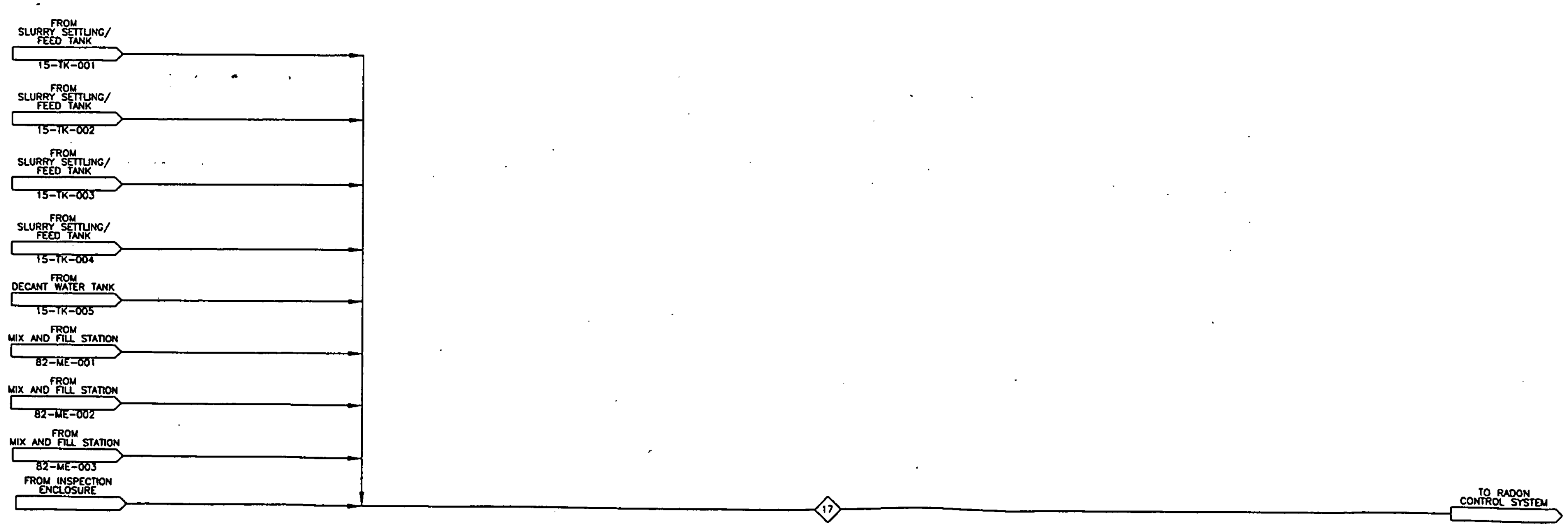
CHEMICAL STABILIZATION - OTHER TREATMENT SYSTEM

SCALE: NONE
REFERENCE

PF-003
MECHANICAL
DATE: 20 MAY 1999



MAIN BUILDING EXHAUST W/ EMERGENCY RADON CONTROL SYSTEM



VESSEL VENT SYSTEM

GENERAL NOTES

1. MAIN BUILDING EXHAUST SYSTEM SHOWN TO ILLUSTRATE EMERGENCY CARBON CONTROL SYSTEM INTERFACE.
2. — — — — — — INDICATES STANDBY SYSTEM.

2290

98

SYM	NO.	DESCRIPTION	APP/DATE
	0		P. FRINK/ 5/20/99

REVISIONS

DESIGN CONTRACTOR

PARSONS

PROCESS FLOW DIAGRAM

CHEMICAL STABILIZATION – OTHER VENTILLATION SYSTEMS

SCALE: NONE

REFERENCE

PF-004

MECHANICAL

DATE: 20 MAY 1999

APPENDIX B

LABORATORY ANALYTICAL RESULTS

(96 PAGES)

(These documents are not available electronically. Please go to Document Control for a hard copy.)

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210.
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: December 10, 1998

Sample ID	: CNS-120198-SO-D-1
Lab ID	: 9812285-01
Matrix	: TCLP
Date Collected	: 12/07/98
Date Received	: 12/07/98
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	MBL	12/10/98	0826	137485	1
Silver	U	ND	1.46	10.0	ug/l	2.0	MBL	12/09/98	2231	137484	2
Arsenic		13.1	9.02	10.0	ug/l	2.0					
Barium		260	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		41.4	1.12	10.0	ug/l	2.0					
Nickel		75.4	2.58	10.0	ug/l	2.0					
Lead		812	3.18	10.0	ug/l	2.0					
Antimony	U	ND	7.88	20.0	ug/l	2.0					
Selenium		156	5.42	10.0	ug/l	2.0					
Thallium	J	10.8	6.16	20.0	ug/l	2.0					
Vanadium	U	ND	1.18	10.0	ug/l	2.0					
Zinc	J	4.28	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	AJM	12/09/98	1745	137485	1
TCLP Prep for Metals	JL	12/07/98	1945	137351	3

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 1311

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SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: December 10, 1998

Sample ID : CNS-120198-SO-D-1

M = Method **Method-Description**

Notes:
The qualifiers in this report are defined as follows.
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories standard operating procedures. Please direct any questions to your Project Manager, Jack Spitz at (843) 769-7390.

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NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: December 10, 1998

Sample ID	: CNS-120198-SO-D-2
Lab ID	: 9812285-02
Matrix	: TCLP
Date Collected	: 12/07/98
Date Received	: 12/07/98
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	MBL	12/10/98	0828	137485	1
Silver	J	3.10	1.46	10.0	ug/l	2.0	MBL	12/09/98	2236	137484	2
Arsenic		85.0	9.02	10.0	ug/l	2.0					
Barium		234	1.02	10.0	ug/l	2.0					
Beryllium	J	1.10	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		1230	1.12	10.0	ug/l	2.0					
Nickel	J	6.42	2.58	10.0	ug/l	2.0					
Lead		17.9	3.18	10.0	ug/l	2.0					
Antimony		30.6	7.88	20.0	ug/l	2.0					
Selenium		289	5.42	10.0	ug/l	2.0					
Thallium	J	10.9	6.16	20.0	ug/l	2.0					
Vanadium		13.8	1.18	10.0	ug/l	2.0					
Zinc	J	4.65	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	AJM	12/09/98	1745	137485	1
TCLP Prep for Metals	JL	12/07/98	1945	137351	3

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 1311

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NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description	Hazardous Waste Characterization

cc: CNUC00398 Report Date: December 10, 1998

Sample ID : CNS-120198-SO-D-2

M = Method	Method-Description

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
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* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: December 10, 1998

Sample ID : CNS-120198-SO-D-3
Lab ID : 9812285-03
Matrix : TCLP
Date Collected : 12/07/98
Date Received : 12/07/98
Priority : Rush
Collector : Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	MBL	12/10/98	0830	137485	1
Silver	J	1.52	1.46	10.0	ug/l	2.0	MBL	12/09/98	2241	137484	2
Arsenic		85.7	9.02	10.0	ug/l	2.0					
Barium		244	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		1960	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead		10.2	3.18	10.0	ug/l	2.0					
Antimony		38.5	7.88	20.0	ug/l	2.0					
Selenium		333	5.42	10.0	ug/l	2.0					
Thallium	J	9.25	6.16	20.0	ug/l	2.0					
Vanadium		97.3	1.18	10.0	ug/l	2.0					
Zinc	J	9.76	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	AJM	12/09/98	1745	137485	1
TCLP Prep for Metals	JL	12/07/98	1945	137351	3

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 1311

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NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: December 10, 1998

Sample ID : CNS-120198-SO-D-3

M = Method **Method-Description**

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

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SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: December 10, 1998

Sample ID	: CNS-120198-SO-D-4
Lab ID	: 9812285-04
Matrix	: TCLP
Date Collected	: 12/07/98
Date Received	: 12/07/98
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	MBL	12/10/98	0835	137485	1
Silver	U	ND	1.46	10.0	ug/l	2.0	MBL	12/09/98	2247	137484	2
Arsenic		83.6	9.02	10.0	ug/l	2.0					
Barium		231	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		1510	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead	J	7.33	3.18	10.0	ug/l	2.0					
Antimony		29.2	7.88	20.0	ug/l	2.0					
Selenium		303	5.42	10.0	ug/l	2.0					
Thallium	J	7.48	6.16	20.0	ug/l	2.0					
Vanadium		81.0	1.18	10.0	ug/l	2.0					
Zinc	J	4.41	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Mercury	AJM	12/09/98	1745	137485	1
TCLP Prep for Metals	JL	12/07/98	1945	137351	3

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 1311

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NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: December 10, 1998

Sample ID : CNS 120198-SO-D-4

M = Method	Method-Description

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories standard operating procedures. Please direct any questions to your Project Manager, Jack Spitz at (843) 769-7390.

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SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398   Report Date: December 10, 1998

Sample ID : CNS-120198-SO-D-5
Lab ID : 9812285-05
Matrix : TCLP
Date Collected : 12/07/98
Date Received : 12/07/98
Priority : Rush
Collector : Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	MBL	12/10/98	0837	137485	1
Silver	J	1.80	1.46	10.0	ug/l	2.0	MBL	12/09/98	2252	137484	2
Arsenic		73.3	9.02	10.0	ug/l	2.0					
Barium		247	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		1170	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead	J	7.60	3.18	10.0	ug/l	2.0					
Antimony		30.7	7.88	20.0	ug/l	2.0					
Selenium		270	5.42	10.0	ug/l	2.0					
Thallium	J	11.5	6.16	20.0	ug/l	2.0					
Vanadium		94.0	1.18	10.0	ug/l	2.0					
Zinc	J	4.83	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Mercury	AJM	12/09/98	1745	137485	1
TCLP Prep for Metals	JL	12/07/98	1945	137351	3

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 1311

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NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: December 10, 1998

Sample ID : CNS-120198-SO-D-5

M = Method **Method-Description**

Notes:

The qualifiers in this report are defined as follows:

ND indicates that the analyte was not detected at a concentration greater than the detection limit.

J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).

U indicates that the analyte was not detected at a concentration greater than the detection limit.

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NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: December 17, 1998

Sample ID	: CNS-120198-SO-U-1
Lab ID	: 9812285-06
Matrix	: TCLP
Date Collected	: 12/07/98
Date Received	: 12/07/98
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	MBL	12/10/98	0838	137485	1
Silver	U	ND	1.46	10.0	ug/l	2.0	MBL	12/09/98	2258	137484	2
Arsenic		51.8	9.02	10.0	ug/l	2.0					
Barium		276	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		1250	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead	J	7.71	3.18	10.0	ug/l	2.0					
Antimony		29.8	7.88	20.0	ug/l	2.0					
Selenium		222	5.42	10.0	ug/l	2.0					
Thallium	J	9.56	6.16	20.0	ug/l	2.0					
Vanadium		95.2	1.18	10.0	ug/l	2.0					
Zinc	J	5.39	3.18	400	ug/l	2.0					

The following prep procedures were performed:

	Analyst	Date	Time	Batch	M
Mercury	AJM	12/09/98	1745	137485	1
TCLP Prep for Metals	JL	12/07/98	1945	137351	3

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 1311

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STATE	GEL	EPI
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NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: December 17, 1998

Sample ID : CNS-120198-SO-U-1

M = Method	Method-Description

Notes:
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ND indicates that the analyte was not detected at a concentration greater than the detection limit.
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NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 08, 1999

Sample ID	: SO-D-7A
Lab ID	: 9901006-01
Matrix	: TCLP
Date Collected	: 12/17/98
Date Received	: 01/04/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	Units	Method	Analyst	Date	Time	Batch
Metals Analysis								
Mercury	<	0.0200	mg/l	EPA 7470	MBL	01/06/99	0703	139093
Silver	<	10.0	ug/l	EPA 6010A	MBL	01/06/99	0946	139092
Arsenic		84.1	ug/l	EPA 6010A				
Barium		169	ug/l	EPA 6010A				
Beryllium	<	10.0	ug/l	EPA 6010A				
Cadmium	<	10.0	ug/l	EPA 6010A				
Chromium		2170	ug/l	EPA 6010A				
Nickel	<	10.0	ug/l	EPA 6010A				
Lead	<	10.0	ug/l	EPA 6010A				
Antimony		34.2	ug/l	EPA 6010A				
Selenium		270	ug/l	EPA 6010A				
Thallium	<	20.0	ug/l	EPA 6010A				
Vanadium		72.9	ug/l	EPA 6010A				
Zinc	<	400	ug/l	EPA 6010A				

The following prep procedures were performed:

Procedure	Method	Analyst	Date	Time	Batch
Mercury	EPA 7470A	AJM	01/05/99	1800	139093
TCLP Prep for Metals	EPA 1311	JL	01/04/99	1500	138997

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 08, 1999

Sample ID : SO-D-7A

Parameter	Qualifier	Result	Units	Method	Analyst	Date	Time	Batch

This data report has been prepared and reviewed
in accordance with General Engineering Laboratories
standard operating procedures. Please direct
any questions to your Project Manager, Jack Spitz at (843) 769-7390.

Thomas N. [signature]

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NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 26, 1999

Sample ID	: SO-D-7B
Lab ID	: 9901647-04
Matrix	: TCLP
Date Collected	: 12/17/98
Date Received	: 01/21/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	01/25/99	1635	140592	1
Silver	U	ND	1.46	10.0	ug/l	2.0	MBL	01/25/99	1533	140562	2
Arsenic		69.8	9.02	10.0	ug/l	2.0	MBL	01/26/99	0806	140562	2
Barium		160	1.02	10.0	ug/l	2.0	MBL	01/25/99	1533	140562	2
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		1710	1.12	10.0	ug/l	2.0					
Nickel	J	2.68	2.58	10.0	ug/l	2.0					
Lead		42.9	3.18	10.0	ug/l	2.0					
Antimony		25.8	7.88	20.0	ug/l	2.0					
Selenium		247	5.42	10.0	ug/l	2.0					
Thallium	J	18.5	6.16	20.0	ug/l	2.0					
Vanadium		59.2	1.18	10.0	ug/l	2.0					
Zinc	J	3.95	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Mercury	RMJ	01/25/99	1130	140592	3
TCLP Prep for Metals	JL	01/21/99	2050	140307	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 26, 1999

Sample ID : SO-D-7B

M = Method **Method-Description**

Notes:
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ND indicates that the analyte was not detected at a concentration greater than the detection limit.
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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398   Report Date: March 16, 1999

Sample ID	: SO-D-7B
Lab ID	: 9903525-02
Matrix	: Solid
Date Collected	: 03/15/99
Date Received	: 03/15/99
Priority	: Urgent
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Cyanide, Reactive	U	ND	0.0139	250	mg/kg	1.0	HSC	03/15/99	2106	144594	1
Sulfide, Reactive	U	ND	0.0150	500	mg/kg	1.0	JBK	03/15/99	1900	144559	2
Flash Point, closed cup	>	145	140	140	F	1.0	JBH	03/16/99	1000	144639	3
Corrosivity (pH <2 or >12)		12.4	0.0100	0.100	SU	1.0	LAA	03/15/99	1530	144606	4

M = Method	Method-Description
M 1	SW-846 Chapter 7-7.3.3
M 2	SW-846 Chapter 7-7.3.4
M 3	SW 846 1010
M 4	EPA 9045C

Notes:
The qualifiers in this report are defined as follows:
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* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

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CNVC 00598

1042

CHAIN-OF-CUSTODY RECORD

Location: CNCF - Lab

Project/Number: FDF-POP/46692

Sample Type(s): Solid

Sample Analysis Required: TCLP FOR ALL UTS METALS

CHEM-NUCLEAR SYSTEMS
Consolidation Facility
16043 Dunbarton Blvd
Barnwell, SC 29812

Page 1 of 1

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Total	Remarks
9812285-01	CNS-120198-SO-D-1	120798		100 Gm SAMPLE
02	CNS-120198-SO-D-2	120798		"
03	CNS-120198-SO-D-3	120798		"
04	CNS-120198-SO-D-4	120798		"
05	CNS-120198-SO-D-5	120798		"
06	CNS-120198-SO-V-1	120798		"

Sampled by CARL STUCKEY

Total # of Container

Relinquished by: CARL STUCKEY
Date: 12/07/98
Received by: [signature]
Organization: CHEM-NUCLEAR SYSTEMS
Time: 1105
Organization: GEL

Relinquished by:
Date: 12-7-98
Received by: [signature]
Organization: GEL
Time: 1645
Organization: G.E.L

Relinquished by:
Date:
Received by:
Organization:
Time:
Organization:

Delivery Method:
Shipping container ID:

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0662

CNUC 005

CHAIN-OF-CUSTODY RECORD 9901006

CHEM-NUCLEAR SYSTEMS
Consolidation Facility (37092)
16043 Dunbarton Blvd
Barnwell, SC 29812

Page 1 of 1

Location: CNCF - Lab

Project/Number: FDF-POP/46692

Sample Type(s): Solid

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required										Total	Remarks
					TCLP on UTS Metals									
-01	SO-D-7A	12/17/98			X								1	Prepare Sample for TCLP analysis
02	SO-U-4A	12/17/98			X								1	↓
03	SO-U-5A	12/17/98			X								1	↓

Sampled by John Carlsen

Total # of Containers 3

Relinquished by: [signature] Date: 12/23/98 Received by: [signature]

Organization: CNS Time: Organization:

Relinquished by: Date: Received by:

Organization: Time: Organization:

Relinquished by: Date: Received by:

Organization: Time: Organization:

Delivery Method: Shipping container ID:

8/1

2290

CHAIN-OF-CUSTODY RECORD

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803)259-1781

Page 1 of 1

Location: CNCF-LAB

Project/Number: FDF/PUP 46692

Sample Type(s): Solid

Sample Analysis Required

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	TCLP or UTS Metals	Total	Remarks
	50-U-6B	1/12/99	✓	1	Prepare sample for TCLP Analyses
	50-U-7B	1/12/99	✓	1	
	50-U-8B	1/12/99	✓	1	↓
	50-D-7B	12/17/98	✓	1	

Total # of Container 4

Sampled by DAN HOWARD

Relinquished by: [signature]
Organization: CNS
Date: 1/20/99
Time: 915
Received by: A VAN DOREN [signature]
Organization: GEL

Relinquished by:
Organization:
Date:
Time:
Received by:
Organization:

Relinquished by:
Organization:
Date:
Time:
Received by:
Organization:

Delivery Method:

Shipping container ID:

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STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 08, 1999

Sample ID	: SO-U-4A
Lab ID	: 9901006-02
Matrix	: TCLP
Date Collected	: 12/17/98
Date Received	: 01/04/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	Units	Method	Analyst	Date	Time	Batch
Metals Analysis								
Mercury	<	0.0200	mg/l	EPA 7470	MBL	01/06/99	0705	139093
Silver	<	10.0	ug/l	EPA 6010A	MBL	01/06/99	0951	139092
Arsenic		45.6	ug/l	EPA 6010A				
Barium		164	ug/l	EPA 6010A				
Beryllium	<	10.0	ug/l	EPA 6010A				
Cadmium	<	10.0	ug/l	EPA 6010A				
Chromium		1490	ug/l	EPA 6010A				
Nickel	<	10.0	ug/l	EPA 6010A				
Lead	<	10.0	ug/l	EPA 6010A				
Antimony		30.1	ug/l	EPA 6010A				
Selenium		212	ug/l	EPA 6010A				
Thallium	<	20.0	ug/l	EPA 6010A				
Vanadium		89.3	ug/l	EPA 6010A				
Zinc	<	400	ug/l	EPA 6010A				

The following prep procedures were performed:

Procedure	Method	Analyst	Date	Time	Batch
Mercury	EPA 7470A	AJM	01/05/99	1800	139093
TCLP Prep for Metals	EPA 1311	JL	01/04/99	1500	138997

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STATE	GEL	EPI
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SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 08, 1999

Sample ID : SO-U-4A

Parameter	Qualifier	Result	Units	Method	Analyst	Date	Time	Batch

This data report has been prepared and reviewed in accordance with General Engineering Laboratories standard operating procedures. Please direct any questions to your Project Manager, Jack Spitz at (843) 769-7390.

Thomas M. Seabrook

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STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 08, 1999

Sample ID	: SO-U-5A
Lab ID	: 9901006-03
Matrix	: TCLP
Date Collected	: 12/17/98
Date Received	: 01/04/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	Units	Method	Analyst	Date	Time	Batch
Metals Analysis								
Mercury	<	0.0200	mg/l	EPA 7470	MBL	01/06/99	0710	139093
Silver	<	10.0	ug/l	EPA 6010A	MBL	01/06/99	0957	139092
Arsenic		47.9	ug/l	EPA 6010A				
Barium		200	ug/l	EPA 6010A				
Beryllium	<	10.0	ug/l	EPA 6010A				
Cadmium	<	10.0	ug/l	EPA 6010A				
Chromium		1050	ug/l	EPA 6010A				
Nickel	<	10.0	ug/l	EPA 6010A				
Lead	<	10.0	ug/l	EPA 6010A				
Antimony		30.6	ug/l	EPA 6010A				
Selenium		202	ug/l	EPA 6010A				
Thallium	<	20.0	ug/l	EPA 6010A				
Vanadium		100	ug/l	EPA 6010A				
Zinc	<	400	ug/l	EPA 6010A				

The following prep procedures were performed:

Procedure	Method	Analyst	Date	Time	Batch
Mercury	EPA 7470A	AJM	01/05/99	1800	139093
TCLP Prep for Metals	EPA 1311	JL	01/04/99	1500	138997

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 08, 1999

Sample ID : SO-U-5A

Parameter	Qualifier	Result	Units	Method	Analyst Date	Time	Batch

This data report has been prepared and reviewed in accordance with General Engineering Laboratories standard operating procedures. Please direct any questions to your Project Manager, Jack Spitz at (843) 769-7390.

Thomas M. [signature]

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NC	233	
SC	10120	10582
TN	02934	02934

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Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398

Report Date: February 19, 1999

Sample ID	: SO-U-6A
Lab ID	: 9902552-01
Matrix	: TCLP
Date Collected	: 01/12/99
Date Received	: 02/12/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	02/17/99	1646	142601	1
Silver	U	ND	7.30	50.0	ug/l	10.	MBL	02/19/99	0920	142544	2
Arsenic	U	ND	45.1	50.0	ug/l	10.					
Barium		159	5.10	50.0	ug/l	10.					
Beryllium	U	ND	0.520	10.0	ug/l	2.0	MBL	02/18/99	1532	142544	2
Cadmium	U	ND	4.40	50.0	ug/l	10.	MBL	02/19/99	0920	142544	2
Chromium		377	5.60	50.0	ug/l	10.					
Nickel	U	ND	12.9	50.0	ug/l	10.					
Lead	U	ND	15.9	50.0	ug/l	10.					
Antimony	U	ND	39.4	100	ug/l	10.					
Selenium		138	27.1	50.0	ug/l	10.					
Thallium	J	17.4	6.16	20.0	ug/l	2.0	MBL	02/18/99	1532	142544	2
Vanadium		67.4	5.90	50.0	ug/l	10.	MBL	02/19/99	0920	142544	2
Zinc	U	ND	15.9	2000	ug/l	10.					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	RMJ	02/17/99	1100	142601	3
TCLP Prep for Metals	JL	02/15/99	1650	142140	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: February 19, 1999

Sample ID : SO-U-6A

M = Method **Method-Description**

Notes:
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NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 16, 1999 Page 1 of 1

Sample ID	: SO-U-6A
Lab ID	: 9903525-01
Matrix	: Solid
Date Collected	: 03/15/99
Date Received	: 03/15/99
Priority	: Urgent
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Cyanide, Reactive	U	ND	0.0139	250	mg/kg	1.0	HSC	03/15/99	2105	144594	1
Sulfide, Reactive	J	0.0450	0.0150	500	mg/kg	1.0	JBK	03/15/99	1900	144559	2
Flash Point, closed cup	>	145	140	140	F	1.0	JBH	03/16/99	1000	144639	3
Corrosivity (pH <2 or >12)		12.3	0.0100	0.100	SU	1.0	LAA	03/15/99	1530	144606	4

M = Method	Method-Description
M 1	SW-846 Chapter 7-7.3.3
M 2	SW-846 Chapter 7-7.3.4
M 3	SW 846 1010
M 4	EPA 9045C

Notes:
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STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 26, 1999

Sample ID	: SO-U-6B
Lab ID	: 9901647-01
Matrix	: TCLP
Date Collected	: 01/12/99
Date Received	: 01/21/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	01/25/99	1630	140592	1
Silver	J	2.00	1.46	10.0	ug/l	2.0	MBL	01/25/99	1517	140562	2
Arsenic		50.6	9.02	10.0	ug/l	2.0	MBL	01/26/99	0749	140562	2
Barium		208	1.02	10.0	ug/l	2.0	MBL	01/25/99	1517	140562	2
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		536	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead		34.1	3.18	10.0	ug/l	2.0					
Antimony		26.7	7.88	20.0	ug/l	2.0					
Selenium		180	5.42	10.0	ug/l	2.0					
Thallium	J	14.5	6.16	20.0	ug/l	2.0					
Vanadium		92.8	1.18	10.0	ug/l	2.0					
Zinc	U	ND	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	RMJ	01/25/99	1130	140592	3
TCLP Prep for Metals	JL	01/21/99	2050	140307	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 26, 1999

Sample ID : SO-U-6B

M = Method **Method-Description**

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

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STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 26, 1999

Sample ID	: SO-U-7B
Lab ID	: 9901647-02
Matrix	: TCLP
Date Collected	: 01/12/99
Date Received	: 01/21/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	01/25/99	1631	140592	1
Silver	U	ND	1.46	10.0	ug/l	2.0	MBL	01/25/99	1522	140562	2
Arsenic		40.7	9.02	10.0	ug/l	2.0	MBL	01/26/99	0755	140562	2
Barium		222	1.02	10.0	ug/l	2.0	MBL	01/25/99	1522	140562	2
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		521	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead		24.4	3.18	10.0	ug/l	2.0					
Antimony		28.7	7.88	20.0	ug/l	2.0					
Selenium		173	5.42	10.0	ug/l	2.0					
Thallium	J	18.7	6.16	20.0	ug/l	2.0					
Vanadium		92.9	1.18	10.0	ug/l	2.0					
Zinc	J	3.98	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Mercury	RMJ	01/25/99	1130	140592	3
TCLP Prep for Metals	JL	01/21/99	2050	140307	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 26, 1999

Sample ID : SO-U-7B

M = Method **Method-Description**

Notes:
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ND indicates that the analyte was not detected at a concentration greater than the detection limit.
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STATE	GEL	EPI
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NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 26, 1999

Sample ID	: SO-U-8B
Lab ID	: 9901647-03
Matrix	: TCLP
Date Collected	: 01/12/99
Date Received	: 01/21/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	01/25/99	1633	140592	1
Silver	U	ND	1.46	10.0	ug/l	2.0	MBL	01/25/99	1528	140562	2
Arsenic		33.9	9.02	10.0	ug/l	2.0	MBL	01/26/99	0800	140562	2
Barium		235	1.02	10.0	ug/l	2.0	MBL	01/25/99	1528	140562	2
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		644	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead		18.6	3.18	10.0	ug/l	2.0					
Antimony		22.5	7.88	20.0	ug/l	2.0					
Selenium		157	5.42	10.0	ug/l	2.0					
Thallium	J	15.3	6.16	20.0	ug/l	2.0					
Vanadium		96.9	1.18	10.0	ug/l	2.0					
Zinc	J	4.28	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Mercury	RMJ	01/25/99	1130	140592	3
TCLP Prep for Metals	JL	01/21/99	2050	140307	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: January 26, 1999

Sample ID : SO-U-8B

M = Method **Method-Description**

Notes:

The qualifiers in this report are defined as follows:

ND indicates that the analyte was not detected at a concentration greater than the detection limit.

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CNUC 0034

CHAIN-OF-CUSTODY RECORD

9901006½

37092

Location: CNCF - Lab

Project/Number: FDF-POP/46692

Sample Type(s): Solid

CHEM-NUCLEAR SYSTEMS
Consolidation Facility
16043 Dunbarton Blvd
Barnwell, SC 29812

Page 1 of 1

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required		TCLP on UTS Metals								Total	Remarks
-01	SO-D-7A	12/17/98			X								1	Prepare Sample for TCLP analysis
02	SO-U-4A	12/17/98			X								1	↓
03	SO-U-5A	12/17/98			X								1	↓

Sampled by John Carlsen

Total # of Container 3

Relinquished by: [signature] Date: 12/23/98 Received by: [signature]

Organization: CNS Time: Organization:

Relinquished by: Date: Received by:

Organization: Time: Organization:

Relinquished by: Date: Received by:

Organization: Time: Organization:

Delivery Method: Shipping container ID:

2290

CNU00398

37092

CHAIN-OF-CUSTODY RECORD 9901647%

Location: CNCF-LAB

Project/Number: FDF/PUP - 40692

Sample Type(s): Solid

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803)259-1781

Page 1 of 1

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required: TCLP or UTS Metals										Total	Remarks
-01	50-U-6B	1/12/99	✓										1	Prepare sample for TCLP Analyses
-02	50-U-7B	1/12/99	✓										1	
-03	50-U-8B	1/12/99	✓										1	↓
-04	50-D-7B	12/17/98	✓										1	

Sampled by: DAN HOWARD

Total # of Container: 4

Relinquished by: [signature] Date: 1/20/99

Organization: CNS Time: 915

Received by: A VAN DOREN [signature]

Organization: GEL

Received by: [signature] 1/21/99

Organization: ______

Relinquished by: ______ Date: ______

Organization: ______ Time: ______

Received by: ______

Organization: ______

Relinquished by: ______ Date: ______

Organization: ______ Time: ______

Received by: ______

Organization: ______

Delivery Method: ______

Shipping container ID: ______

2290

CNUC00597

37092

CHAIN-OF-CUSTODY RECORD

Location: CNCF - Lab

Project/Number: FDF-POP/46692

Sample Type(s): Solid

CHEM-NUCLEAR SYSTEMS
Consolidation Facility
16043 Dunbarton Blvd.
Barnwell, SC 29812

Page 1 of 1

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required: TCLP FOR UTS METALS										Total	Remarks
9902552-01	SO-U-6A	1-12-99	X										1	PREPARE SAMPLE
														FOR TCLP TESTING

Sampled by JOHN CARLSON — Total # of Container:

Relinquished by: C.L. Stuckey (signature) — Date: 2-11-99 — Received by: A VAN DOREN (signature)

Organization: CNS — Time: 1210 — Organization: GEL

Relinquished by: — Date: 2/12/99 — Received by: (signature)

Organization: — Time: — Organization:

Relinquished by: — Date: — Received by:

Organization: — Time: — Organization:

Delivery Method: — Shipping container ID:

000623

135

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 02, 1999

Sample ID	: SI-T-2A
Lab ID	: 9902879-01
Matrix	: TCLP
Date Collected	: 02/16/99
Date Received	: 02/23/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	03/02/99	1115	143459	1
Silver	J	3.66	1.46	10.0	ug/l	2.0	MBL	03/02/99	1248	143412	2
Arsenic	U	ND	9.02	10.0	ug/l	2.0					
Barium		73.2	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		77.4	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead	U	ND	3.18	10.0	ug/l	2.0					
Antimony	J	15.1	7.88	20.0	ug/l	2.0					
Selenium		219	5.42	10.0	ug/l	2.0					
Thallium	U	ND	6.16	20.0	ug/l	2.0					
Vanadium		65.2	1.18	10.0	ug/l	2.0					
Zinc	J	12.5	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	RMJ	03/01/99	1725	143459	3
TCLP Prep for Metals	JL	02/25/99	2210	143106	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 02, 1999

Sample ID : SI-T-2A

M = Method **Method-Description**

Notes:
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* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories standard operating procedures. Please direct any questions to your Project Manager, Jack Spitz at (843) 769-7390.

Reviewed By

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398

Report Date: March 16, 1999

Sample ID	: S1-T-2A
Lab ID	: 9903423-02
Matrix	: Solid
Date Collected	: 03/11/99
Date Received	: 03/11/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Cyanide, Reactive	U	ND	0.0139	250	mg/kg	1.0	HSC	03/15/99	2102	144594	1
Sulfide, Reactive	U	ND	0.0150	500	mg/kg	1.0	JBK	03/15/99	1900	144559	2
Flash Point, closed cup	>	145	140	140	F	1.0	JBH	03/16/99	1000	144639	3
Corrosivity (pH <2 or >12)		12.5	0.0100	0.100	SU	1.0	LAA	03/11/99	2116	144444	4

M = Method	Method-Description
M 1	SW-846 Chapter 7-7.3.3
M 2	SW-846 Chapter 7-7.3.4
M 3	SW 846 1010
M 4	EPA 9045C

Notes:
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Flora [signature]

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 02, 1999

Sample ID	: SI-T-3A
Lab ID	: 9902879-02
Matrix	: TCLP
Date Collected	: 02/16/99
Date Received	: 02/23/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	03/02/99	1117	143459	1
Silver	J	2.43	1.46	10.0	ug/l	2.0	MBL	03/02/99	1254	143412	2
Arsenic	U	ND	9.02	10.0	ug/l	2.0					
Barium		83.4	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		215	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead	U	ND	3.18	10.0	ug/l	2.0					
Antimony	U	ND	7.88	20.0	ug/l	2.0					
Selenium		234	5.42	10.0	ug/l	2.0					
Thallium	U	ND	6.16	20.0	ug/l	2.0					
Vanadium		38.5	1.18	10.0	ug/l	2.0					
Zinc	J	11.0	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	RMJ	03/01/99	1725	143459	3
TCLP Prep for Metals	JL	02/25/99	2210	143106	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 02, 1999

Sample ID : SI-T-3A

M = Method	Method-Description

Notes:

The qualifiers in this report are defined as follows:

ND indicates that the analyte was not detected at a concentration greater than the detection limit.

J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 16, 1999 Page 1 of 1

Sample ID	: S1-T-3A
Lab ID	: 9903423-01
Matrix	: Solid
Date Collected	: 03/11/99
Date Received	: 03/11/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Cyanide, Reactive	U	ND	0.0139	250	mg/kg	1.0	HSC	03/15/99	2101	144594	1
Sulfide, Reactive	U	ND	0.0150	500	mg/kg	1.0	JBK	03/15/99	1900	144559	2
Flash Point, closed cup	>	145	140	140	F	1.0	JBH	03/16/99	1000	144639	3
Corrosivity (pH <2 or >12)		12.9	0.0100	0.100	SU	1.0	LAA	03/11/99	2115	144444	4

M = Method	Method-Description
M 1	SW-846 Chapter 7-7.3.3
M 2	SW-846 Chapter 7-7.3.4
M 3	SW 846 1010
M 4	EPA 9045C

Notes:
The qualifiers in this report are defined as follows:
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CNUC 00398

38414

CHAIN-OF-CUSTODY RECORD

9902634%

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803) 259-1781

Page 1 of 1

Location: CNCF - Lab

Project/Number: FDF - POP/46692

Sample Type(s): Solid

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	COMPLETE UTS METALS									Total	Remarks
.01	SI-T-2A		✓									1	
	~~SI-T-2B~~	DNH 2/16/99										~~1~~	DNH
.02	SI-T-3A		✓									1	
	~~SI-T-3B~~	DNH 2/16/99										~~1~~	DNA

Total # of Container ~~4~~ 2 DNH

Sampled by ____________

Relinquished by: D N HOWARD
Organization: CNS
Date: 2 16 99
Time: 1210

Received by: A VanDoren A VAN DOREN
Organization: GEL

Date: 2/16/99

Received by: S Francis
Organization:

Relinquished by:
Organization:
Time:

Received by:
Organization:

Relinquished by:
Organization:
Date:
Time:

Shipping container ID:

Delivery Method:

AL AS BA CA CR FE K

NA NI P PB S SE SI

CNUC00[illegible]

CHAIN OF COSTODY RECORD

General Engineering L[illegible]ies, Inc.
2040 Savage Road
Charleston, South Carolina 29407
P.O. Box 30712
Charleston, South Carolina 29417
(803) 556-8171

Page_____ of _____

9902879 %

Client Name/Facility Name: Chem Nuclear

Collected by/Company: AHMAD GHANDOUR

SAMPLE ANALYSIS REQUIRED (x) - use remarks area to specify specific compounds or methods

Use F or P in the boxes to indicate whether sample was filtered and/or preserved

37092

	SAMPLE ID	DATE	TIME	WELL	SOIL	COMP	GRAB	# OF CONTAINERS	pH, conductivity	TOC/DOC	TOX	Chloride, Fluoride, Sulfide	Nitrite/Nitrate	VOC - Specify Method required	METALS - specify	Pesticide	Herbicide	Total Phenol	Acid Extractables	B/N Extractables	PCB's	Cyanide	Coliform - specify type			Remarks
-01	9902634-01 Si-T-2A	2/16/99	1200																							TCLP Metals
-02	9902634-02 Si-T-3A	2/16/99	1200																							↓ (NO CHARGE)

Relinquished by:	Date:	Time:	Received by:	Relinquished by:	Date:	Time:	Received by:

Relinquished by:	Date:	Time:	Received by lab by:	Date:	Time:	Remarks:
			[signature]	2/23/99		

White = sample collector Yellow = file Pink = with report

0 9 2 9 0

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 03, 1999

Sample ID	: S2-T-2A
Lab ID	: 9902926-01
Matrix	: TCLP
Date Collected	: 02/16/99
Date Received	: 02/24/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	03/02/99	1126	143459	1
Silver	J	2.87	1.46	10.0	ug/l	2.0	MBL	03/02/99	1259	143412	2
Arsenic		44.9	9.02	10.0	ug/l	2.0					
Barium		80.4	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		229	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead	U	ND	3.18	10.0	ug/l	2.0					
Antimony	J	9.22	7.88	20.0	ug/l	2.0					
Selenium		305	5.42	10.0	ug/l	2.0					
Thallium	U	ND	6.16	20.0	ug/l	2.0					
Vanadium		73.0	1.18	10.0	ug/l	2.0					
Zinc	J	13.5	3.18	400	ug/l	2.0					

The following prep procedures were performed:

	Analyst	Date	Time	Batch	M
Mercury	RMJ	03/01/99	1725	143459	3
TCLP Prep for Metals	JL	02/25/99	2210	143106	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 03, 1999

Sample ID : S2-T-2A

M = Method **Method-Description**

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

This data report has been prepared and reviewed
in accordance with General Engineering Laboratories
standard operating procedures. Please direct
any questions to your Project Manager, Jack Spitz at (843) 769-7390.

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STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 06, 1999

Sample ID	: S2-T-2A
Lab ID	: 9902926-02
Matrix	: Misc.
Date Collected	: 02/16/99
Date Received	: 02/24/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Corrosivity (pH <2 or >12)		12.3	0.0100	0.100	SU	1.0	LAA	02/26/99	1825	143404	1
pH - 2 items											
pH		12.3	0.0100	0.100	SU	1.0	LAA	02/26/99	1735	143381	1
pH Temperature		23.7	0.100	0.100	C	1.0					

M = Method	Method-Description
M 1	EPA 9045C

Notes:
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in accordance with General Engineering Laboratories
standard operating procedures. Please direct
any questions to your Project Manager, Flora Ingram at (843) 556-8171.

Reviewed By

CdUC00397

JLS

37092.1

147

CHAIN-OF-CUSTODY RECORD

9902926%.

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803)259-1781

Location: CNCF

Project/Number: FDF-PUP / 40692

Sample Type(s): Solid

Sample Analysis Required: TCLP for UTS Metals; RCRA CHAR; Per Ahmad Ghadour by Phone JLS

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	TCLP for UTS Metals	RCRA CHAR									Total	Remarks
01	52-T-2A	2/16/99	✓	✓									1	

Total # of Container

.1

38642.1

Sampled by D. Howard

Relinquished by: D N Howard
Organization: CNS
Date: 2/24/99
Time: 1332

Received by: A VanDoren
Organization: GEL

Date: 2/24/99
Time: 17:00

Received by: K. Naner

Relinquished by:
Organization:
Date:
Time:

Organization:

Received by:

Relinquished by:
Organization:

Organization:

Shipping container ID:

Delivery Method:

09/23/98 WED 08:46 FAX 803 259 1781 CHEM NUCLEAR 002

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87473/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 04, 1999

Sample ID	: B3D2CORE
Lab ID	: 9902993-01
Matrix	: TCLP
Date Collected	: 02/24/99
Date Received	: 02/25/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	03/04/99	1045	143690	1
Silver	U	ND	1.46	10.0	ug/l	2.0	MBL	03/04/99	1207	143688	2
Arsenic		15.4	9.02	10.0	ug/l	2.0					
Barium		207	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		731	1.12	10.0	ug/l	2.0					
Nickel	J	9.93	2.58	10.0	ug/l	2.0					
Lead	J	5.88	3.18	10.0	ug/l	2.0					
Antimony	U	ND	7.88	20.0	ug/l	2.0					
Selenium		157	5.42	10.0	ug/l	2.0					
Thallium	J	6.97	6.16	20.0	ug/l	2.0					
Vanadium		34.4	1.18	10.0	ug/l	2.0					
Zinc	J	18.9	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Mercury	RMJ	03/03/99	1530	143690	3
TCLP Prep for Metals	JL	03/01/99	1835	143435	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 04, 1999

Sample ID : B3D2CORE

M = Method **Method-Description**

Notes:
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ND indicates that the analyte was not detected at a concentration greater than the detection limit.
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in accordance with General Engineering Laboratories
standard operating procedures. Please direct
any questions to your Project Manager, Flora Ingram at (843) 556-8171.

Reviewed By

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STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 12, 1999

Sample ID	: B3D2CORE
Lab ID	: 9902993-04
Matrix	: Misc.
Date Collected	: 02/24/99
Date Received	: 02/25/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Cyanide, Reactive	U	ND	0.0139	250	mg/kg	1.0	HSC	03/15/99	2057	144594	1
Sulfide, Reactive	U	ND	0.0450	500	mg/kg	1.0	JBK	03/15/99	1900	144559	2
Paint Filter Test		pass					JBK	03/10/99	1645	144346	3
Flash Point, closed cup	>	145	140	140	F	1.0	JBH	03/16/99	1000	144639	4
Corrosivity (pH <2 or >12)		12.8	0.0100	0.100	SU	1.0	LAA	02/26/99	1900	143404	5
pH - 2 items											
pH		12.8	0.0100	0.100	SU	1.0	LAA	02/26/99	1809	143381	5
pH Temperature		22.0	0.100	0.100	C	1.0					

M = Method	Method-Description
M 1	SW-846 Chapter 7-7.3.3
M 2	SW-846 Chapter 7-7.3.4
M 3	EPA 9095
M 4	SW 846 1010
M 5	EPA 9045C

Notes:
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* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

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STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 12, 1999

Sample ID : B3D2CORE

M = Method **Method-Description**

This data report has been prepared and reviewed
in accordance with General Engineering Laboratories
standard operating procedures. Please direct
any questions to your Project Manager, Flora Ingram at (843) 556-8171.

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STATE	GEL	EPI
FL	E87156/87294	EK7472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398

Report Date: March 12, 1999

Sample ID : B6D2CORE

M = Method Method-Description

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
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Flora Ingram

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 16, 1999

Sample ID	: B6D2CORE
Lab ID	: 9902993-05
Matrix	: Misc.
Date Collected	: 02/24/99
Date Received	: 02/25/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Cyanide, Reactive	U	ND	0.0139	250	mg/kg	1.0	HSC	03/15/99	2058	144594	1
lfide, Reactive	U	ND	0.0150	500	mg/kg	1.0	JBK	03/15/99	1900	144559	2
nt Filter Test		pass					JBK	03/10/99	1645	144346	3
ash Point, closed cup	>	145	140	140	F	1.0	JBH	03/16/99	1000	144639	4
Corrosivity (pH <2 or >12)		12.8	0.0100	0.100	SU	1.0	LAA	02/26/99	1911	143404	5
pH - 2 items											
pH		12.8	0.0100	0.100	SU	1.0	LAA	02/26/99	1811	143381	6
pH Temperature		22.2	0.100	0.100	C	1.0					

M = Method	Method-Description
M 1	SW-846 Chapter 7-7.3.3
M 2	SW-846 Chapter 7-7.3.4
M 3	EPA 9095
M 4	SW 846 1010
M 5	EPA 9045C
M 6	EPA 9045

Notes:
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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 16, 1999

Sample ID	: B6D2CORE
Lab ID	: 9902993-05
Matrix	: Misc.
Date Collected	: 02/24/99
Date Received	: 02/25/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Cyanide, Reactive	U	ND	0.0139	250	mg/kg	1.0	HSC	03/15/99	2058	144594	1
Sulfide, Reactive	U	ND	0.0150	500	mg/kg	1.0	JBK	03/15/99	1900	144559	2
Paint Filter Test		pass					JBK	03/10/99	1645	144346	3
Flash Point, closed cup	>	145	140	140	F	1.0	JBH	03/16/99	1000	144639	4
Corrosivity (pH <2 or >12)		12.8	0.0100	0.100	SU	1.0	LAA	02/26/99	1911	143404	5
pH - 2 items											
pH		12.8	0.0100	0.100	SU	1.0	LAA	02/26/99	1811	143381	6
pH Temperature		22.2	0.100	0.100	C	1.0					

M = Method	Method-Description
M 1	SW-846 Chapter 7-7.3.3
M 2	SW-846 Chapter 7-7.3.4
M 3	EPA 9095
M 4	SW 846 1010
M 5	EPA 9045C
M 6	EPA 9045

Notes:

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U indicates that the analyte was not detected at a concentration greater than the detection limit.

* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 16, 1999

Sample ID : B6D2CORE

M = Method	Method-Description

This data report has been prepared and reviewed in accordance with General Engineering Laboratories standard operating procedures. Please direct any questions to your Project Manager, Flora Ingram at (843) 556-8171.

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 04, 1999

Sample ID	: B9D2CORE
Lab ID	: 9902993-03
Matrix	: TCLP
Date Collected	: 02/24/99
Date Received	: 02/25/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	03/04/99	1048	143690	1
Silver	U	ND	1.46	10.0	ug/l	2.0	MBL	03/04/99	1218	143688	2
Arsenic	J	9.40	9.02	10.0	ug/l	2.0					
Barium		317	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		582	1.12	10.0	ug/l	2.0					
Nickel	J	8.81	2.58	10.0	ug/l	2.0					
Lead	J	7.45	3.18	10.0	ug/l	2.0					
Antimony	U	ND	7.88	20.0	ug/l	2.0					
Selenium		100	5.42	10.0	ug/l	2.0					
Thallium	J	8.14	6.16	20.0	ug/l	2.0					
Vanadium		12.6	1.18	10.0	ug/l	2.0					
Zinc	J	15.6	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Mercury	RMJ	03/03/99	1530	143690	3
TCLP Prep for Metals	JL	03/01/99	1835	143435	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 04, 1999

Sample ID : B9D2CORE

M = Method Method-Description

Notes:
The qualifiers in this report are defined as follows:
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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 16, 1999

Sample ID	: B9D2CORE
Lab ID	: 9902993-06
Matrix	: Misc.
Date Collected	: 02/24/99
Date Received	: 02/25/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Cyanide, Reactive	U	ND	0.0139	250	mg/kg	1.0	HSC	03/15/99	2100	144594	1
Sulfide, Reactive	U	ND	0.0150	500	mg/kg	1.0	JBK	03/15/99	1900	144559	2
Paint Filter Test		pass					JBK	03/10/99	1645	144346	3
Flash Point, closed cup	>	145	140	140	F	1.0	JBH	03/16/99	1000	144639	4
Corrosivity (pH <2 or >12)		12.9	0.0100	0.100	SU	1.0	LAA	02/26/99	1914	143404	5
pH - 2 items											
pH		12.9	0.0100	0.100	SU	1.0	LAA	02/26/99	1814	143381	6
pH Temperature		22.4	0.100	0.100	C	1.0					

M = Method	Method-Description
M 1	SW-846 Chapter 7-7.3.3
M 2	SW-846 Chapter 7-7.3.4
M 3	EPA 9095
M 4	SW 846 1010
M 5	EPA 9045C
M 6	EPA 9045

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 16, 1999

Sample ID : B9D2CORE

M = Method **Method-Description**

This data report has been prepared and reviewed
in accordance with General Engineering Laboratories
standard operating procedures. Please direct
any questions to your Project Manager, Flora Ingram at (843) 556-8171.

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CNUC00398

37092.1 38142.1

38142
37092

160

CHAIN-OF-CUSTODY RECORD

22290

Location: CNCF

Project/Number: FDF-POP/46622

Sample Type(s): SOLID

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803)259-1781

Page ____ of ____

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required: TCLP for UTS Metals	RCRA CHARACTERISTICS									Total	Remarks
9902993-01/04	B3 D2 CORE	2/24/99	✓	✓									1	
02/05	B6 D2 CORE	2/24/99	✓	✓									1	
03/06	B9 D2 CORE	2/24/99	✓	✓									1	

Sampled by D. Howard

Total # of Container 3

Relinquished by: D. Howard
Organization: CNS
Date: 2/25/99
Time: 1120
Received by: A Van Doren
Organization: GEL

Relinquished by:
Organization:
Date: 2/25/99
Time:
Received by: S Francis
Organization: Gel

Relinquished by:
Organization:
Date:
Time:
Received by:
Organization:

Delivery Method:
Shipping container ID:

0229

CHAIN-OF-CUSTODY RECORD

Location: CNCF

Project/Number: FDF-POP/46492

Sample Type(s): SOLID

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803) 259-1781

Page ___ of ___

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required: TCLP for UTS Metals	RCRA Characteristics									Total	Remarks
														Additional
	B3D2CORE	2/24/99	✓	✓									1	sample to
	B6D2CORE	2/24/99	✓	✓									1	perform
	B9D2CORE	2/24/99	✓	✓									1	RCRA char-
														acteristics
														per Release
														order 120994

Total # of Container: 3

Sampled by: D. Howard

Relinquished by: D. Howard
Organization: CNS
Date: 3/4/99
Time:

Relinquished by: [illegible signature]
Organization: GEL
Date: 3/5/99
Time:

Relinquished by:
Organization:
Date:
Time:

Received by:
Organization: [illegible]
Received by: Francis
Organization: gel
Received by:
Organization:

Shipping container ID:

Delivery Method:

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09/23/98 WED 08:46 FAX 803 259 0770 CHEM NUCLEAR 002

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Laboratory Certifications 2290

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 — Report Date: March 15, 1999 —

Sample ID	: S1-T-3B
Lab ID	: 9903401-01
Matrix	: TCLP
Date Collected	: 02/09/99
Date Received	: 03/10/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	03/12/99	1143	144433	1
Silver	J	2.08	1.46	10.0	ug/l	2.0	MBL	03/12/99	1054	144369	2
Arsenic	U	ND	9.02	10.0	ug/l	2.0					
Barium		61.2	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		196	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead		13.6	3.18	10.0	ug/l	2.0					
Antimony	U	ND	7.88	20.0	ug/l	2.0					
Selenium		232	5.42	10.0	ug/l	2.0					
Thallium	J	7.48	6.16	20.0	ug/l	2.0					
Vanadium		16.8	1.18	10.0	ug/l	2.0					
Zinc	J	4.91	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	AJM	03/11/99	1815	144433	3
TCLP Prep for Metals	JJ	03/10/99	1905	144340	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 15, 1999

Sample ID : S1-T-3B

M = Method	Method-Description

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
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* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories standard operating procedures. Please direct any questions to your Project Manager, Flora Ingram at (843) 556-8171.

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc.
	140 Stoneridge Drive
	Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 07, 1999

Sample ID	: S1-T-3B
Lab ID	: 9903401-02
Matrix	: Solid
Date Collected	: 02/09/99
Date Received	: 03/10/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Corrosivity (pH <2 or >12)		12.8	0.0100	0.100	SU	1.0	LAA	03/10/99	2146	144361	1

M = Method	Method-Description
M 1	EPA 9045C

Notes:
The qualifiers in this report are defined as follows:
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99034 01

165

CHAIN-OF-CUSTODY RECORD 9903401 %

Location: CNS CNCF

Project/Number: FDF-POP/416692

Sample Type(s): SOLID

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803) 259-1781

Page 1 of 1

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required: TCLP for UTS metals									Total	Remarks
9903401-01	51-T-3B	2/9/99	✓									1	
02													
											Total # of Container	1	

Sampled by D. Howard

Relinquished by: D Howard
Organization: CNS
Date: 3/10/99
Time: 1125
Received by: A Van [illegible]
Organization: GEL

Relinquished by:
Organization:
Date:
Time:
Received by: [illegible]
Organization: ACL

Relinquished by:
Organization:
Date:
Time:
Received by:
Organization:

Delivery Method:

Shipping container ID:

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: February 04, 1999

Sample ID	: CNS-DECANT
Lab ID	: 9901852-01
Matrix	: Misc.-L
Date Collected	: 01/23/99
Date Received	: 01/27/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Aluminum		485000	11800	50000	ug/l	100	MBL	01/29/99	1625	140957	1
Arsenic		203000	4550	10000	ug/l	100					
Barium		1030000	540	10000	ug/l	100					
Calcium		166000	69700	100000	ug/l	100					
Chromium		305000	760	10000	ug/l	100					
Iron		1580000	121000	121000	ug/l	100					
Potassium		132000	28400	100000	ug/l	100					
Magnesium		1260000	5070	10000	ug/l	100					
Sodium		2890000	64200	100000	ug/l	100					
Nickel		893000	630	10000	ug/l	100					
Phosphorus		2440000	20000	50000	ug/l	100	MBL	02/02/99	1040	140957	2
Lead		12100000	1570	5000	ug/l	100	MBL	01/29/99	1625	140957	1
Sulfur		555000	22600	50000	ug/l	100					
Selenium		131000	2700	5000	ug/l	100					
Silicon		965000	28000	100000	ug/l	100					
Vanadium		110000	530	10000	ug/l	100					
Zinc		40300	3700	20000	ug/l	100					
General Chemistry											
pH - 2 items											
pH		9.40	0.0100	0.100	SU	1.0	JEN	01/28/99	2150	141034	3
pH Temperature		18.4	0.100	0.100	C	1.0					
Solids, Total Dissolved		11400	50.4	100	mg/l	10.	TSM2	02/01/99	1455	141241	4
Solids, Total Suspended		237000	12.9	20.0	mg/l	10.	TSM2	02/01/99	1440	141240	5
Total Carbon		6500	24.1	24.1	mg/l	1.0	LS	02/02/99	0936	141187	6

The following prep procedures were performed:

TRACE	FGD	01/28/99	1230	140957	7

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: February 04, 1999

Sample ID : CNS-DECANT

M = Method	Method-Description
M 1	EPA 6010A
M 2	EPA 6010B
M 3	EPA 9040
M 4	EPA 160.1
M 5	EPA 160.2
M 6	EPA 415.1
M 7	EPA 3005

Notes:
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This data report has been prepared and reviewed in accordance with General Engineering Laboratories standard operating procedures. Please direct any questions to your Project Manager, Jack Spitz at (843) 769-7390.

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CdUC00398

9901852%

41

CHAIN-OF-CUSTODY RECORD

Location: CNCF

Project/Number: POP

Sample Type(s): Liquid

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803)259-1781

Page 1 of 1

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	TSS	TDS	PH	Elemental Analysis							Total	Remarks
-01	CNS-Decant	1/23/99	X	X	X	X							6	Normal Turn Around

Sampled by ______ Total # of Container 6

Relinquished by: [illegible signature] Date: 1/26/99 Received by: A [illegible signature]

Organization: ______ Time: 1418 Organization: GEL

Relinquished by: ______ Date: 1/2 Received by: [illegible signature]

Organization: ______ Time: ______ Organization: ______

Relinquished by: ______ Date: ______ Received by: ______

Organization: ______ Time: ______ Organization: ______

Delivery Method: ______ Shipping container ID: ______

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0290

GENERAL ENGINEERING LABORATORIES

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E 2290

Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 12, 1999

Sample ID : S2-T-3A
Lab ID : 9903355-03
Matrix : TCLP
Date Collected : 03/04/99
Date Received : 03/09/99
Priority : Urgent
Collector : Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	03/11/99	1526	144287	1
Silver	J	4.72	1.46	10.0	ug/l	2.0	MBL	03/11/99	1752	144285	2
Arsenic	U	ND	9.02	10.0	ug/l	2.0					
Barium		70.8	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		381	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead		22.9	3.18	10.0	ug/l	2.0					
Antimony	U	ND	7.88	20.0	ug/l	2.0					
Selenium		248	5.42	10.0	ug/l	2.0					
Thallium	U	ND	6.16	20.0	ug/l	2.0					
Vanadium		33.9	1.18	10.0	ug/l	2.0					
Zinc	J	4.46	3.18	400	ug/l	2.0					

The following prep procedures were performed:

	Analyst	Date	Time	Batch	M
Mercury	AJM	03/10/99	1715	144287	3
TCLP Prep for Metals	JJ	03/09/99	1930	144231	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 12, 1999

Sample ID : S2-T-3A

M = Method	Method-Description

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

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Flora G

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CHAIN-OF-CUSTODY RECORD 9903355%

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803)259-1781

Page ___ of ___

Location: CNS-CNCF
Project/Number: FDF-POP/410092
Sample Type(s): SOLID

Sample Analysis Required

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	TCLP for UTS metals										Total	Remarks
9903355-01	S1-T-5A	3/4/99	✓										1	
9903355-02	S2-T-4A	3/4/99	✓										1	
9903355-03	S2-T-3A	2/23/99	✓										1	

Total # of Container 3

Sampled by D Howard

Relinquished by: D. Howard
Organization: CNS
Date: 3/9/99
Time: 1006
Received by: A VAN DOREN AVan[illegible]
Organization: GEL

Relinquished by:
Organization:
Date: 3/9/99
Time: 1700
Received by: Gustavus Chandler
Organization: GEL

Relinquished by:
Organization:
Date:
Time:
Received by:
Organization:

Shipping container ID:

Delivery Method:

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0069[illegible]

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 06, 1999 Page 1 of 2

Sample ID	: S2-T-3B
Lab ID	: 9903843-01
Matrix	: Solid
Date Collected	: 02/23/99
Date Received	: 03/23/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	DN	0.000350	0.0200	mg/l	1.0	RMJ	03/26/99	1337	145397	1
Arsenic		37.8	9.02	10.0	ug/l	2.0	MBL	03/29/99	1320	145385	2
Barium		65.5	1.02	10.0	ug/l	2.0					
Beryllium	J	0.601	0.520	10.0	ug/l	2.0					
Cadmium	U	DN	0.880	10.0	ug/l	2.0					
Chromium		360	1.12	10.0	ug/l	2.0					
Nickel	U	DN	2.58	10.0	ug/l	2.0					
Lead	J	7.24	3.18	10.0	ug/l	2.0					
Antimony	J	14.3	7.88	20.0	ug/l	2.0					
Selenium		304	5.42	10.0	ug/l	2.0					
Thallium	J	7.39	6.16	20.0	ug/l	2.0					

The following prep procedures were performed:

Mercury	RMJ	03/25/99	1745	145397	1
TCLP Prep for Metals	JJ	03/24/99	1540	145290	3

M = Method	Method-Description
M 1	EPA 7470A
M 2	SW846 6010B
M 3	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 06, 1999 Page 2 of 2

Sample ID : S2-T-3B

M = Method Method-Description

Notes:
The qualifiers in this report are defined as follows:
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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 06, 1999 Page 1 of 1

Sample ID	: S2-T-3B
Lab ID	: 9903843-02
Matrix	: Solid
Date Collected	: 02/23/99
Date Received	: 03/23/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Cyanide, Reactive	U	DN	0.0139	250	mg/kg	1.0	JLP	03/31/99	1614	145697	1
Sulfide, Reactive	U	DN	0.0150	500	mg/kg	1.0	JBK	03/31/99	1330	145639	2
Flash Point, closed cup	>	145	140	140	F	1.0	JBH	03/31/99	1000	145735	3
Corrosivity (pH <2 or >12)		12.6	0.0100	0.100	SU	1.0	LAA	03/23/99	2021	145233	4

M = Method	Method-Description
M 1	SW-846 Chapter 7-7.3.3
M 2	SW-846 Chapter 7-7.3.4.2
M 3	SW 846 1010
M 4	EPA 9045C

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories standard operating procedures. Please direct any questions to your Project Manager, Flora Ingram at (843) 556-8171.

Flora [signature]

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CHAIN-OF-CUSTODY RECORD 9903843

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803) 259-1781

Page 1 of 1

Location: CNCF

Project/Number: 46692 - POP

Sample Type(s): Solid

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required	TCLP on UTS Metals		RCRA Characteristics							Total	Remarks
01/02	S2-T-3B	2/23/99		X		X							1	Normal Turn Around
												Total # of Container	1	

Sampled by

Relinquished by: [signature]	Date: 3/23/99	Received by: [signature]
Organization: CNS	Time: 14:36	Organization: GEL
Relinquished by: [signature]	Date: 3/23/99	Received by: [signature]
Organization: GEL	Time: 1645	Organization: GEL
Relinquished by:	Date:	Received by:
Organization:	Time:	Organization:
Delivery Method:		Shipping container ID:

175

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GENERAL ENGINEERING LABORATORIES
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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 12, 1999

Sample ID	: S2-T-4A
Lab ID	: 9903355-02
Matrix	: TCLP
Date Collected	: 03/04/99
Date Received	: 03/09/99
Priority	: Urgent
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	03/11/99	1524	144287	1
Silver	J	5.11	1.46	10.0	ug/l	2.0	MBL	03/11/99	1747	144285	2
Arsenic	U	ND	9.02	10.0	ug/l	2.0					
Barium		77.0	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		656	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead	U	ND	3.18	10.0	ug/l	2.0					
Antimony	U	ND	7.88	20.0	ug/l	2.0					
Selenium		175	5.42	10.0	ug/l	2.0					
Thallium	U	ND	6.16	20.0	ug/l	2.0					
Vanadium		24.8	1.18	10.0	ug/l	2.0					
Zinc	J	8.08	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	AJM	03/10/99	1715	144287	3
TCLP Prep for Metals	JJ	03/09/99	1930	144231	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398   Report Date: March 12, 1999

Sample ID : S2-T-4A

M = Method	Method-Description

Notes:
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CHAIN-OF-CUSTODY RECORD 9903355%

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803) 259-1781

Page ____ of ____

Location: CNS-CNCF

Project/Number: FDF-POP/416692

Sample Type(s): SOLID

Sample Analysis Required

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	TCLP for UTS metals	Total	Remarks
9903355-01	S1-T-5A	3/4/99	✓	1	
9903355-02	S2-T-4A	3/4/99	✓	1	
9903355-03	S2-T-3A	2/23/99	✓	1	

Total # of Container 3

Sampled by D Howard

Relinquished by: D. Howard
Organization: CNS
Date: 3/9/99
Time: 1006
Received by: A VAN DOREN
Organization: GEL

Relinquished by: ____
Organization: ____
Date: 3/9/99
Time: 1700
Received by: Gustavus Chandler
Organization: GEL

Relinquished by: ____
Organization: ____
Date: ____
Time: ____
Received by: ____
Organization: ____

Delivery Method: ____

Shipping container ID: ____

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 12, 1999 Page 1 of 2

Sample ID : S2-T-4B
Lab ID : 9904060-03
Matrix : Solid
Date Collected : 03/04/99
Date Received : 04/01/99
Priority : Rush
Collector : Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	04/08/99	1141	146102	1
Arsenic		15.8	9.02	10.0	ug/l	2.0	MBL	04/08/99	1822	146110	2
Barium		68.5	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		563	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead	U	ND	3.18	10.0	ug/l	2.0					
Antimony	U	ND	7.88	20.0	ug/l	2.0					
Selenium		187	5.42	10.0	ug/l	2.0					
Thallium	U	ND	6.16	20.0	ug/l	2.0					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	RMJ	04/06/99	1720	146102	1
TCLP Prep for Metals	JJ	04/05/99	1620	145975	3

M = Method	Method-Description
M 1	EPA 7470A
M 2	SW846 6010B
M 3	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 12, 1999 Page 2 of 2

Sample ID : S2-T-4B

M = Method	Method-Description

Notes:
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STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 12, 1999

Sample ID	: S2-T-4B
Lab ID	: 9904060-04
Matrix	: Solid
Date Collected	: 03/04/99
Date Received	: 04/01/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Cyanide, Reactive	U	ND	0.0139	250	mg/kg	1.0	HSC	04/05/99	1708	146030	1
Sulfide, Reactive	U	ND	0.0450	500	mg/kg	1.0	JBK	04/05/99	1400	145994	2
Flash Point, closed cup	>	145	140	140	F	1.0	JBH	04/02/99	1330	145905	3
Corrosivity (pH <2 or >12)		12.8	0.0100	0.100	SU	1.0	LAA	04/01/99	2110	145879	4

M = Method	Method-Description
M 1	SW-846 Chapter 7-7.3.3
M 2	SW-846 Chapter 7-7.3.4.2
M 3	SW 846 1010
M 4	EPA 9045C

Notes:
The qualifiers in this report are defined as follows:
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J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
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Flora Ingram

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CHAIN-OF-CUSTODY RECORD

9904060%

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CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803) 259-1781

Page 1 of 1

Location: CNCF

Project/Number: FDF/46692

Sample Type(s): Solid

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required: TCLP on UTS Metals	Sample Analysis Required: RCRA Characteristics	Total	Remarks
9904060-01, -02	S1-T-5B	3/4/99	X	X	1	
9904060-03, -04	S2-T-4B	3/4/99	X	X	1	

Total # of Container

Sampled by: ______

Relinquished by: [signature]	Date: 4/1/99	Received by: Alan Van Doren
Organization:	Time: 1444	Organization: GEL
Relinquished by:	Date: 4/1/99	Received by: Ryan P. B[illegible]
Organization:	Time: 17:00	Organization: GEL
Relinquished by:	Date:	Received by:
Organization:	Time:	Organization:
Delivery Method:		Shipping container ID:

182

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 12, 1999

Sample ID	: S1-T-5A
Lab ID	: 9903355-01
Matrix	: TCLP
Date Collected	: 03/04/99
Date Received	: 03/09/99
Priority	: Urgent
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	03/11/99	1522	144287	1
Silver	J	5.57	1.46	10.0	ug/l	2.0	MBL	03/11/99	1741	144285	2
Arsenic	U	ND	9.02	10.0	ug/l	2.0					
Barium		45.8	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		213	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead		1370	3.18	10.0	ug/l	2.0					
Antimony	U	ND	7.88	20.0	ug/l	2.0					
Selenium		146	5.42	10.0	ug/l	2.0					
Thallium	U	ND	6.16	20.0	ug/l	2.0					
Vanadium	J	1.38	1.18	10.0	ug/l	2.0					
Zinc	J	3.99	3.18	400	ug/l	2.0					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	AJM	03/10/99	1715	144287	3
TCLP Prep for Metals	JJ	03/09/99	1930	144231	4

M = Method	Method-Description
M 1	EPA 7470
M 2	EPA 6010A
M 3	EPA 7470A
M 4	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 12, 1999

Sample ID : S1-T-5A

M = Method	Method-Description

Notes:
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CHAIN-OF-CUSTODY RECORD 9903355%

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CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803)259-1781

Page ___ of ___

Location: CNS-CNCF

Project/Number: FDF-POP/46692

Sample Type(s): SOLID

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required: TCLP for UTS metals										Total	Remarks
9903355-01	S1-T-5A	3/4/99	✓										1	
9903355-02	S2-T-4A	3/4/99	✓										1	
9903355-03	S2-T-3A	2/23/99	✓										1	

Sampled by D Howard

Total # of Container 3

Relinquished by: D. Howard
Organization: CNS
Date: 3/9/99
Time: 1006
Received by: A VAN DOREN [signature]
Organization: GEL

Relinquished by: ______
Organization: ______
Date: 3/9/99
Time: 1700
Received by: Gustavus Chandler
Organization: GEL

Relinquished by: ______
Organization: ______
Date: ______
Time: ______
Received by: ______
Organization: ______

Delivery Method: ______

Shipping container ID: ______

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmud Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 12, 1999 Page 1 of 2

Sample ID : S1-T-5B
Lab ID : 9904060-01
Matrix : Solid
Date Collected : 03/04/99
Date Received : 04/01/99
Priority : Rush
Collector : Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Mercury	U	ND	0.000350	0.0200	mg/l	1.0	RMJ	04/08/99	1139	146102	1
Arsenic	U	ND	9.02	10.0	ug/l	2.0	MBL	04/08/99	1817	146110	2
Barium		60.1	1.02	10.0	ug/l	2.0					
Beryllium	U	ND	0.520	10.0	ug/l	2.0					
Cadmium	U	ND	0.880	10.0	ug/l	2.0					
Chromium		296	1.12	10.0	ug/l	2.0					
Nickel	U	ND	2.58	10.0	ug/l	2.0					
Lead		10.7	3.18	10.0	ug/l	2.0					
Antimony	U	ND	7.88	20.0	ug/l	2.0					
Selenium		164	5.42	10.0	ug/l	2.0					
Thallium	J	6.60	6.16	20.0	ug/l	2.0					

The following prep procedures were performed:

Procedure	Analyst	Date	Time	Batch	M
Mercury	RMJ	04/06/99	1720	146102	1
TCLP Prep for Metals	JJ	04/05/99	1620	145975	3

M = Method	Method-Description
M 1	EPA 7470A
M 2	SW846 6010B
M 3	EPA 1311

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/K7458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 12, 1999 Page 2 of 2

Sample ID : S1-T-5B

M = Method **Method-Description**

Notes:
The qualifiers in this report are defined as follows:
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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: April 12, 1999

Sample ID	: S1-T-5B
Lab ID	: 9904060-02
Matrix	: Solid
Date Collected	: 03/04/99
Date Received	: 04/01/99
Priority	: Rush
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
General Chemistry											
Cyanide, Reactive	U	ND	0.0139	250	mg/kg	1.0	HSC	04/05/99	1706	146030	1
Sulfide, Reactive	U	ND	0.0450	500	mg/kg	1.0	JBK	04/05/99	1400	145994	2
Flash Point, closed cup	>	145	140	140	F	1.0	JBH	04/02/99	1330	145905	3
Corrosivity (pH <2 or >12)		13.0	0.0100	0.100	SU	1.0	LAA	04/01/99	2105	145879	4

M = Method	Method-Description
M 1	SW-846 Chapter 7-7.3.3
M 2	SW-846 Chapter 7-7.3.4.2
M 3	SW 846 1010
M 4	EPA 9045C

Notes:
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Flora Ingram

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CHAIN-OF-CUSTODY RECORD

9904060%

Location: CNCF

Project/Number: FDF/46692

Sample Type(s): Solid

CHEM-NUCLEAR SYSTEMS
CONSOLIDATION FACILITY
16043 DUNBARTON BLVD.
BARNWELL, SC 29812
(803)259-1781

Page 1 of 1

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required	TCLP on UTS Metals		RCRA Characteristics							Total	Remarks
9904060-01, -02	S1-T-5B	3/4/99		X		X							1	
9904060-03, -04	S2-T-4B	3/4/99		X		X							1	

Sampled by ______ Total # of Container

Relinquished by: [signature] Date: 4/1/99 Received by: Alan Van Doren

Organization: ______ Time: 1444 Organization: GEL

Relinquished by: ______ Date: 4/1/99 Received by: Ryan R.B.

Organization: ______ Time: 17:00 Organization: GEL

Relinquished by: ______ Date: ______ Received by: ______

Organization: ______ Time: ______ Organization: ______

Delivery Method: ______ Shipping container ID: ______

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client:	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, South Carolina 29210
Contact:	Mr Ahmad Ghandour
Project Description:	Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 15, 1999

Sample ID	: 40720-2233 C3-014
Lab ID	: 9901490-01
Matrix	: Misc.
Date Collected	: 01/14/99
Date Received	: 01/18/99
Priority	: Routine
Collector	: Client

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	M
Metals Analysis											
Aluminum		12400000	1900	4990	ug/kg	10.	AME	03/12/99	1810	143831	1
Arsenic		458000	447	1500	ug/kg	10.					
Barium		8230000	37.4	150	ug/kg	10.					
Calcium		1320000	40200	49900	ug/kg	10.					
Chromium		331000	554	1500	ug/kg	10.					
Iron		12400000	2400	12500	ug/kg	10.					
Potassium		4430000	5290	150000	ug/kg	10.					
Magnesium		2540000	1070	1500	ug/kg	10.					
Sodium		11200000	16300	150000	ug/kg	10.					
Nickel		2300000	613	613	ug/kg	10.					
Phosphorus		2820000	2150	25000	ug/kg	10.					
Lead		64100000	303	303	ug/kg	10.					
Selenium		216000	832	998	ug/kg	10.					
Silicon	U	ND	23000	99800	ug/kg	10.					
Vanadium		373000	895	2500	ug/kg	10.					
Zinc		504000	4530	4990	ug/kg	10.					
Sulfur		1940000	2220	4920	ug/kg	1.0	MBL	01/31/99	1313	140050	2
General Chemistry											
Total Carbon		8000	24.1	100	mg/kg	1.0	LS	02/01/99	1821	141187	3

The following prep procedures were performed:

ICP Mass Spec	FGD	03/11/99	1330	143831	4
TRACE	FGD	01/29/99	2000	140050	5

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NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210

Contact: Mr Ahmad Ghandour

Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 15, 1999

Sample ID : 40720-2233 C3-014

M = Method	Method-Description
M 1	SW 846 6020
M 2	EPA 6010A
M 3	EPA 9060 modified
M 4	EPA 3050/3005
M 5	EPA 3050

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories standard operating procedures. Please direct any questions to your Project Manager, Jack Spitz at (843) 769-7390.

Reviewed By

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CNK 007

31

CHAIN-OF-CUSTODY RECORD

Location: CNCF - Lab

Project/Number: FDF-POP/46692

Sample Type(s): Solid

CHEM-NUCLEAR SYSTEMS
Consolidation Facility
16043 Dunbarton Blvd
Barnwell, SC 29812

Page 1 of 1

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Al, As, Ba	Cr, Pb, Se	Ni, Zn, V	Fe, K, Ca	Na, Mg, Cd	S, Si, P					Total	Remarks
DNH	~~40720-2233-C3-015~~													
9901496-01	40720-2233-C3-014	1/14/99											100g	70% solids lab mix
02	40720-2233-C3-015	1/14/99											2L	30% solids truck mix

Sampled by D N Howard

Total # of Container 3

Relinquished by: DN Howard
Organization: CNSI
Date: 1/15/99
Time: 1510
Received by: [signature]
Organization: GEL
Relinquished by:
Organization:
Date:
Time:
Received by: B Franco 1/15/99
Organization: GEL
Relinquished by:
Organization:
Date:
Time:
Received by:
Organization:
Delivery Method:
Shipping container ID:

0620

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Laboratory Certifications

STATE	GEL	EPI
FL	E87156/87294	E87472/87458
NC	233	
SC	10120	10582
TN	02934	02934

Client: Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, South Carolina 29210
Contact: Mr Ahmad Ghandour
Project Description: Hazardous Waste Characterization

cc: CNUC00398 Report Date: March 15, 1999

Sample ID : 40720-2233 C3-015

M = Method	Method-Description
M 1	SW 846 6020
M 2	EPA 6010A
M 3	EPA 9060 modified
M 4	EPA 3050/3005
M 5	EPA 3050

Notes:
The qualifiers in this report are defined as follows:
ND indicates that the analyte was not detected at a concentration greater than the detection limit.
J indicates presence of analyte at a concentration less than the reporting limit (RL) and greater than the detection limit (DL).
U indicates that the analyte was not detected at a concentration greater than the detection limit.
* indicates that a quality control analyte recovery is outside of specified acceptance criteria.

This data report has been prepared and reviewed
in accordance with General Engineering Laboratories
standard operating procedures. Please direct
any questions to your Project Manager, Jack Spitz at (843) 769-7390.

Reviewed By

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CNC0079.

310

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2290

CHAIN-OF-CUSTODY RECORD

Location: CNCF - Lab

Project/Number: FDF-POP/46692

Sample Type(s): Solid

CHEM-NUCLEAR SYSTEMS
Consolidation Facility
16043 Dunbarton Blvd
Barnwell, SC 29812

Page 1 of 1

Lab. ID # (Lab use only)	Sample Identity	Date Sampled	Sample Analysis Required: Al, As, Ba	Cr, Pb, Se	Ni, Zn, V	Fe, K, Ca	Na, Mg, Cd	S, Si, P					Total	Remarks
	DUP ~~40720-2233-C3-015~~													
990149 0-01	40720-2233-C3-014	1/14/99											100g	70% solids lab mix
✓ 02	40720-2233-C3-015	1/14/99											2L	30% solids truck mix

Sampled by D N Howard

Total # of Containers 3

Relinquished by: DN Howard
Organization: CNSI
Date: 1/15/99
Time: 1510
Received by: [signature]
Organization: GEL
Received by: [signature] 1/15/99
Organization: GEL

Relinquished by:
Organization:
Date:
Time:

Relinquished by:
Organization:
Date:
Time:
Received by:
Organization:

Delivery Method:

Shipping container ID:

APPENDIX C

EQUIPMENT DATA SHEETS

(16 PAGES)

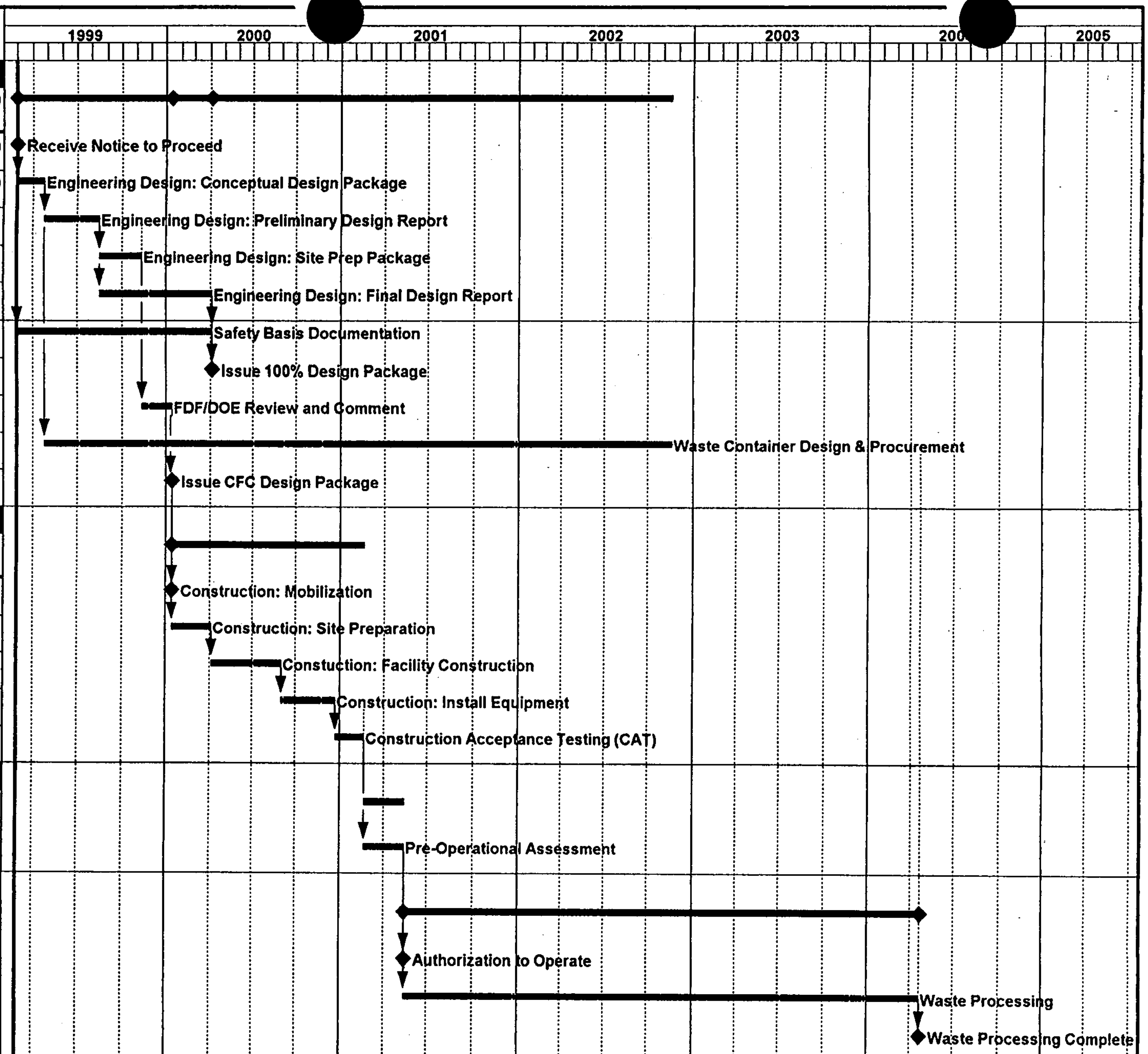
APPENDIX D

FULL-SCALE REMEDIATION FACILITY SCHEDULE

(1 PAGE)

(This document is not available electronically. Please contact Document Control for a hard copy.)

Activity ID	Activity Description	Orig Dur
Design		
Subtotal		950
1000	Receive Notice to Proceed	0
1010	Engineering Design: Conceptual Design	40
1020	Engineering Design: Preliminary Design Report	80
1030	Engineering Design: Site Prep Package	60
1040	Engineering Design: Final Design Report	160
1050	Safety Basis Documentation	280
1060	Issue 100% Design Package	0
1070	FDF/DOE Review and Comment	40
1075	Waste Container Design & Procurement	910
1080	Issue CFC Design Package	0
Construction		
Subtotal		280
2000	Construction: Mobilization	0
2010	Construction: Site Preparation	60
2020	Constuction: Facility Construction	100
2030	Construction: Install Equipment	80
2040	Construction Acceptance Testing (CAT)	40
Start-Up Preparations		
Subtotal		60
3000	Pre-Operational Assessment	60
Operations		
Subtotal		750
4000	Authorization to Operate	0
4010	Waste Processing	750
4020	Waste Processing Complete	0



Project Start	01MAR99	Early Bar	CHEM
Project Finish	21APR04	Progress Bar	
Data Date	01MAR99		
Run Date	24MAY99		

Sheet 1 of 1

Parsons I & T
Chem-Nuclear Summary Schedule
Summary Schedule Layout

0628

APPENDIX E

CALUCULATIONS

(24 PAGES)

(These documents are not available electronically. Please go to Document Control for a hard copy.)

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ENGINEERING CALCULATIONS TITLE AND SUMMARY SHEET

E 2290

Date 2/24/99

Sheet 1 of 12

Job/WBS No. 733903-01000 Calculation No. 16-01

Title Silo 1&2 POP

Calculation Subject Cement Heat Generation Date Verified/Checked

STATUS: PRELIMINAR X FINAL ___ SUPERSEDED ___ VOID ___

STATEMENT OF PROBLEM

Cylinders of curing waste cement will generate significant amounts of heat. The amount of heat generated per cylinder was estimated so that HVAC equipment can be sized. The heat of hydration typically decays exponentially, and the maximum heat and decay rate are difficult to estimate without material-specific test data. Therefore, a computer model of transient heat transfer in cylindrical coordinates was used to estimate parameter values from experimental data. Once heat of hydration and thermal property parameters were determined, an estimate was made of the total heat generated by a full-scale cylinder over a 14-day period.

SUMMARY OF CONCLUSIONS	Originator's Signature and Date
For a 76-inch ID, 59-inch tall cylinder, the total energy released to ambient surroundings is estimated to be 358,000 BTU over a 14-day period, for an average power of 1065 BTU/hr.	[signature] 3/7/99

CHECKING METHOD	Checker's Signature and Date
1. Review ✓ 2. Alternate Calculation ___	Greg McFarlity 3/17/99
	Technical Lead's Signature and Date: [signature] 3/10/99

Rev. No.	Sheet No.	Description	Reviser's Signature/Date	Checker's Signature/Date	Approved by Signature/Date
					200

10/98

PARSONS
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ENGINEERING CALCULATIONS BASIS SHEET

E 2290

Revision No. 0
Sheet 2 of 12

Job/WBS No. 733903-01000 Calculation No. 16-01

Title Silo 1&2 POP

Calculation Subject Cement Heat Generation Date Verified/Checked 3/7/99

Prepared By: P. Schwind Checked/Verified By:

Date 2/24/99

SUMMARY OF DATA SOURCES – CODES – ASSUMPTIONS

DATA SOURCES:

- Experimental temperature data from P. Frink, file cin-fp-01\933903_POP\Sampling & Analysis\Poptempp.xls.
- Dimensions of experimental and full-scale cement cylinders from P. Frink.
- Initial thermal property estimates from J. Carlson (CNC), "Concrete Construction Handbook," 2nd Ed., J.J. Waddell, 1974, and "Convective Heat and Mass Transfer," 2nd Ed., W.M. Kays and M.E. Crawford, 1980.

ASSUMPTIONS:

- Cement is homogeneous with constant thermal properties.
- Heat of hydration decreases exponentially with time.

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16-01 RΦ

COMPUTER CALCULATION SUMMARY SHEET

2290

Job/WBS No. 733903-01000 TO: Title: Silo 1&2 POP

Computer Code: CRETERZ Version: 1

Code Verification Status: Verified 2/23/99

Description of Program: Finite difference code to solve the 2-D unsteady heat conduction equation in cylindrical coordinates, allowing for specification of an exponentially decaying heat source.

Source of Data: See Engineering Calculation Basis Sheet

Purpose/Description of Calculation: See attached Discussion

Run Performed By: P. Schwind

Date/Time of Run: 2/24/99

Computer Time of Run: 1-5 minutes

Input Filename: See attached Discussion

Output Filename: See attached Discussion

Files Saved to Diskname: See attached Discussion Disk Location: See attached Discussion

Results: See attached Discussion

Performed By: P. Schwind Date: 2/24/99

Checked By: Greg McNulty Date: 3/7/99

Approved By: Date:

Technical Lead

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10/96 G095

4/12
16·01 Rϕ

Job-WBS No.: 733903-01000
Calculation No.: 16-01
Title: Silo 1&2 POP
Subject: Cement Heat Generation

2290

DISCUSSION

It is anticipated that cylinders of curing waste/cement mixture will generate significant amounts of heat, requiring extra HVAC capacity at the initial storage facility. To size HVAC equipment, the total amount of heat generated over a 14-day curing period by a single, full-scale cement cylinder was estimated.

Cement thermal properties are composition-dependent and cement compositions can vary over wide ranges, making accurate property estimates difficult. The heat of hydration, which typically decays exponentially with time, is particularly difficult to estimate as both maximum source strength and decay constant are required. Experimental temperature data were taken over the period 1/25/99 to 2/2/99 for smaller-scale cylindrical buckets (26.5-inch diameter, 32-inch height) of cement/waste mixture, typical of the mixture anticipated for full-scale operations. To estimate heat generation for a full-scale cylinder, parameters were estimated by using a numerical model to match experimental data from the smaller scale test. Details of the numerical model can be found in the CRETERZ Computer Code Verification Report.

Experimental data consisted of roughly 7-day temperature histories from thermocouples in and on the cement buckets. The best data sets for parameter estimation consisted of histories at two points: one in the cylinder interior, about 2 inches off the axis, and another measuring skin temperature at the outside cylinder surface. Three such sets existed, however the third of these appeared different from the other two and was deemed unreliable. Figures 1 and 2 show the temperature histories for the two tests selected for parameter estimation.

Initial estimates of thermal parameters were taken from the sources cited in the calculation basis sheet. Surface heat transfer coefficients due to natural convection were modified to allow for a contact resistance at the inside surface of the bucket, and for the small amount of resistance due to conduction through the steel bucket. The contact resistance results when the cement solidifies and pulls away from the bucket wall slightly, leaving small gaps between cement and steel. An effective overall heat transfer coefficient was defined by analogy with resistances in series, ignoring curvature effects due to the cylindrical coordinates:

$$h_{eff} = \frac{1}{1/h_{nc} + \partial_s/k_s + R_{cont}}$$

where

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h_{nc} = natural convection heat transfer coefficient (W/m^2 - K)

∂_s = steel bucket thickness (m)

k_s = steel thermal conductivity (W/m - K)

R_{cont} = cement - steel contact resistance (m^2 - K/W)

With this definition of an effective heat transfer coefficient, at each time step temperature on the outside of the bucket, T_{skin}, may be calculated from temperature at the outer edge of the cement, T_{edge}, which is obtained as part of the solution:

$$T_{skin} = T_{edge} - \left(R_c + \frac{\partial_s}{k_s} \right) h_{eff} \left(T_{edge} - T_a \right)$$

where T_a is the ambient temperature.

Of the thermal parameters, heat of hydration magnitude and decay constant were varied significantly, surface heat transfer coefficients, contact resistances, thermal conductivity, and specific heat were varied slightly, and density was left unchanged from an initial laboratory estimate. Table 1 lists the final parameters and total heat flux estimates obtained from the parameter estimation exercise. Figure 3 shows the temperature histories predicted by the numerical code at the same locations as the test measurements. Comparison of Figure 3 with Figures 1 and 2 shows that predictions closely match the measured time histories.

Table 1. Final Parameter and Energy Release Estimates for Parameter Estimate Exercise.

Parameter	**Value**
Thermal Conductivity	1.0 W/m-K
Specific Heat	1150. J/kg-K
Density	1680. kg/cu.m
Heat of Hydration Maximum	8000. W/cu.m
Heat of Hydration Decay Constant	0.40 1/hr
Bottom Natural Convection HT Coefficient	0.51 W/sq.m-K
Side Natural Convection HT Coefficient	4.00 W/sq.m-K
Top Natural Convection HT Coefficient	3.58 W/sq.m-K
Bottom Thermal Contact Resistance	0.00 sq.m-K/W
Side Thermal Contact Resistance	0.15 sq.m-K/W
Top Thermal Contact Resistance	0.15 sq.m-K/W
Ambient Temperature	22.0 C
Initial Mixture Temperature	32.78 C
Available Heat of Hydration	20824.2 kJ (19738.6 BTU)
Available Enthalpy	6023.6 kJ (5709.6 BTU)
Initial Energy Present	26847.8 kJ (25448.2 BTU)
Heat of Hydration Released	20824.2 kJ (19738.6 BTU)

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16-01 R0

Enthalpy Dissipated	5501.1 kJ (5214.2 BTU)
Total Energy Dissipated	26325.2 kJ (24952.8 BTU)
Average Power Released	40.625 W (138.63 BTU/hr)

2290

The thermal parameters listed in Table 1 were used to predict temperatures and heat losses for the anticipated dimensions of a full-scale cement cylinder. The full-scale cylinder was assumed to have a 76-inch ID and a height of 59 inches, with a 5/8-inch thick steel bucket. Table 2 lists the total heat flux estimates for curing of a full-scale cylinder of cement over a 14-day period. The total heat generated is 357,895 BTU and the average power released is 1065.2 BTU/hr.

Table 2. Energy Release Estimates for Single Full-Scale Cement Cylinder.

Parameter	**Value**
Available Heat of Hydration	315795 kJ (299332 BTU)
Available Enthalpy	91348 kJ (86586 BTU)
Initial Energy Present	407143 kJ (385918 BTU)
Heat of Hydration Released	315795 kJ (299332 BTU)
Enthalpy Dissipated	61784 kJ (58563 BTU)
Total Energy Dissipated	377579 kJ (357895 BTU)
Average Power Released	312.15 W (1065.2 BTU/hr)

Figure 4 contains time histories of instantaneous power released and cumulative energy released for the full-scale cylinder. These plots may be important for estimating peak cooling loads if ever cylinders of waste are not processed and placed in short-term storage at a uniform rate.

Figure 5 depicts temperature histories for the full-scale cylinder at a center point two inches from the cylinder axis and on the outside of the cylinder at the same height. Because of the decreased surface-to-volume ratio and increased thermal mass of the full-scale cylinder, temperatures are higher and stay elevated for longer than for the smaller experimental cylinders.

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Figure 1. Measured Temperature Histories in Cylinder of Curing Cement, Batch 3 Drum 2

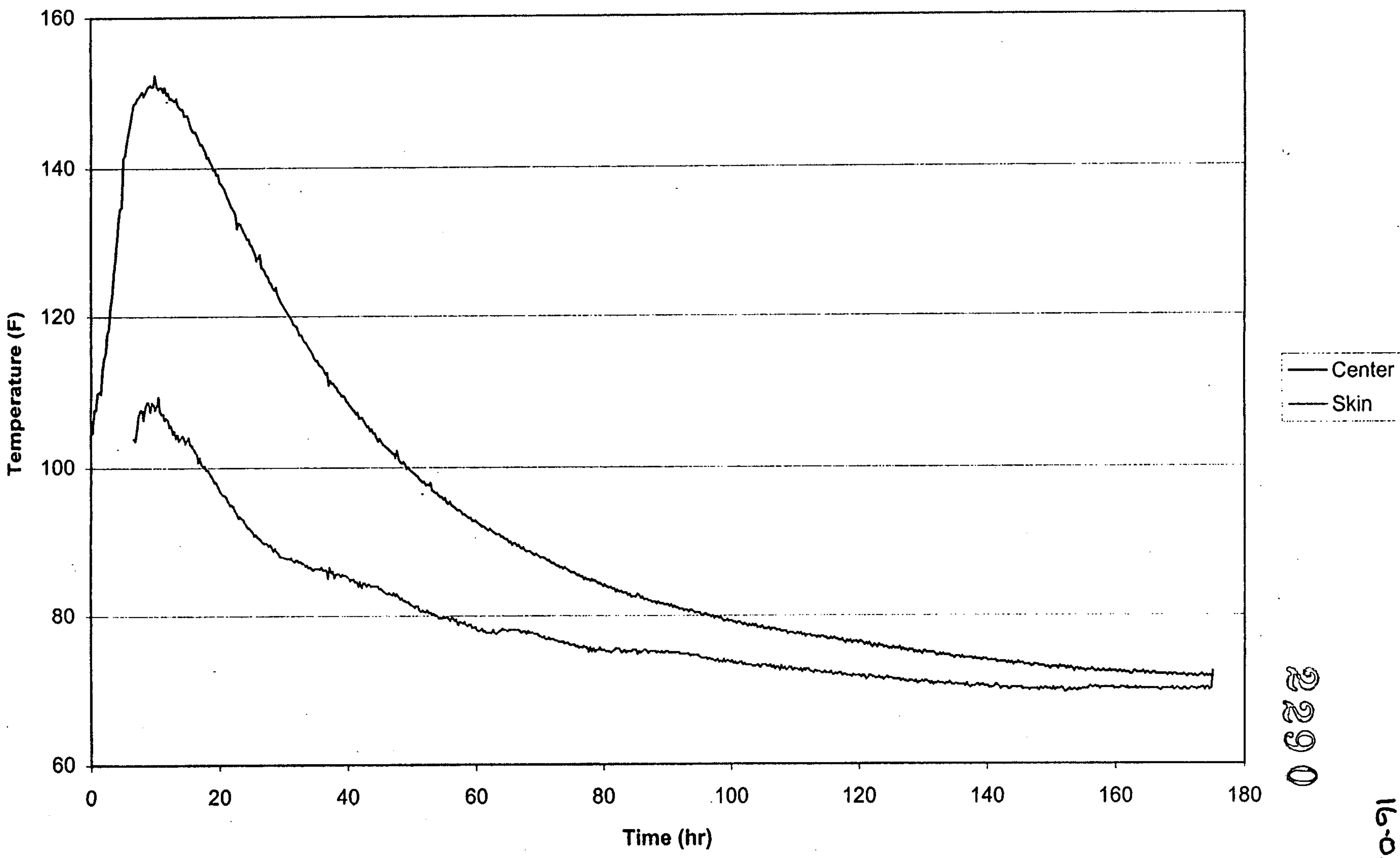


Figure 2. Measured Temperature Histories in Cylinder of Curing Cement, Batch 6 Drum 2

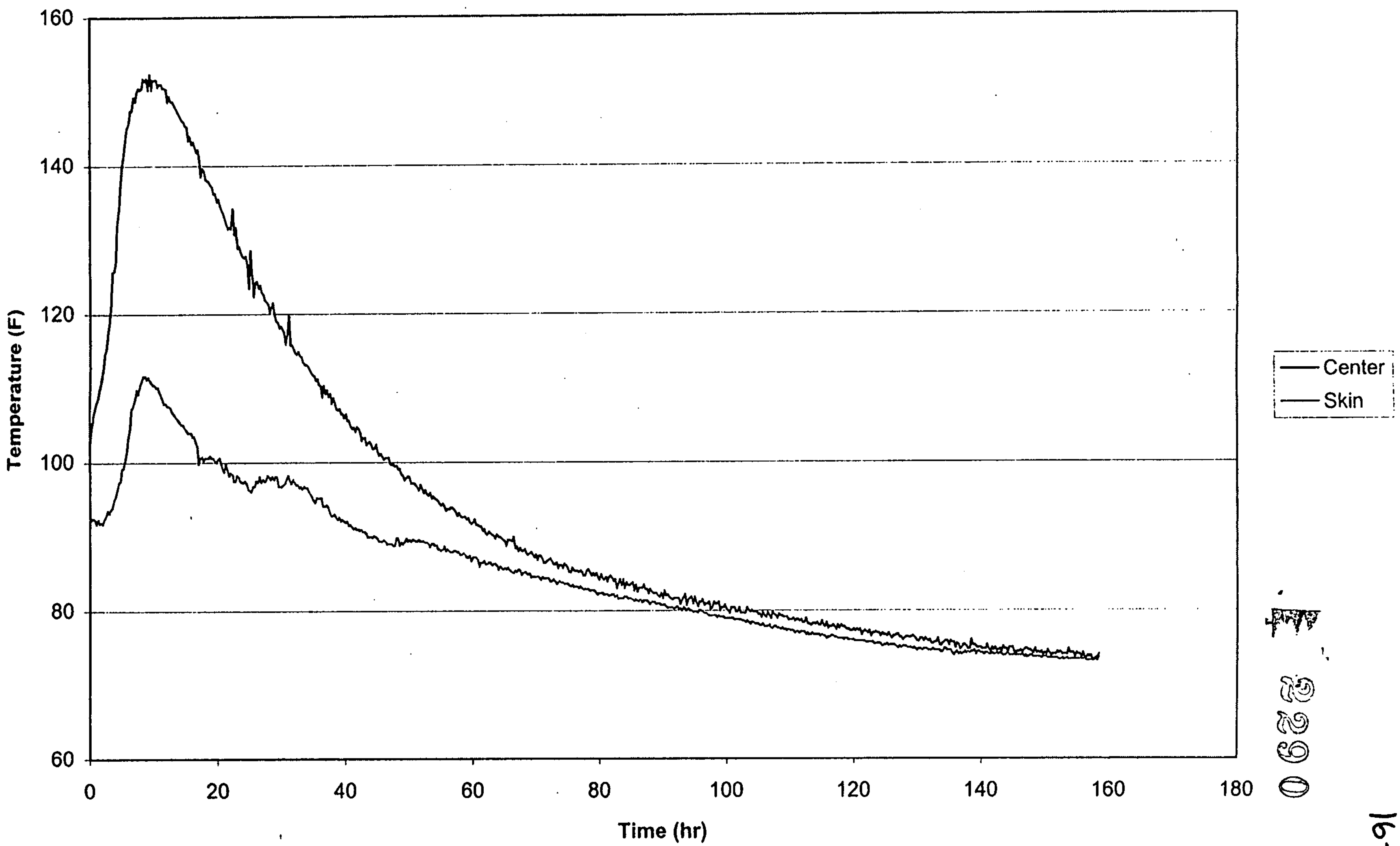


Figure 3. Predicted Temperature Histories in Cylinder of Curing Cement, Silos 1&2 POP

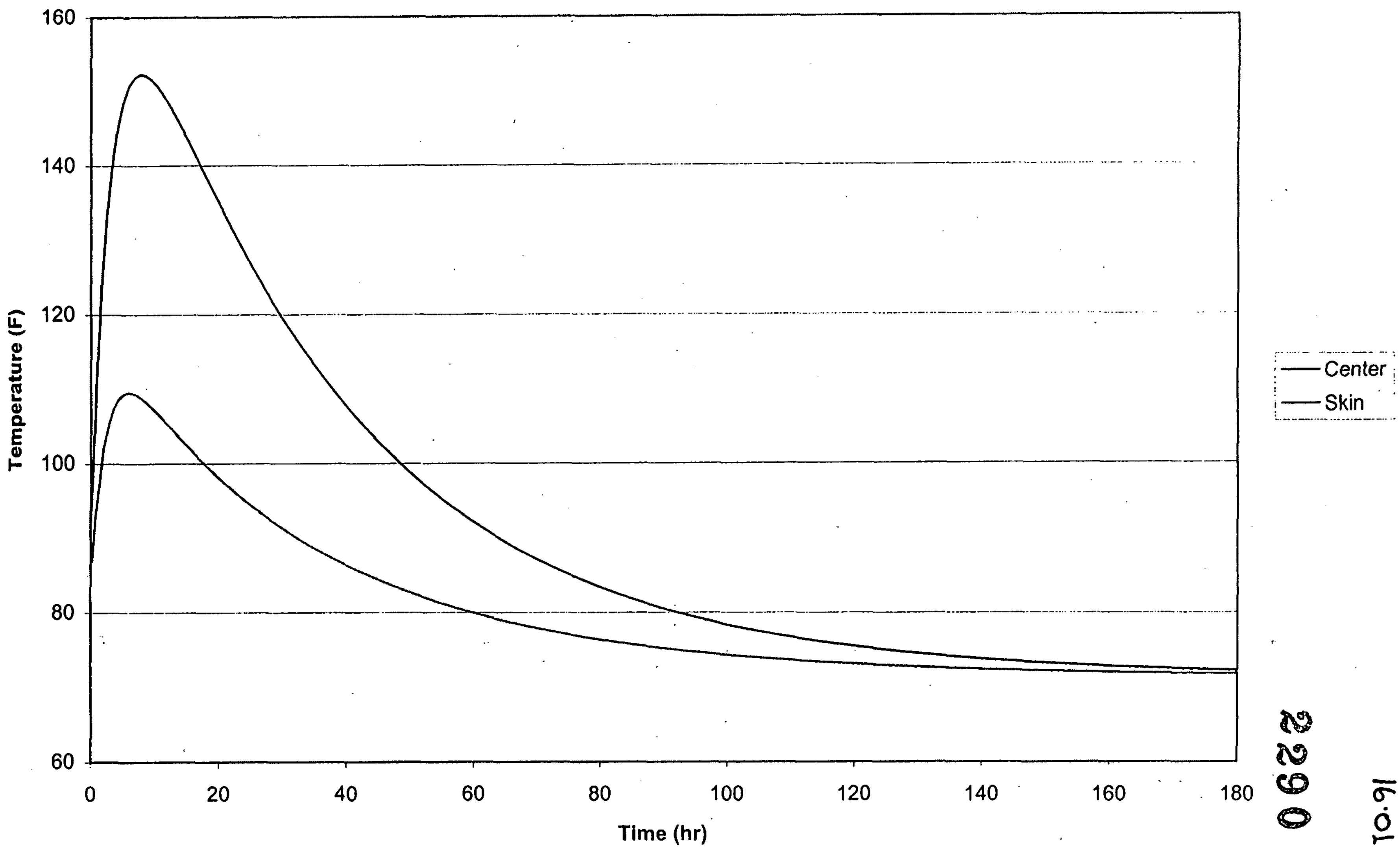


Figure 4. Instantaneous Power and Cumulative Energy Released by Full-Scale Cement Cylinder

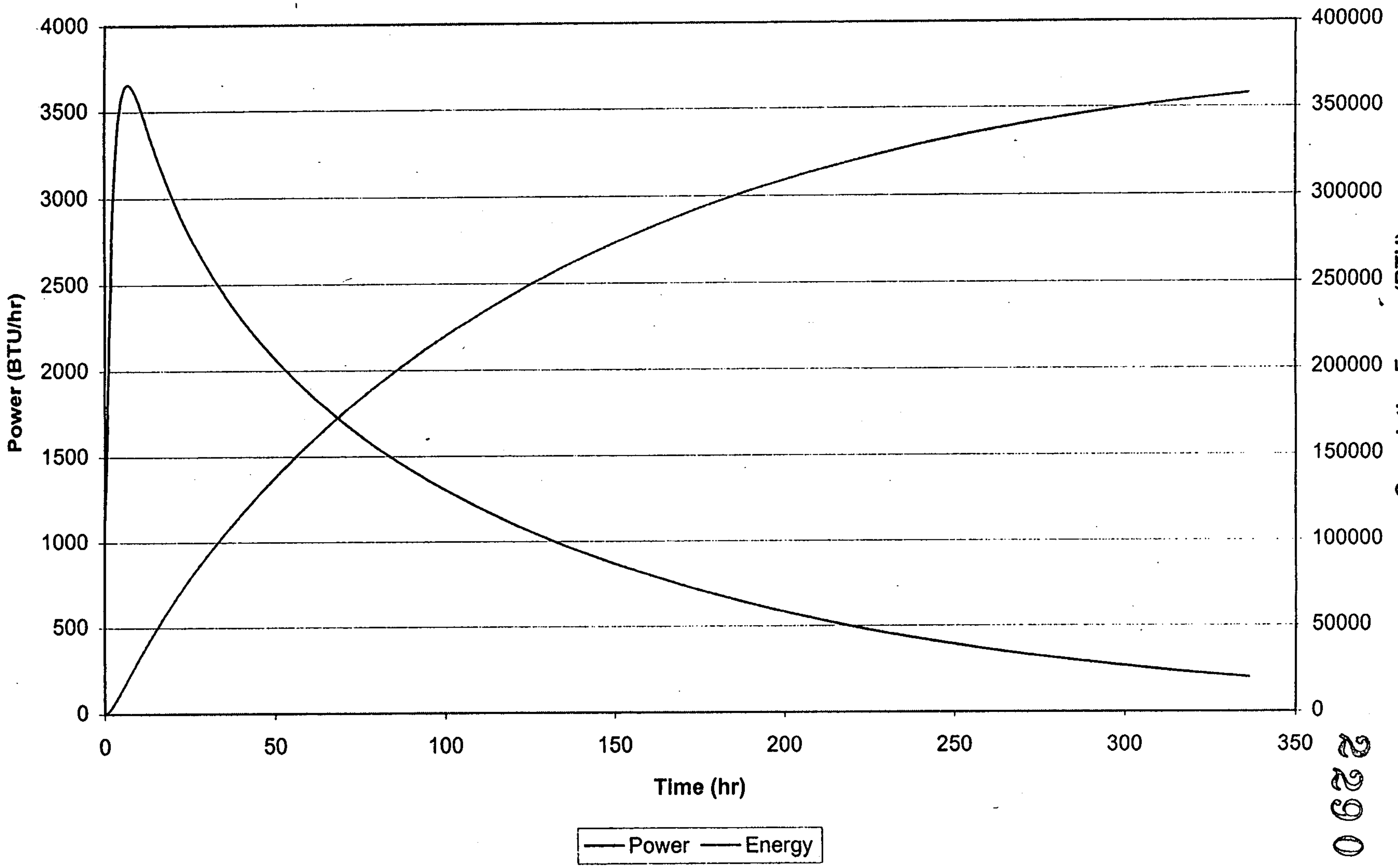
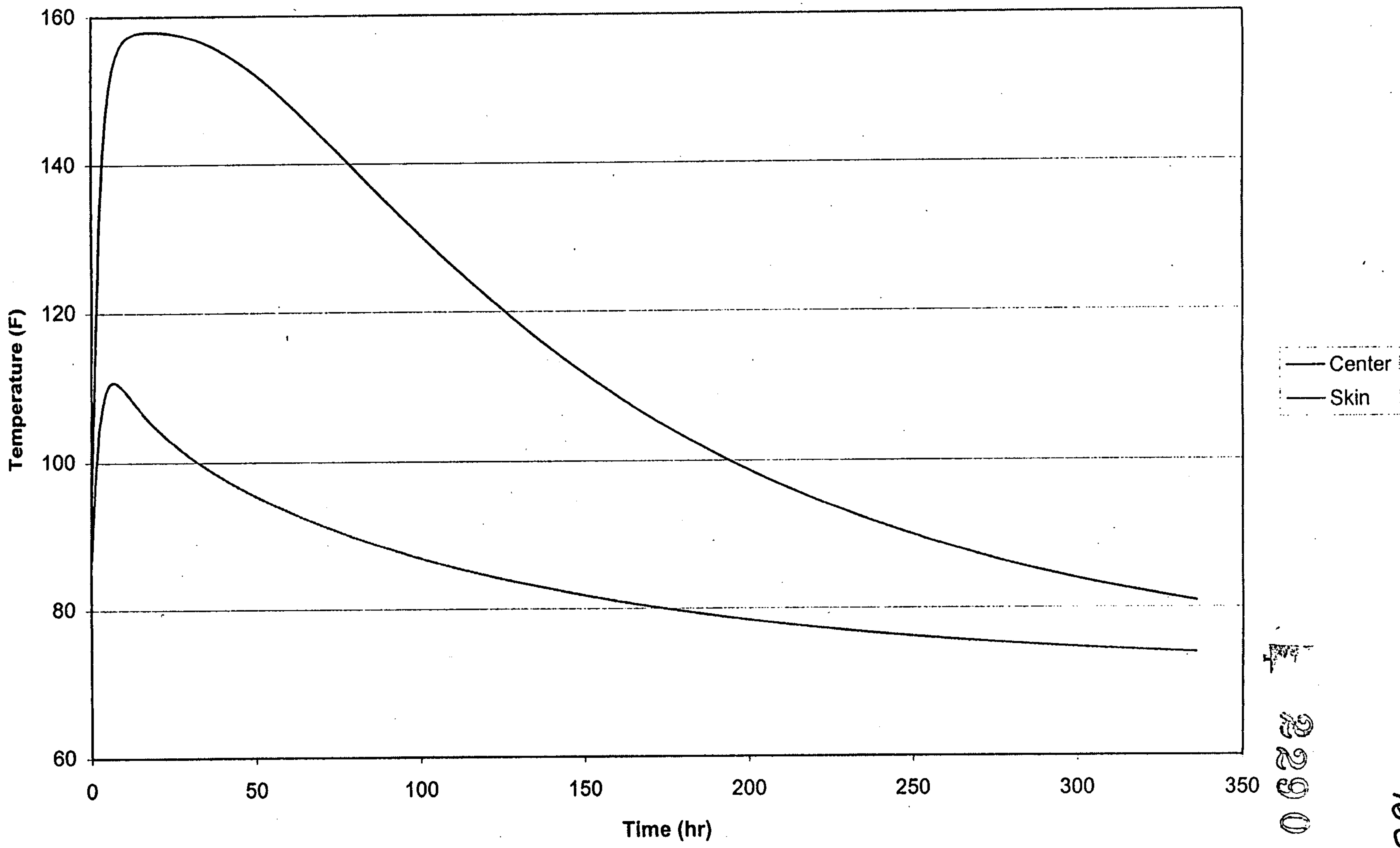


Figure 5. Predicted Temperature Histories in Full-Scale Cylinder of Curing Cement.



12/12
16-01 RΦ

File Names and Locations

The following is a directory listing containing the electronic calculation files: 2290

```
Volume in drive C has no label.
 Volume Serial Number is 07CE-0512

 Directory of C:\fernald\SILO1-2

02/19/99  03:53p                      800 calib.in
02/24/99  12:51p                   34,332 CALIB.out
02/24/99  12:51p                   30,282 CALIB.obs
02/24/99  01:00p                      805 scaleup.in
02/24/99  01:05p                   63,660 SCALEUP.out
02/24/99  01:05p                   56,490 SCALEUP.obs
```

CALIB - Files for parameter estimation exercise.
SCALEUP - Files for full-scale heat generation prediction.

*.IN - Problem Input File
*.OUT - Problem Output File, contains energy balance information
*.OBS - Temperature histories at observation points

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ENGINEERING CALCULATIONS TITLE AND SUMMARY SHEET

2290

Date 5/19/99

Sheet 1 of 6

Job/WBS No. 733903-01000 Calculation No. 16-03

Title Silo 1&2 POP

Calculation Subject Liner Headspace Radon Concentration/Emission Date Verified/Checked 5/20/99

STATUS: PRELIMINAR X FINAL ___ SUPERSEDED ___ VOID ___

STATEMENT OF PROBLEM	
Liners of curing waste cement will generate both heat and radon. During the initial period of rising headspace temperatures, positive pressures will lead to the venting of small amounts of radon. An analytical mixing model was used to calculate the time-history of vented radon, as well as the headspace concentration history and headspace equilibrium concentration at the end of the initial 15-day curing period.	
SUMMARY OF CONCLUSIONS	Originator's Signature and Date
The period of rising headspace temperatures, taken from the previous liner cement heat transfer model, was estimated to last for 6.75 hours. At the end of this period, 8.7654e+7 pCi of Radon had been emitted from the curing cement. Of this total, 8.4453e+7 pCi remained in the headspace, 2.1788e+6 pCi had decayed, and 1.022e+6 pCi had vented to the curing room. Because temperatures were falling for the remainder of the curing period, no radon was vented and all emitted radon accumulated in the headspace. Accounting for decay, the radon headspace concentration at the end of the 15-day curing period was 3.188e+6 pCi/l.	[signature] 5/20/99
CHECKING METHOD #1	Checker's Signature and Date [signature] 5/20/99
1. Review 2. Alternate Calculation	Technical Lead's Signature and Date [signature] 5/20/99

Rev. No.	Sheet No.	Description	Reviser's Signature/Date	Checker's Signature/Date	Approved by Signature/Date

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ENGINEERING CALCULATIONS BASIS SHEET

2290

Revision No. 0
Sheet 2 of 6

Job/WBS No. 733903-01000 Calculation No. 16-03

Title Silo 1&2 POP

Calculation Subject Liner Headspace Radon Concentration/Emission Date Verified/Checked

Prepared By: P. Schwind Checked/Verified By:

Date 5/19/99

SUMMARY OF DATA SOURCES – CODES – ASSUMPTIONS

DATA SOURCES:

- Radon emanation rate and half-life from P. Frink.
- Headspace temperature history from Cement Heat Generation calculation, Silo 1&2 POP Calculation No. 16-01.
- Dimensions of full-scale cement liner from P. Frink.

ASSUMPTIONS:

- Headspace temperature history is same as liner surface temperature history predicted by cement heat generation model.
- Radon concentration is uniform within headspace (i.e., perfect mixing may be assumed).
- Venting from headspace may be determined by assumption of perfect gas expansion.

3/6
Calc. 16-03
Rev 0

Job-WBS No.: 733903-01000
Calculation No.: 16-03
Title: Silo 1&2 POP
Subject: Liner Headspace Radon Concentration/Emission

2290

DISCUSSION

It is anticipated that cylinders of curing waste/cement mixture will generate heat and radon, resulting in headspace gas expansion, positive headspace pressures, and venting of small amounts of radon to the curing room. To estimate the amount of radon vented to the curing room and the radon concentration in the headspace at the end of the 15-day curing period, an analytical mixing model was developed. The model accounts for radon emanation from the cement top surface into the headspace, radon decay, and venting of headspace gases due to volume expansion.

Assuming that the headspace gas is well mixed, the following differential equation reflects the radon mass balance in the liner headspace:

$$V\frac{dC}{dt} = qA - \lambda VC - QC$$

where

C = headspace radon concentration (pCi/m^3)

t = time (hr)

V = headspace volume (m^3)

q = radon flux rate through cement top surface(pCi/m^2/hr)

A = cement top surface area (m^2)

λ = radon decay constant (hr^{-1})

Q = venting volumetric flow rate (m^3/hr)

All terms in the equation have units of pCi/hr. The first term on the right-hand side of the equation represents the rate of radon addition to the headspace by emanation through the cement top surface. The second and third terms on the right account for the rate of radon removal by decay and venting to the curing room, respectively. The left-hand side represents the rate of change of radon in the headspace and is equal to the net sum of the rates of addition and removal.

If at any time t_0 the radon headspace concentration is C_0, the above equation may be integrated forward in time to obtain

$$C(t) = \left(\frac{qA}{\lambda V + Q}\right) + \left(C_0 - \frac{qA}{\lambda V + Q}\right)\exp\left(-\left(\lambda + \frac{Q}{V}\right)(t - t_0)\right)$$

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This relation is valid for any time period in which the problem parameters (all variables except C and t) are constant. For this problem, all parameters are constant except the venting rate Q. The calculation approach was therefore to create a spreadsheet that stepped forward in time over small enough steps such that Q was relatively constant. Accuracy was improved by integrating Q over the time step to obtain the best average value to be used in the $C(t)$ equation.

The venting rate Q was assumed to result from rising temperatures and expanding headspace gas at the start of curing. Maintaining the initial pressure in the headspace requires venting of the extra volume due to rising temperatures. The temperature history of the headspace, $T(t)$, was taken to be the same as surface temperatures predicted with the cement curing heat transfer model (see Calculation No. 16-01, "Cement Heat Generation"). Applying the perfect gas law at constant pressure for a time step Δt,

$$Q = \frac{\Delta V}{\Delta t} = \frac{\left(\frac{T(t+\Delta t)}{T(t)} - 1\right)V}{\Delta t}$$

Assuming linear variation of temperature between $T(t)$ and $T(t + \Delta t)$, Q may be integrated over the time step to obtain the average volumetric venting rate

$$\overline{Q} = \frac{V}{\Delta t}\ln\left(\frac{T(t+\Delta t)}{T(t)}\right)$$

This is the value of the volumetric venting rate used in the equation for $C(t)$. Venting occurs only as long as headspace temperatures are rising during the curing process. This period was estimated to be 6.75 hours long (as per the cement heat generation model). After the peak headspace temperature is reached, volume expansion ceases and $Q = 0$.

Spreadsheet output is attached for the 6.75-hour period during which headspace temperatures are rising. Also calculated in the spreadsheet is the expected headspace concentration after the initial 15-day curing period. This calculation assumes that no venting occurred at the start of curing, and is therefore slightly conservative.

The spreadsheet file is on the Parsons I&T Cincinnati Office network at:

//cinfp-01/7???pop\documents\headspace radon conc vs time

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hs vol =	0.5012	m^3	Equil Conc w/ no Air Flux = (q*A)/(lambda*vol) =
q =	4.68E+06	pCi/m^2-hr	= 3.4090E+09 pCi/m^3
A =	2.77473	m^2	3.4090E+06 pCi/L
lambda =	0.0076003	1/hr	
half-life =	3.8	d	

Headspace Temperature, Integrated Air Flux Qav, & Concentration (pCi/m^3) vs. Time (hr)

time (hr)	temp (F)	temp (R)	Qav (m^3/hr)	D1 (1/hr)	D2 (pCi/m^3)	C (pCi/m^3)	Integral C
0	71.6	531.27	0.0000E+00	0.000000	0.0000E+00	0.0000E+00	0.0000E+00
0.25	86.9763	546.6463	5.7200E-02	0.121727	2.1285E+08	6.3798E+06	8.0151E+05
0.5	89.8623	549.5323	1.0556E-02	0.028663	9.0394E+08	1.2788E+07	3.1985E+06
0.75	92.5786	552.2486	9.8852E-03	0.027323	9.4825E+08	1.9157E+07	7.1925E+06
1	94.9602	554.6302	8.6272E-03	0.024813	1.0442E+09	2.5495E+07	1.2775E+07
1.25	97.0963	556.7663	7.7064E-03	0.022976	1.1277E+09	3.1808E+07	1.9939E+07
1.5	98.9738	558.6438	6.7491E-03	0.021066	1.2299E+09	3.8101E+07	2.8678E+07
1.75	100.6423	560.3123	5.9788E-03	0.019529	1.3267E+09	4.4377E+07	3.8988E+07
2	102.1069	561.7769	5.2335E-03	0.018042	1.4360E+09	5.0640E+07	5.0866E+07
2.25	103.4008	563.0708	4.6122E-03	0.016803	1.5420E+09	5.6892E+07	6.4308E+07
2.5	104.5328	564.2028	4.0264E-03	0.015634	1.6573E+09	6.3135E+07	7.9312E+07
2.75	105.5269	565.1969	3.5293E-03	0.014642	1.7695E+09	6.9369E+07	9.5875E+07
3	106.3922	566.0622	3.0669E-03	0.013719	1.8885E+09	7.5598E+07	1.1400E+08
3.25	107.1465	566.8165	2.6697E-03	0.012927	2.0043E+09	8.1821E+07	1.3367E+08
3.5	107.7981	567.4681	2.3034E-03	0.012196	2.1244E+09	8.8039E+07	1.5491E+08
3.75	108.3607	568.0307	1.9866E-03	0.011564	2.2405E+09	9.4253E+07	1.7769E+08
4	108.8415	568.5115	1.6962E-03	0.010985	2.3587E+09	1.0046E+08	2.0203E+08
4.25	109.2511	568.9211	1.4439E-03	0.010481	2.4720E+09	1.0667E+08	2.2793E+08
4.5	109.5955	569.2655	1.2133E-03	0.010021	2.5855E+09	1.1287E+08	2.5537E+08
4.75	109.8831	569.5531	1.0126E-03	0.009621	2.6931E+09	1.1907E+08	2.8436E+08
5	110.1189	569.7889	8.2983E-04	0.009256	2.7992E+09	1.2526E+08	3.1490E+08
5.25	110.3095	569.9795	6.7051E-04	0.008938	2.8987E+09	1.3145E+08	3.4699E+08
5.5	110.459	570.129	5.2577E-04	0.008649	2.9955E+09	1.3764E+08	3.8063E+08
5.75	110.5726	570.2426	3.9942E-04	0.008397	3.0855E+09	1.4382E+08	4.1581E+08
6	110.6537	570.3237	2.8510E-04	0.008169	3.1716E+09	1.5000E+08	4.5254E+08
6.25	110.7064	570.3764	1.8524E-04	0.007970	3.2509E+09	1.5617E+08	4.9082E+08
6.5	110.7336	570.4036	9.5602E-05	0.007791	3.3255E+09	1.6234E+08	5.3063E+08
6.75	110.7386	570.4086	1.7573E-05	0.007635	3.3933E+09	1.6850E+08	5.7198E+08

Cavg (pCi/m^3) = 84738491.7
Cavg (pCi/L) = 84738.492

	(hr)			Qav				
At 15 days:	360	71.6	531.27	0.0000E+00	0.007600	3.4090E+09	3.1880E+09	pCi/m^3
							3.1880E+06	pCi/L

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CUMULATIVE MASS BALANCE COMPONENTS (pCi)

Time (hr)	Emitted	In-place	Decayed	Fluxed	Balance
0.00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0
0.25	3.2464E+06	3.1975E+06	3.0532E+03	4.5847E+04	0
0.50	6.4929E+06	6.4095E+06	1.2184E+04	7.1150E+04	0
0.75	9.7393E+06	9.6013E+06	2.7398E+04	1.1063E+05	0
1.00	1.2986E+07	1.2778E+07	4.8663E+04	1.5879E+05	0
1.25	1.6232E+07	1.5942E+07	7.5951E+04	2.1400E+05	0
1.50	1.9479E+07	1.9096E+07	1.0924E+05	2.7298E+05	0
1.75	2.2725E+07	2.2242E+07	1.4852E+05	3.3463E+05	0
2.00	2.5971E+07	2.5381E+07	1.9376E+05	3.9679E+05	0
2.25	2.9218E+07	2.8514E+07	2.4497E+05	4.5879E+05	0
2.50	3.2464E+07	3.1643E+07	3.0212E+05	5.1920E+05	0
2.75	3.5711E+07	3.4768E+07	3.6522E+05	5.7765E+05	0
3.00	3.8957E+07	3.7890E+07	4.3424E+05	6.3323E+05	0
3.25	4.2204E+07	4.1009E+07	5.0920E+05	6.8576E+05	0
3.50	4.5450E+07	4.4125E+07	5.9008E+05	7.3467E+05	0
3.75	4.8697E+07	4.7240E+07	6.7689E+05	7.7994E+05	0
4.00	5.1943E+07	5.0352E+07	7.6960E+05	8.2123E+05	0
4.25	5.5189E+07	5.3463E+07	8.6823E+05	8.5861E+05	0
4.50	5.8436E+07	5.6571E+07	9.7277E+05	8.9191E+05	0
4.75	6.1682E+07	5.9678E+07	1.0832E+06	9.2126E+05	0
5.00	6.4929E+07	6.2783E+07	1.1996E+06	9.4661E+05	0
5.25	6.8175E+07	6.5885E+07	1.3218E+06	9.6813E+05	0
5.50	7.1422E+07	6.8986E+07	1.4499E+06	9.8581E+05	0
5.75	7.4668E+07	7.2084E+07	1.5840E+06	9.9986E+05	0
6.00	7.7914E+07	7.5180E+07	1.7239E+06	1.0103E+06	0
6.25	8.1161E+07	7.8274E+07	1.8696E+06	1.0174E+06	0
6.50	8.4407E+07	8.1365E+07	2.0213E+06	1.0212E+06	0
6.75	8.7654E+07	8.4453E+07	2.1788E+06	1.0220E+06	0

Average Flux Rate (pCi/hr) = 151401.27
Average Flux Rate (pCi/s) = 42.0559

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ENGINEERING CALCULATIONS
TITLE AND SUMMARY SHEET

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Date 5/19/99

Sheet 1 of 6

Job/WBS No. 733903-01000 Calculation No. 16-04

Title Silo 1&2 POP

Calculation Subject Vessel Vent System Loading Date Verified/Checked

STATUS: PRELIMINAR X FINAL ___ SUPERSEDED ___ VOID ___

STATEMENT OF PROBLEM	
The Vessel Vent System (VVS) must handle radon loading due to the 1) slurry tank fill/empty cycles, 2) individual liner fill cycles, 3) post-mixing headspace purges, and 4) post-curing headspace purges. Daily offgas volumetric flow rates to the VVS for each of these four sources were estimated, as was average offgas radon concentration. The overall average radon concentration in the VVS input stream was then calculated by flow rate-averaging the concentrations of the four streams.	
SUMMARY OF CONCLUSIONS	Originator's Signature and Date
For steady operation, the four offgas sources mentioned above added only 4.15 scfm of volumetric flow to the assumed 250 scfm of fresh air in the VVS input stream. When diluted with this fresh air stream, the average radon concentration in the VVS input stream was estimated to be 1.4266e+5 pCi/l.	[signature] 5/20/99
CHECKING METHOD	Checker's Signature and Date
1. Review 1 2. Alternate Calculation ___	[signature] 5/20/99
	Technical Lead's Signature and Date
	[signature] 5/20/99

Rev. No.	Sheet No.	Description	Reviser's Signature/Date	Checker's Signature/Date	Approved by Signature/Date

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ENGINEERING CALCULATIONS BASIS SHEET

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Revision No. ϕ
Sheet 2 of 6

Job/WBS No. 733903-01000 Calculation No. 16-04

Title Silo 1&2 POP

Calculation Subject Vessel Vent System Loading Date Verified/Checked 5/20/99

Prepared By: P. Schwind Checked/Verified By: [signature]

Date 5/19/99

SUMMARY OF DATA SOURCES – CODES – ASSUMPTIONS

DATA SOURCES:

- Radon emanation rates from P. Frink.
- Dimensions of full-scale mixing tank and cement liner from P. Frink.
- Fill rates, empty rates, mixing/curing times, VVS system fresh air rate from P. Frink.
- Post-curing equilibrium liner headspace concentration from headspace mixing model, Silo 1&2 POP Calculation No. 16-03.

ASSUMPTIONS:

- Steady plant operation at following processing rates: 1.5 slurry tank empty/fill cycles per day, 9 cement liner fill cycles per day, 9 post-mixing liner headspace purges per day, 9 post-curing liner headspaces purges per day.

Job-WBS No.: 733903-01000
Calculation No.: 16-04
Title: Silo 1&2 POP
Subject: Vessel Vent System Loading

DISCUSSION

The Silo 1&2 POP Vessel Vent System (VVS) removes high-radon gases that build up in process vessels. The VVS is necessary to prevent release of this gas into the facility. VVS radon loading is primarily due to 1) slurry tank fill/empty cycles, 2) individual liner fill cycles, 3) post-mixing liner headspace purges, and 4) post-curing liner headspace purges. Steady-state radon loading due to each of these sources was calculated assuming the following processing rates, based on 150% design basis capacity:

- 1.5 slurry mixing tank fill/empty cycles per day
- 9 cement liner fill cycles per day
- 9 post-mixing liner headspace purges per day
- 9 post-curing liner headspace purges per day

The calculations of average off-gas radon concentration for each of the four sources were performed as outlined below. Per cycle volumetric gas flows to the RCS were also calculated. The steady-state average gas flow rate to the RCS was obtained by multiplying per cycle flows by the number of cycles per day, and adding to an estimated 250 scfm of fresh air going to the RCS. The steady-state radon concentration for the combined flow to the RCS was obtained by volumetric flow-averaging the off-gas radon concentrations in the component streams.

This calculation is intended to provide a preliminary estimate of VVS radon loading. Actual values will be based on further calculations using actual title design.

PER CYCLE AVERAGE OFF-GAS RADON CONCENTRATIONS

Slurry Mixing Tank Fill/Empty Cycle

The radon emanation flux rate was taken to be equal to the pre-bentonite silo emanation flux rate. The time required to fill and empty the slurry mixing tank was obtained by dividing the tank fill volume by the tank fill/empty rate. Total radon emitted was calculated by multiplying the radon emanation flux rate by the slurry mixing tank free surface area and the total time required to fill and empty the slurry mixing tank. The total volume displaced is equal to one slurry mixing tank fill volume and the average off-gas volumetric flow rate is equal to the displaced volume divided by the total fill/empty time. The average off-gas radon concentration is equal to the total radon emitted divided by the total volume of off-gas displaced. It should be noted that while one fill/empty cycle takes

3 days, the calculation assumes that enough slurry mixing tanks are operating simultaneously to result in 1.5 fill/empty cycles per day.

Cement Liner Fill Cycle

The radon emanation flux rate was taken to be equal to the pre-bentonite silo emanation flux rate. The time required to fill the liner was obtained by dividing the liner fill volume by the liner fill rate. Total radon emitted was calculated by multiplying the radon emanation flux rate by the liner free surface area and the total time required to fill the liner. The total volume displaced is equal to one liner fill volume and the average off-gas volumetric flow rate is equal to the displaced volume divided by the total fill time. The average off-gas radon concentration is equal to the total radon emitted divided by the total volume of off-gas displaced.

Post-Mixing Liner Headspace Purge

The radon emanation flux rate was taken to be equal to the pre-bentonite silo emanation flux rate. Total radon emitted was calculated by multiplying the radon emanation flux rate by the liner free surface area and the total time spent mixing the cement in the liner. The total volume purged is equal to one liner headspace volume. The average off-gas radon concentration is equal to the total radon emitted divided by the total volume of off-gas purged.

Post-Curing Liner Headspace Purge

The radon concentration in the liner headspace after 15 days of curing was calculated as part of the Liner Headspace Radon Concentration/Emission Calculation (Calculation No. 16-03). The total volume purged is equal to one liner headspace volume. Total radon emitted was calculated by multiplying the headspace radon concentration by total volume of off-gas purged.

Spreadsheet output is attached for each of the four source streams as well as for the combined VVS input stream. The spreadsheet file is on the Parsons I&T Cincinnati Office network at:

\\CIN-FP-01\733903_POP\Calcs\vvscalc.xls

Slurry Feed Tank Empty/Fill

Input:	Rn Emanation Rate =	214141 pCi/m^2-s
	Tank Diameter =	15 ft
	Tank Height =	16.67 ft
	Tank Empty/Fill Rate =	5.10102 gpm
Output:	Tank Surface Area =	16.4174 sq.m
	Tank Volume =	22036.41 gal
	Tank Empty/Fill Time =	259200.00 sec
	Total Rn =	9.1125E+11 pCi
	Off-Gas Flow Rate =	0.6819 scfm
	Off-Gas Displaced =	2945.839 cu.ft
	Off-Gas Avg Rn Conc =	1.0924E+10 pCi/cu.m

Cement Liner Fill

Input:	Rn Emanation Rate =	214141 pCi/m^2-s
	Tank Diameter =	6.2083 ft
	Tank Height =	4.955 ft
	Tank Fill Rate =	40 gpm
Output:	Tank Surface Area =	2.8123 sq.m
	Tank Volume =	1122.05 gal
	Tank Fill Time =	1683.07 sec
	Total Rn =	1.0136E+09 pCi
	Off-Gas Flow Rate =	5.3472 scfm
	Off-Gas Displaced =	149.996 cu.ft
	Off-Gas Avg Rn Conc =	2.3864E+08 pCi/cu.m

Purge Headspace After Mixing

Input:	Rn Emanation Rate =	214141 pCi/m^2-s
	Tank Diameter =	6.2083 ft
	Headspace Volume =	1.7 cu. ft
	Mixing Time =	2.5 hr
Output:	Tank Surface Area =	2.8123 sq.m
	Total Rn =	5.4201E+09 pCi
	Off-Gas Avg Rn Conc =	1.1259E+11 pCi/cu.m

Purge Headspace After Curing

Input:	Rn Equilibrium Conc =	3.4090E+09 pCi/m^3
	Headspace Volume =	1.7 cu. ft
Output:	Total Rn =	1.6410E+08 pCi

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Gas Stream	Volumetric Flow Rate (scfm)	Displaced Volume (cu. ft.)	VOC Concentration (ppm)	Temperature (F)	Relative Humidity (%)	Radon Concentration (pCi/cu. m)	Event Frequency (1/day)
Assumed Inleakage to Full-Scale Facility Process Components	250.000		0	70	50	0.0000E+00	
Displaced Gas While Filling Slurry Feed Tank	3.184	2945.8	8	90	100	1.0924E+10	1.5
Displaced Gas While Filling Container in Process Room	0.955	150.0	8	80	100	2.3864E+08	9
Purge Container Headspace After Mixing	0.011	1.7	50	90	100	1.1259E+11	9
Purge Container Headspace After Initial Cure Period	0.011	1.7	50	80	100	1.6410E+08	9
VVS Output Stream	254.15		0.13	70.29		1.4266E+08	
RCS Limits	500		40	90			

Note: This calculation pertains to radon concentrations. See report text for pilot-scale values for VOC, temperature, and humidity.

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