ATCOR ENGINEERED SYSTEMS, INC.

TOPICAL REPORT
ATC-8019-1-N
for
Atcor Liquid Volume Reduction Process

THE

ATCOR AVRS-80

VOLUME REDUCTION PROCESS

T O P I C A L   R E P O R T

ATC-8019-1-N

SUBMITTED TO:
STANDARDIZATION AND SPECIAL PROJECTS BRANCH
US NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

MAY, 1982

REVISION 0

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ABSTRACT

This Topical Report describes the design and operation of the ATCOR Liquid Volume Reduction System. The system was developed in conjunction with Belgonucleaire, S.A. to provide a simple to operate and reliable method for the reduction of the volume of radioactive liquid wastes or waste slurrys, and solidifying the dehydrated residue for transportation and disposal.

The system features, verified by extensive pilot plant testing, are as follows:

1. Chemical pretreatment of the wastes to place the waste in a chemical form which will solidify acceptably in a variety of solidification matrices.

2. Volume reduction by evaporation to achieve volume reduction ratios after solidification between 7 to 1 and 10 to 1 depending on the waste processed. Average Decontamination Factors (DF) achieved during system operation are in the neighborhood of 6,000.

3. Solidification is accomplished as an operation integral to the drying operation or as a separate operation. The solidified product contains no free water, is free standing and exhibits acceptable leaching characteristics.

4. The process has been successfully tested using a variety of waste streams and combinations of waste streams to simulate power plant wastes.

5. The process does not generate secondary waste streams which must in turn be processed. Any secondary wastes produced can be processed in the same equipment.

6. The system is readily adaptable to a mobile application due to the simplicity of design and the ability to skid mount the equipment.

7. The system meets all Federal regulations for installation and operation at a nuclear power plant.

PROPRIETARY INFORMATION

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CHAPTER 1

INTRODUCTION

1.0 Introduction

The increasing costs for the disposal and transportation of low-activity liquid wastes generated at nuclear power plants and facilities has made the volume reduction of these wastes increasingly attractive in recent years. The system described in this topical report reduces the volume of these wastes by evaporation and provides for the solidification of the dried residues into a variety of acceptable matrices. The reduction of volume of the solidified wastes by factors ranging from 7:1 to 10:1 depending on the waste streams processed. This is accomplished in reliable, heavy duty equipment which is designed to minimize radiation exposures resulting from operation and maintenance.

The design of the system is based on research conducted by both Belgonucleaire, S.A. and Atcor Engineered Systems, Inc. over the last nine years. Testing conducted at the Nuclear Research Facility located at Mol, Belgium began in 1969 and resulted in the installation of liquid waste volume reduction and solidification systems at Foresmark in Sweden and at Tihange, Unit II, in Belgium. The Mol testing concentrated on determining waste chemistry and pre-treatment philosophies as well as equipment selection. An operating pilot plant system has been extensively operated to verify the process and equipment selected. ATCOR's testing has resulted in over 20 radioactive waste solidification systems in operation world wide. The combination of two compatible testing has resulted in the system described in this topical report.

Wastes tested in the system include, separately and combined, simulated waste streams containing boric acid, sodium sulfate, decontamination solutions, filter aids, resin slurries and iron oxides. Pre-treatment of these waste streams is utilized to produce the waste in a chemical form which is relatively insoluble and which behaves well from a materials handling aspect during drying and solidification. Drying of the wastes is accomplished under a slight negative pressure using a twin screw intensive dryer. The screws provide a self-wiping action on the dryer walls and paddles to improve the heat transfer characteristics and to prevent the build up of waste on the inner surfaces of the equipment. The dried wastes can be combined with the solidification matrices within the last section of the intensive dryer or stored and solidified at a later time in a similar mixer or using an in-container process. The evaporated water vapor is condensed and monitored provide iondication of system operation. Non-condensable gases are discharged to the station ventillation system.

The purpose of this report is to present the necessary data on the system design and testing to allow the Nuclear Regulatory Commission to evaluate the system for installation in nuclear facilities in the United States.

1.1 Experience

1.1.1 ATCOR Engineered Systems, Inc.

ATCOR Engineered Systems, Inc. (ATCOR) has provided Radwaste Solidification and Processing Systems to nuclear power plants, both in the United States and abroad, since 1972. ATCOR has designed solidification systems for both PWR and BWR stations. The operating experience from these systems has provided a solid background of experience in the processing of radioactive wastes, which has allowed for the constant improvement of radioactive waste systems providing for increased equipment reliability, system simplicity and ease of operation. ATCOR holds U.S. Patent #3833441, which is one of the earliest patents in the field of radwaste processing. ATCOR's Topical Report ATC-132A for liquid radioactive waste solidification was approved by the N.R.C. on September 4, 1981.

1.1.2 Belgonucleaire, S.A.

Belgonucleaire (BN) radioactive waste experience extends to 1963 when Belgonucleaire was charged with the operation of the Waste Treatment Station of the Nuclear Study Center located in Mol, Belgium. The experience received in the operation of this asphalt solidification system lead to the design by BN of an asphalt VR system installed at the Mol Nuclear Study Center in 1971 and later commercially installed at the Forsmark Station in Sweden in 1979.

Operation of these installations lead to the testing program and system design which are discussed in this Topical Report. The volume reduction process with integral solidification matrix mixer design described in this Topical Report is supported by a seven year developmental program.

1.2 System Design Objectives

1.2.1 Equipment

The equipment was designed to meet the following objectives to the greatest extent possible:

1) Allowance for changes in the feed solutions from one batch to the other (chemical content, nature, quantities,) with only simple adjustments of the operating parameters and without modification of the main components involved;
2) To be easily, safely and remotely operable and capable of semi-automatic control with respect to the main process parameters;
3) To have an availability which corresponds to the power plant operation needs;
4) To be reliable and safe;
5) To be capable of continuous operation, at least for the majority of the process, without the permanent attendance of an operator and with very few, if any, operations required inside the shielded cells;
6) To use equipment and components available either on the industrial market or easily convertible to the particular requirements of radwaste service and which have been previously demonstrated as industrially adequate for applications in non-nuclear situations.
7) To allow infrequent, simple and rapid maintenance or parts replacement;
8) To be properly designed with respect to the accessibility of the components, separation of the subassemblies and segregation of the waste sources;
9) To require only unsophisticated decontamination methods;
10) To provide the flexibility of alternative operations or handling for the major process operations;
11) To allow economical process operations;

12) To provide for slightly negative pressure operation to minimize the contamination potential of the system;
13) To design a system which is simple and durable enough that it can be adapted to a mobile operation cycle.

1.2.2 Solidified Product

The following properties of the final solidified product are considered to be desirable. The ATCOR/BN system is designed to obtain a solidified waste with these properties:

1) minimum volume;
2) continuous monolith with no residual free water;
3) no appreciable differential settling of materials;
4) free standing without outer receptacle or packaging;
5) little degradation with time (within acceptable limits) of the product properties;
6) binder which shows no radiation damage for the expected integrated dose rate up to the end of the storage period;
7) compatibility between the matrix material and the chemical compounds of the residues (during and after incorporation in the matrix);
8) sufficient mechanical resistance, such as compressive strength, to meet existing waste burial criteria.
9) low leaching rate for the particular radioactive species trapped in the residues;
10) long term satisfactory behavior under the storage conditions in open air, above ground engineered storage, or burial storage;
11) no detrimental attack of the product when exposed to fire;
12) readily producible on an industrial scale;
13) cost of matrix material and additive chemicals should be small when compared to the overall production and disposal cost.

C H A P T E R 2

PROCESS DESCRIPTION

2.0 PROCESS DESCRIPTION

The ATCOR AVRS-80 combines a liquid radwaste Volume Reduction (VR) system with a proven solidification system. This process allows the safe encapsulation of the dehydrated radioactive compounds into a variety of solidification matrices, together with the highest possible decrease in the solidified waste volume.

2.1 Process Schematic

Fig. 2-1 is the schematic drawing of the process. It shows that the main process line is composed of three major sub-systems:

a. Pretreatment: the incoming liquid wastes undergo a chemical pretreatment to prepare them for the remaining process steps. Sampling of the waste is accomplished prior to the addition of the pretreatment chemicals. Pretreatment is required to assure the quality of the solidified wastes by providing proper dehydration of the wastes assuring compatibility with the binder, and improving the characteristics of the solidified product.

b. Dehydration: the actual waste volume reduction takes place in this stage. The small volume of contaminated solid residues are separated from the larger volume of non-radioactive transportation water.

c. Encapsulation: the dehydrated solid residues are incorporated into an inert solidification matrix (either cement or polymer,) based upon the utility's option. The encapsulated residues are placed into the appropriate storage drum or container (unshielded or shielded, as required based upon the end-product activity) in which the mixture solidifies prior to its transportation to the waste disposal site.

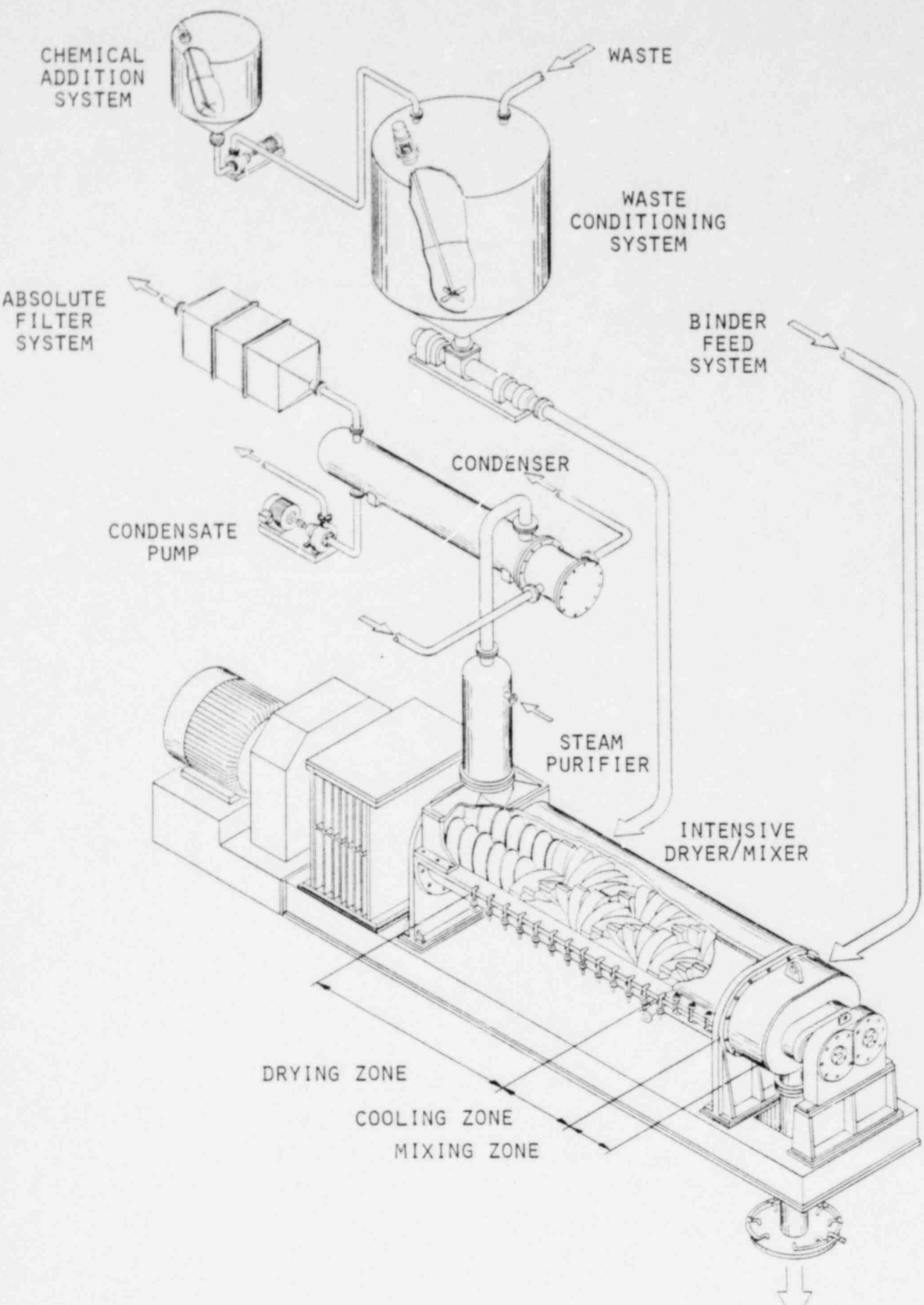

FIGURE 2-1 LIQUID VOLUME REDUCTION SYSTEM

Other supporting sub-systems are provided as shown:

a. Off Gas: the vapor released during the dehydration operation, is processed in the following sections:

   1. Vapor Treatment: the evaporated water is processed by a static filter, a demister to remove entrained water, and a condenser to collect the evaporated water.

   2. Condensate Storage: the condensed vapor is collected and monitored prior to its discharge to either final disposal or to an upstream holding tank for further polishing.

   3. Off-Gas Filtration (optional): the non-condensable gases can be passed through a set of three filter (i.e.: prefilter, HEPA filter, iodine filter) before being discharged to the station's off gas system.

b. Chemical Addition: the preparation, storage and injection of the waste pre-treatment chemicals is accomplished by this sub-system.

c. Solidification Matrix Preparation: the storage of the solidification binder materials and the feeding of the binder to the mixer is included in this sub-system.

d. Heating: the energy required to evaporate the water from the waste can be provided by electric heaters or by steam jacketing.

e. Cooling Water: the cooling water required for the condenser and other components is provided by this sub-system.

f. Materials Handling: the equipment needed to convey, cap, smear and decontaminate the solidified product and container are included in this sub-system.

2.2 SYSTEM DESIGN CONSIDERATIONS

2.2.1. Pretreatment

Extensive experimentation has shown that an adequate chemical pretreatment is essential in order to obtain satisfactory results. The objectives of the pre-treatment are to provide:

a) the dehydration of the waste to a fine powder without surface scaling;

b) the obtaining of an acceptable solidified end-product from the standpoints of:
   - the compatibility of the residues with the matrix material;
   - the long term behavior under the storage condtions;
   - the leaching rates of the contaminated compounds;
   - the physical properties.

Should the required pretreatment be neglected, unsuitable products, process failure or poor end-product properties may result. Although failures of the matrix may not be apparent immediately following encapsulation, rigorous testing and experimentation has shown that lack of proper pretreatment will contribute to failures over a period of time. In the case of boron containing wastes, pretreatment also reduces the danger of crystallization in the storage and pretreatment sub-systems at ambient temperatures.

From the above, it is obvious that waste solutions may not be blindly processed. Operators must have sufficient knowledge of the chemical composition of the incoming waste to select the correct process parameters to ensure a properly encapsulated final product. The ATCOR/BN Process Control Plan (PCP), which is used to determine the proper pretreatment, is based upon extensive experimentation with all of the potential waste forms.

2.2.2. Dehydration

The AVRS-80 system yields an excellent was e volume reduction ratio of approximately 10:1 by the removal of the free water from the conditioned residues. It has been established that complete dehydration appreciably improves the results of the encapsulation operation, since precise amounts of water and cement can be fed to the mixer in proper proportion to the known amount of dried waste. The weight of dried waste is proportional to the flow of condensate from the dehydration system and thus can be known accurately. This information combined with the PCP, results in a precise encapsulation process.

The efficiency and quality of the dehydration process depends upon the operational characteristics of the dryer. Problems such as product scaling, melting, jamming, uneven feed, and dusting during the dehydration stage have been overcome through the proper choice of equipment, operating conditions and waste pretreatment. Extensive pilot plant operations have refined the process to eliminate these very real problems.

The evaporating capacity per unit heating surface is also an important factor, since it directly affects the size of equipment for a given feed flow rate. Because most of the waste solutions at the dehydration system inlet contain a variable concentration of dissolved solids (typically 5 to 20% by weight), a considerable amount of water has first to be evaporated before reaching the granular powder stage. The waste becomes increasingly more pasty and difficult to transport as the transportation water is removed from the waste slurry. The choice of dehydrator is especially important as a result of this property. The AVRS-80 Intensive Dryer is designed not only to efficiently evaporate the water from the waste but to also efficiently transport the dehydrated waste to the product outlet. The action of the paddles in the dryer breaks up any clumps which may form in the dryer, and provides a self-wiping feature to minimize the amount of waste contained inside the dryer at a time. The rugged paddles and shafts prevent jamming or shearing of the dryer during operation; a characteristic which has been proven in many tests conducted at the pilot plant.

A two stage drying system can be provided for waste streams which either contain very low solids concentrations or which involve larger volumes of waste. The initial drying stage uses a thin film evaporator to raise the waste solids concentration to approximately 40 per cent by weight prior to the final drying stage in an Intensive Dryer as described above. Both vertical and horizontal thin film evaporators has been coupled with the Intensive Dryer without affecting the operation of the system. The choice of the horizontal or vertical thin film evaporator depends on the space allowed for the installation of the system.

This equipment operates under a slight vacuum, allowing evaporation to take place at a slightly reduced temperature. Negative pressure operation also provides the assurance that any leaks are into the equipment, eliminating the potential for airborne contamination.

2.2.3 Encapsulation

The AVRS-80 process allows for a variety of media to be used to encapsulate the dried waste. The decision not to select only one of the three currently acceptable matrix materials was based on the following three reasons:

1. the different user preferences concerning the solidification matrices and the storage of the conditioned dried wastes which may be affected by national or corporate commitments;

2. the fact that the compatibility of the dehydrated wastes and solidification matrix may not be optimum for all waste/matrix combinations.

3. the continual research and development on binder materials by ATCOR, BN and others to develop the best possible matrix materials for individual wastes will eventually produce another accepted binder.

Therefore, one of the main concerns in the design was to work out a process which could readily be adapted to several types of matrices. The concept of drying the waste stream to dry granules satisfies this requirement, since dry wastes can easily be combined with either cements, polymers or other matrices as a separate operation. This flexibility will also result in a superior volume reduced solidified end product.

From a different standpoint, should a plant operator wish to switch to another solidification matrix, the major part of the VR System would not need modification, since only the matrix preparation stage would need to be retrofitted.

The AVRS-80 process has been designed to permit the drying step and the encapsulation step to be combined in a single unit, the Intensive Dryer/Mixer. Dried residue moves directly from the drying section to the water cooled mixing section into which the cement and water (or other solidification agents, i.e.: Dow) can be precisely metered to achieve complete mixing. This eliminates the need for intermediate storage and feeding steps for the dry active residue which would be required by a separate mixer.

A separate solidification mixer can be coupled with the Intensive Dryer to allow for the solidification of other waste streams, such as resins, independently of the dehydrated wastes. This option provides an added flexibility, which could be required based on the customer's preference.

The benefits in equipment cost, complexity, system flexibility and reduction in the potential for failure are obvious for this system.

2.3 SUB-SYSTEM DESCRIPTIONS

The following general sub-system descriptions are provided to describe the system operation. Detailed component descriptions are provided in Section 4.0 of this Topical Report. awings showing the system are contained in Appendix 4 (Proprietary) of this Topical Report.

2.3.1 Pretreatment Sub-System

The Pretreatment Sub-system typically consists of a dual-use Waste Conditioning Tank, a Chemical Addition Tank and Pump, a Waste Metering Pump, an Emergency Waste Return Pump and a Waste Sampling System. Sizing of the equipment depends upon the quantity and type of waste generated by each Nuclear Power Station.

The Waste Conditioning Tank is identical to the waste conditioning tanks provided by ATCOR in the non-volume reduction radwqste systems as described in ATCOR's approved Topical Report #ATC-132A. Both liquid wastes and resins are collected in the tank prior to the dehydration stage. The tank has the capability for the addition and agitation of pretreatment chemicals to liquid wastes, and the dewatering of resins.

Strip heaters are provided to maintain the wastes in solution prior to the addition of the pretreatment chemicals. The waste is metered to the Dehydration Subsystem by either of the two pumps. The Emergency Waste Return Pump has the ability to pump the waste to another tank in the event of failure of the Waste Metering Pump or the Intensive Dryer/Mixer. The Sample system allows a waste sample to be withdrawn from the Waste Metering Pump recirculation piping prior to dehydration. Resin dewatering is accomplished by withdrawing the transport water from the resins through filters located in the bottom of the Waste Conditioning Tank by either of the pumps.

2.3.2 Dehydration Sub-System

Dehydration of the wastes is accomplished in the Intensive Dryer/Mixer. The Intensive Dryer/Mixer is constructed of two horizontal cylinders each fitted with longitudinal shafts and lens-shaped mixing paddles, the inner walls of the cylinders are side by side circular major arcs of equal radii, intersecting to provide side-by-side interacting chambers. The rotating paddles cause longitudinal flow as well as flow through the opening between the intersection. The cylinders are electrically heated or steam jacketed for the drying section. The design is such that the quantity of product contained in the Dryer/Mixer during operation is small (less than 30% of the total volume), with virtually no dead space where dried residues might accumulate, and provides positive first-in-first-out flow. A separate drain connection allows for the emptying of flushing or decontamination solutions.

Alternate designs are available for plants without existing efficient evaporators or crystallizer units. A two stage continuous dehydration and solidification process uses, as the first stage, a high efficiency Thin Film Evaporator whose design has been improved specifically for nuclear service. The second stage is an Intensive Dryer similar to the dryer described above.

The Thin Film Evaporator has a single evaporation tube, whose diameter is large, permitting the handling of high viscosity products. The tube is fitted with a rotor, and the interior surface of the tube is bored perfectly cylindrical to form the heating area. Heat is again provided by electric heaters, spaced around the outer circumference of the tube or by a steam jacketed heat transfer area. The liquid waste is distributed over the interior of the heated tube by the centrifugal effect of the rotor. The film thus formed has a thickness of approximately 1 mm. It presents, for evaporation, a very small volume over a large surface. Turbulance considerably increases the heat transfer (boiling is almost instantaneous) and the volatile components are rapidly evaporated. The waste remains in the evaporator for a very brief time preventing product deterioration and plugging.

2.3.3. Encapsulation

The V/R product encapsulation normally takes place in the final section of the Intensive Mixer/Dryer. This section is water cooled to lower the temperature of the dried solids to a point where they are compatible with the solidification media. Cement can be introduced by means of the side stream injection screw directly into the barrel of the mixer. Water is metered into this section via a proportioning pump. The Dow binder and catalysts can be added in the mixing section in a similar manner. In each case only a single screw type binder feed device penetrates shield walls to the active area containing the mixers.

The dried waste/matrix mixture produced in the encapsulation mixer is then discharged into a shipping liner or drum where it solidifies.

A special dust-tight hood on the fill head, against which the storage container is pressed, will avoid splatter of the contaminated product.

At the end of each batch the components of the encapsulation step are sequentially stopped and a disposable drip-tray or slide gate is slid beneath the discharge chute in order to prevent the dripping of the contaminated mixture during the exchange of the storage containers.

2.3.4. Vapor Treatment - Condensate

The water vapor released by the Dehydration Sub-system is processed by the vapor treatment section composed of:

a. A steam purifier, a packed column, which collects the droplets and entrained dried waste which may have passed through the intensive dryer outlet. The collected liquid returns to the dryer. A flush connection is provided to clean the purifier of dried waste. The steam purifier is replaced on the two stage system by the scrubbing action of the Thin Film Evaporator.

b. A condenser which condenses the filtered vapor. The noncondensable gases are drawn by vacuum into the plant off gas system maintaining a slight negative pressure inside the contaminated sections of the system. The plant off gas system may also be equipped with a complete set of filters. An option for a prefilter, HEPA filter and iodine filter (activated charcoal) can be provided, if required.

   The condensed water falls into the condensate collection tank where the level is regulated by means of the speed of the condensate pump. This level measurement (when combined with the condensate flow measurement) permits the control of the system water balance by an automatic adjustment of the feed flow.

With the average decontamination factor of the system (i.e. ratio of the radioactivity level in the concentrate tank to the one in the condensate tank) in the range of 10^3, the distillate may either be directed towards the plant liquid discharge line or be transferred to an upstream liquid waste storage tank for further polishing, depending upon the incoming waste activity.

2.3.5. Materials Handling

Two types of transfer modes for container positioning are available for use. One method uses a powered roller drum conveyor system, while the second method uses a motorized transfer cart. As the name implies, the drum conveyor is limited to the transfer and positioning of standard 55 gallon drums. The use of transfer cart provides the flexibility of transporting drums, large volume liners or a combination of both. The motorized cart normally rides on two floor mounted rails.

2.3.5.1. Container Handling

The roller conveyor drum handling system, if provided, allows simple and positive drum transfer operations. The operator manually places empty drums on the input conveyor. Next, drums are remotely transferred to the various stations for filling, accumulation, capping, decontamination, radiological smear inspection and accumulation for storage pick-up. Positioning at each station is automatic and controlled by the operator from the control area. Filled drums are finally accumulated on the remaining conveyor sections for eventual transfer to the storage area. All control actions are from the central control panel.

Transfer carts used for transporting liners to the fill station, capping, decontamination and radiological smear station normally contain a single liner ranging in volume from 50 cubic feet to 195 cubic feet. Where there is a requirement to handle drums and larger liners, the cart can be designed with a drum spacer section. When drums are to be filled, the operator installs the spacer thereby making the drum height equal to the filling height of the liner.

Accurate container positioning is achieved by using photo-electric switches to remotely position the container and stop the drum conveying system or transfer cart. Photo switches are preferred over standard mechanically actuated limit switches, since operating experience indicates that mechanical switches do not achieve the same reliability as photo-electric units.

2.3.5.2. Capping

Using the controls provided on the main panel, the operator moves the container to the capping station. At the capping station, the operator can attach any labels or information (radiation level, date, identification number, etc.) on the drum cover prior to placing it on the remote capper.

The pneumatic capping device, Crimp-A-Cap™, will be mounted on an electrically operated overhead crane rail. The crane rail system will permit the operator to remotely pick up a cap from the automatic loader located adjacent to the capper station, and load a cap into the capping head. Reloading of the capping head automatic loader is done on a batch basis. The following is a brief description of the operating instructions used to cap a container:

1. Load cap into capping head from automatic loader.
2. Transfer the capping head above container to be capped using crane controls.
3. Lower capping head above the liner using crane controls.
4. Using crimp controls provided, crimp the cap onto the container.
5. Release the capping head from the container using crimp-a-cap controls.
6. Raise and stow the capping head using the crane controls.
7. Load capping head with a new cap.

The service required for the Crimp-A-Cap is 20 Amp-110 VAC, the crane requires 10 Amp-110 VAC service. The Crimp-A-Cap and crane controls will be integrated into one (1) control panel to insure safe operation.

For liners that do not have a standard drum opening, a remote, mechanically operated liner closure tool is provided. The liner opening is equipped with a two step, self latching Tiona Betts, Inc. or equal cover. The closure tool operates on the principle of a reach rod and mechanically closes the cover.

Container placement at the capping station is accomplished as previously discussed in the Container Positioning section. Operator viewing during the entire capping operation is provided by either a TV monitoring system or a lead glass shield window. Capped containers are then remotely moved to the subsequent decontamination station.

2.3.5.3. Decontamination

Drum decontamination is accomplished using a spray booth which is remotely lowered over the drum. When in place, the mating surfaces of the booth and drum conveyor or transfer cart are completely sealed to enclose the drum and prevent the spread of contamination. Water is used to spray wash all of the drum surfaces. An air blast cycle is used to remove most of the remaining water accumulated atop the drum cover. Spread of contamination is prevented by performing decontamination in a contained area separate from the other stations on the process aisle. Liners can be similarly decontaminated using a turntable and stationary spray header.

2.4 RADIATION MONITORING

Radiation level detectors should be located 1) adjacent to the waste tank; 2) at the container filling station. Remote readout from each detector should be displayed on the main control panel. At the filling station, the monitoring system measures the specific activity of the final solidified product. Radiation monitoring systems are normally provided by the customer to ensure compatibility with existing plant systems.

ATCOR can provide an optional remote operated radiological smear device for testing the external surfaces of the container filled with radioactive solidified waste. The entire smear operation is performed remotely from a control console behind a shield wall. Once the sample has been taken, the swab is extended through a wall opening for removal. The results of the smear determine if the container can be picked up for storage or returned to the decontamination station for further cleaning.

2.5. RADIATION EXPOSURE

2.5.1 Assumptions

Radiation exposures discussed in this section are based on the following assumptions:

- maximum incoming waste activity: $5Ci/m^3$
- dry solids content in the incoming waste: 12 W/O
- expected average decontamination factor of the system: 3,000 to 6,000 depending on the isotope.

These assumptions for the incoming waste are slightly higher than those appearing in the WASH-1258, table 2.22 (page 2-10) for a BWR, and in tables 2.45 (page 2-155) and 2.39 (page 2-137) for a PWR.

2.5.2 Control Room

The control room is located in a non-controlled access zone. Its protection from the point of view of radiation and transfer of radioactive products, is within the requirements of 10 CFR 20.

2.5.3 Controlled Access Zones

Components specified for "radioactive service" are located in shielded cells, either alone for ease of access, or grouped in accordance with their function when activity levels are low. In general the radiation exposure remains quite low in most sections of the installation since the amount of radioactive material contained in the majority of the system at any time is limited. In addition, operators are not normally expected to stay in or pass through the shielded areas during operation of the system.

Table 2-1 - Radiation Zone Designations, shows the anticipated dose rates for the AVRS-80 process, during operation, after shutdown and during maintenance.

TABLE 2-1-RADIATION ZONE DESIGNATIONS

Area	Clean Shutdown	During Operation	During Maintenance
Process Aisle	3	5	2
Waste Tank Cubicle	3	5	2
Evaporator/Dryer/Mixer	3	5	3
Cement Bin Area	1	2	1
Condenser/Condensate Tank	1	2	1
Operator Control Area	1	2	1
Truck Bay Area	1	5	1

Legend:

Radiation Zone 1	1. mrem/hour
2	2.5 mrem/hour
3	15. mrem/hour
4	100. mrem/hour
5	100. mrem/hour

2.6 FLUSHING - DECONTAMINATION

The system design contains the following features for simple and efficient flushing or decontamination of the equipment in radioactive service:

a) small inner volumes and surfaces of the process equipment.

b) demineralized water injection nozzles and drain connections provided at key points.

c) automatic water flushing of the lines containing the waste slurries initiated by a loss of flow signal.

d) spray nozzles to wash the inner wall surfaces of the radioactive tanks.

e) layout of lines to allow draining towards the upstream tank, and to avoid low spots whenever possible as constrained by the space available..

f) equipment design and construction features to eliminate areas of potential residue build up such as wide radius corners, polished interiors, and steeply sloped hoppers.

g) provisions for the addition of nitric acid for chemical cleaning of the equipment prior to performing maintenance.

2.7 INSTRUMENTATION & CONTROL

The System P & ID drawings (Appendix 4) detail the motor driven components, the remote pneumatic actuators, the position indicators and level controls, and the instrumentation channels which enable the operator to safely and easily operate the system.

All remote instrumentation and controls are centralized in one control panel with the required pushbuttons, switches, selector switches, controllers, pilot lights, indicators, recorders, regulators, annunciators, and audible alarms necessary to perform and monitor the operation of the system.

2.7.1. Instrumentation

The following parameters can be automatically monitored and controlled:

a) feed flow rate of the pretreated waste to the dryer.
b) reagent feed
c) distillate level in the condensate tank
d) feed rate of binder to the mixer
e) water flow rate for encapsulation, when required
f) differential pressure at the ventillation exhaust filters (optional)
g) dryer temperature
h) condensate flow
i) pH of wastes during pretreatment

Start-up signals must be triggered by the operator. Some operation sequences (i.e. encapsulation) are automatically cut-off by one or two sensors, depending upon the required safety level. Emptying of mixers and conveyors can be achieved with a manual back-up in the event of power or motor failure.

Radiation monitoring is not part of the System instrumentation, as it is normally included in the general radiation monitoring system of the nuclear plant.

2.7.2. Interlocks and Alarms

Various interlocks and alarms are provided in order to prevent the occurence of:

- operation incidents or operator's mistakes that would cause damage to the equipment or endanger the process quality.
- accidents which would be hazardous to the operating personnel or might lead to an abnormal contamination of the equipment or the building.

The following features are included:

a) automatic shut-down in case of failure of the electrical supply, cooling water, heating, etc.

b) low flow alarm and interlock on the pretreated waste feed

c) pH interlock on the pretreated waste feed

d) interlock in case of incorrect alignment of control switches

e) interlock on the mixer operation in case of improper positioning of storage container or overfilling of storage container

f) interlock on the storage container transfer during a filling operation

g) automatic initiation of flushing upon loss of feed flow or power.

Abnormal situations, alarms and interlocks are indicated by means of annunciators with visual and audible alarms.

CHAPTER 3

PROCESS PARAMETERS

3.1 ALTERNATIVE SOLIDIFICATION MEDIA

Solidification media selection in view of today's regulatory environment and best available data on products is at best a difficult question, that often reduces to a personal user decision. This is further complicated by preferences or limitations of individual radwaste systems suppliers. However, whether the finally selected media is cement, Dow or asphalt, or other polymers and cement-like matrices one must look at the benefits derived from pre-treatment of the waste stream along with drying (VR) prior to solidification. These two points insure maximization of waste incorporation and successful solidification of the waste stream to the media's best ability and thus no loss of the advantages gained from VR. The balance of this section will discuss technical merits of each solidification media culminating with a sample economic comparison.

3.1.1 Asphalt

Asphalt, while it has the advantage that it will normally always harden regardless of the nature of the waste stream, has several deficiencies which must be considered prior to its selection as a binder, or as a combination binder/evaporator lubricant/heat transfer media.

1) Drum filling capacities rarely exceed 80% due to the fact that the material shrinks up to 20% as it cools. Most installations using asphalt require a second filling of the 55 gal. drum after the first filling has cooled to reach the 80% capacity. Typically the time required to cool the drum is 9 hours.
2) Because of this shrink affect and the time which is required to cool the container, the filling of the larger liners is prohibited.
3) Asphalt decomposes by radiolysis to form hydrogen gas when exposed to high and intermediate cumulative radiation levels greater than 10^9 Rads. Because of this, filling of drums to greater than 85% is not recommended. The drums are normally not tightly capped to allow venting of the internal pressure. Storage areas for the drums are typically well ventilated for this reason.

4) The binding agent and the final solidified product are both flammable and require fire protection systems. Flammability and the associated insurance considerations, although not unreasonable, must be considered since an asphalt binder VR system has recently been part of a delayed fire incident at a European radwaste facility.

5) Asphalt has poor mechanical properties and is not free standing without the container, however it does have excellent coating properties when intensively mixed with waste.

6) Binder storage, feed and incorporation equipment require heat tracing.

7) The binder carbonizes if subject to excessive local temperatures, in particular during storage.

8) The binder has the potential to react with the waste to form explosive products. Pre-treatment of the waste is required to reconfigure the waste to prevent the problem.

9) Ventilation of the water vapor/asphalt fumes from the drying equipment causes high maintenance problems and extensive system shutdowns for preventive maintenance.

10) Asphalt is currently unacceptable as a binder in Europe due to on-site storage limitations and unknown long term disposal criteria.

3.1.2 Cement

Although cement requires a chemical reaction for solidification more complex than the cooling of asphalt, the use of cement as a binder for radioactive waste solutions has been accepted for general use in the nuclear industry. Experience and the proper process controls assure effective solidification, and the following properties are advantages:

1) Drum filling capacities in excess of 95% are routinely experienced using continuous mixers, thus allowing more waste to be incorporated per drum.

Section 3.1 (Cont'd)

2) The matrix is relatively immune to radiation attack and, in fact, provides shielding for the embedded particles.

3) No fire protection is required for the binder or the solidified product. Certain cement types have withstood temperatures up to 800 C during fuel fire tests.

4) Cement has excellent compressive strength up to 7000 psi) and is free standing.

5) Heat tracing is not required.

6) Cement is commonly available at a low price.

7) Cement can be easily fed and metered.

8) Storage can be indoors without hazard, and dusting of the cement during material transfer can be easily controlled.

Cement's known drawbacks include:

1) The cement matrix is porous which makes the leach properties questionable. The range of leach rates varies considerably with the type of cement used and the thoroughness of the waste pretreatment. Proper pretreatment of the wastes prior to solidification improves the leach properties of the product.

2) Incorporation of dried waste in cement has caused swelling and cracking of the matrix. This problem is overcome by the proper chemical "fixing" of the waste in an insoluble form by pretreating. However, even without pretreatment, certain elements such as Cobalt remain firmly embedded in the matrix.

3) The dried waste must be cooled prior to incorporation in cement to control thermal reactions.

4) The product is relatively heavy, which increases the transportation costs.

3.1.3 Dow Binder

The Dow binder storage system is relatively new to the radwaste industry. Its advantages include:

1) Drum filling capacities in excess of 95% are routinely experienced using continuous mixers, thus allowing a very high amount of waste to be incorporated in each drum. The acceptable waste weight fractions for Dow are higher than for other solidification media.

2) The solidified product has good mechanical and thermal properties and is free standing.

3) Available test data indicates that the solidified product has excellent leach properties.

4) Less attention may be paid to the pretreatment of the waste, since the Dow media does not react with the dried waste.

5) The solidified product is relatively light-weight.

Drawbacks to selecting the Dow binder include:

1) The material is relatively expensive.

2) Fire protection is required for the binder, although the solidified product is fire resistant.

3) The process is more sophisticated than for other binders requiring the addition of several chemicals in precise amounts to form the polymer. The reaction is exothermic, therefore requiring separation of the containers for cooling during the curing period.

3.2 PROPERTIES OF THE WASTE STREAM

The proper choice of the equipment, the material of construction, and the chemical pretreatment which should be used for a liquid volume reduction process depends upon the actual waste which is to be evaporated. The waste streams to be processed from a PWR and a BWR are those identified in the literature; however, these wastes must be assumed as only theoretical waste types. A small amount of contaminent waste chemicals can drastically change the type of equipment or materials of construction chosen for VR systems due to the resulting different waste products formed. This section will discuss some of these chemical reactions and the resulting impact on equipment selection based on the over eight years of research conducted by ATCOR and Belgonucleaire.

3.2.1 12% Boric Acid

A solution of 12% Boric Acid is simple to dry to a free flowing dry powder in a batch or continuous dryer. However, the addition of only small amounts of contaminants, notably sodium, results in a different dry product which does not have good handling properties. Sodium meta- borate, the new compound, forms a glassy, tough and extremely tenacious product as it dries, which must be removed to avoid fouling of the heat transfer surfaces. The proper pre-treatment of the "boric acid plus trace of sodium" waste stream will produce a dried product which loses most of the undesirable qualities of sodium meta borate, but which still requires mechanical cleaning of the interior of the machine to prevent blocking of the material flow. It is for this reason that the ATCOR VR process has selected an intensive continuous twin shafted dryer/mixer whose interior surfaces are self-cleaned at each revolution. Extensive testing at the pilot plant has proved the feasibility of this method and this equipment. Experiments with systems utilizing asphalt as a combined lubricating, heat transfer, and binding media in continuous processers of several types (i.e. thin film evaporators and extruders) have shown that it is possible to ignore this product fouling characteristic, but only at the expense of incorporating less solids in the matrix, higher horsepowers, and frequent downtime for maintenance, required to remove condensed vapors from the off-gas equipment.

A further advantage of the pretreatment of the "12% Boric Acid" waste is the vastly increased DF received by the process. The solubility of Boric Acid, or derivatives, in the evaporated water vapor limits the anticipated DF across the drying process to only 20. This is true for both the boric acid and the sodium metaborate compounds. Through the use of the same pretreatment required to obtain an acceptable dried product, the DF can be increased to exceed 2000. This hundred fold increase in process efficiency is accomplished by the fixing of the boron into an insoluble compound. This pretreatment is part of the proprietary ATCOR system.

Finally the properties of the encapsulated dried product when properly pretreated are greatly improved. Extensive testing has shown that the leach rate of solidified samples is much better if the product is properly pretreated. The dried product is also more resistant to swelling caused by the absorption of water. Both properties have been found to be true no matter which binder, i.e., cement, asphalt or Dow, is selected. Thus a system of pretreatment, followed by dehydration (without lubricants) followed by incorporation permits the highest incorporation and the most flexibility of binder selection.

3.2.2 Resins and Particulate Wastes

Volume Reduction of resins by dehydration does not reduce the volume of the waste as significantly as that of concentrates. Normally the VR factor is 2 or less. The one exception, VR in asphalt, produces a VR factor near 4.5 but also produces a product which is hydroscopic. Immersion of an asphalt/resin mixture in water will produce a volume increase to a volume greater than that of the original dehydrated waste. This expansion will occur even if other binders, such as the Dow polymer, are mixed with the completely dehydrated resins, and will result in the disintegration of the solid. Another constraint in the dehydration of resin is the temperature restriction on the resins to prevent the thermal decomposition of the resin. Decomposition of resin produces volatile organic gases, particularily trimethylamines, which must be vented to a safe area.

For these reasons, ATCOR recommends that the resin and other particulate wastes be treated simply by dewatering. Removal of the free water is accomplished with the proven ATCOR dewatering fill head to reduce the water content to 50% for the resins (i.e. less than 1% free water). Shipment of this waste would then be in high integrity containers (HIC). If the curie content of the resins exceeds the regulatory limits (currently 350 curies), the resin wastes can be solidified in cement or Dow using an in-container systems.

3.2.3 Sodium Sulfate Wastes

Because of the interaction of the dried sodium sulfate wastes with the binder and due to the relatively high solubility of dried sodium sulfate, the sodium sulfate waste must be pre-treated prior to the drying to form an acceptable product. The interaction of the dried waste with cement requires a more extensive pretreatment be conducted of these wastes when solidification in cement is planned above a threshold weight/binder ratio than for the other two accepted binders. This interaction with the cement produces a gradual volume increase which induces stresses in the solidified product which lead to product deterioration.

The materials handling problems which are characteristic of the drying of PWR wastes are not found to as great an extent for the sodium sulfate based wastes. Equipment chosen for the processing of the borate wastes is therefore acceptable for the sulfate based wastes. In either case, the waste trearment produces a solid which is insoluble (less than 0.01 gm/liter) and which therefore greatly improves the leach rate characteristics of the product.

3.2.4 Decontamination Solutions

Extensive testing of both acidic and basic EDTA decontamination solutions have proven the feasibility of the ATCOR process with these solutions. As with the boric acid concentrates, the waste is first treated to adjust the pH, if necessary, and then treated to form an insoluble waste form.

Dehydration of the wastes prior to solidification again allows the wastes to be incorporated into a stable and strong product.

3.3 Waste/Binder Loadings

Tables 3-1 through 3-4 show a cost comparison of alternate solidification media using the waste types and quantities normally specified by customers.

This analysis considers only the cost for materials, containers, and the transportation and burial costs. Internal costs, such as operator salaries and capital costs are not shown. This analysis shows that the combination of solidification of the volume reduced concentrates in cement, and the dewatering of resins provides the most economical approach for both BWR and PWR wastes.

It is important to note that on a "number-of-drums" basis, the Dow media presents a clear advantage over cement or asphalt. This may be important in the light of both on-site storage considerations as well as off-site disposal costs.

TABLE 3-1
VOLUME REDUCTION ECONOMICS

WASTE TYPE	BORIC ACID	
% CONCENTRATION	12 %	
DENSITY	72 lb/cu ft.	
QUANTITY/YEAR	10000 cu. ft.	
PRE-TREAT FACTOR	1.35	
LB. DRIED WASTE/DRUM		
NO VR-CEMENT	37 lb.	
VR-CEMENT	477 lb.	
VR-DOW	500 lb.	
VR-ASPHALT	252 lb.	
VR-HIC	400 lb.	
LB. BINDER/DRUM		
NO VR-CEMENT	750 lb.	
VR-CEMENT	176 lb. cement	141 lb. water
VR-DOW	200 lb.	
VR-ASPHALT	344 lb.	
VR-HIC	0 lb.	
BINDER COST ($/lb)		
CEMENT	.05	
DOW	1.40	
ASPHALT	.12	
DRUM/LINER SIZE	55 gal	7.34 cu. ft.
DRUM/LINER COST	28.00 $ each	
TRANS COST/TRIP	1500.00 $	
BURIAL COST	12.00 $/cu f_.	
RAD LEVEL/DRUM (no VR)	200 mr/hr	

TABLE 3-1 (continued)
ENCAPSULATION OF BORIC ACID (12%)

BORIC ACID (12%)	NO VOLUME REDUCTION-CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
Volume of Waste Considered	10000	10000	10000	10000	10000
Pretreatment Factor	1.0	1.35	1.35	1.35	1.35
Weight of Dried Wastes Processed	86400 lb.	86400 lb.	86400 lb.	86400 lb.	86400 lb.
Total Weight after pretreatment	86400 lb.	116640 lb.	116640 lb.	116640 lb.	116640 lb.
Wt. of Dried Waste/55 gal. drum	37 lb.	400 lb.	477 lb.	500 lb.	252 lb.
Wt. of Binder/55 gal. drum	750 lb.*	----	317 lb.*	200 lb.	344 lb.
Total Wt. of Drum	787 lb.	400 lb.	794 lb.	700 lb.	596 lb.
Number of 55 gal. drums required	2335	292	245	233	463
Volume Reduction Factor	1.0	8.01	9.55	10.01	5.05
Radiation Levels	200 mr/hr	1602 mr/hr	1910 mr/hr	2002 mr/hr	1009 mr/hr

* Includes Weight of water for Cement Systems.

TABLE 3-1 (continued)
COST OF TRANSPORTATION

BORIC ACID (12%)	NO VOLUME REDUCTION-CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
NUMBER OF DRUMS REQUIRED	2335	292	245	233	463
AVERAGE DRUM WEIGHT (LB)	787	400	794	700	596
MAXIMUM DRUMS/SHIPMENT	51	80	51	58	68
NUMBER OF SHIPMENTS	72	12	14	10	14
COST PER DRUM	$29.23	$18.75	$29.49	$26.03	$22.19

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TABLE 3-1 (continued)

OPERATING COST SUMMARY

BORIC ACID (12%)	NO VOLUME REDUCTION-CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
Container Cost $/Drum	$ 28.00	$ 100.00	$ 28.00	$ 28.00	$ 100.00
Binder Cost $/Drum	37.50	-0-	8.80	280.00	41.28
Disposal Cost $/Drum	88.11	88.11	88.11	88.11	88.11
Radiation Surcharge $/Drum	-0-	51.45	51.45	51.45	51.45
Transportation Cost $/Drum	29.23	18.75	29.49	26.03	22.19
Total Cost $/Drum	$ 182.84	$ 258.31	$ 205.85	$ 473.59	$ 303.03
Qty. of Drums Required	2335	292	245	233	463
Annual Cost	$426,961	$ 75,324.	$ 50,336.	$110,479.	$140,259.
Cost Comparison	$376,625	$ 24,988.	-0-	$ 60,143.	$ 89,923.

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TABLE 3-2
VOLUME REDUCTION ECONOMICS

WASTE TYPE	SODIUM SULFATE	
% CONCENTRATION	20 %	
DENSITY	78 lb/cu ft.	
QUANTITY/YEAR	10000 cu. ft.	
PRE-TREAT FACTOR	1.66	
LB. DRIED WASTE/DRUM		
NO VR-CEMENT	65 lb.	
VR-CEMENT	684 lb.	
VR-DOW	690 lb.	
VR-ASPHALT	333 lb.	
VR-HIC	679 lb.	
LB. BINDER/DRUM		
NO VR-CEMENT	808 lb.	
VR-CEMENT	253 lb. cement	141 lb. water
VR-DOW	150 lb.	
VR-ASPHALT	327 lb.	
VR-HIC	0 lb.	
BINDER COST ($/lb)		
CEMENT	.05	
DOW	1.40	
ASPHALT	.12	
DRUM/LINER SIZE	55 gal	7.34 cu. ft.
DRUM/LINER COST	28.00 $ each	
TRANS COST/TRIP	1500.00 $	
BURIAL COST	12.00 $/cu ft.	
RAD LEVEL/DRUM (no VR)	150 mr/hr	

TABLE 3-2 (continued)
ENCAPSULATION OF SODIUM SULFATE

SODIUM SULFATE (20%)	NO VOLUME REDUCTION-CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
Volume of Waste Considered	12,000 ft^3	12,000 ft^3	12,000 ft^3	12,000 ft^3	12,000 ft^3
Pretreatment Factor	1.0	1.66	2.10	1.66	1.66
Weight of Dried Wastes Processed	187,200 lb.	187,200 lb.	187,200 lb.	187,200 lb.	187,200 lb.
Total Weight after pretreatment	187,200 lb.	310,752 lb.	393,120 lb.	310,752 lb.	310,752 lb.
Wt. of Dried Waste/55 gal. drum	65 lb.	679 lb.	684 lb.	690 lb.	333 lb.
Wt. of Binder/55 gal. drum	808 lb.*	----	456 lb.*	150 lb.	327 lb.
Total Wt. of Drum	873 lb.	679 lb.	1140 lb.	840 lb.	660 lb.
Number of 55 gal. drums required	2880	458	575	450	933
Volume Reduction Factor	1.0	6.29	5.0	6.4	3.1
Radiation Levels	150 mr/hr	944 mr/hr	752 mr/hr	959 mr/hr	463 mr/hr

* Includes Weight of water for Cement Systems.

TABLE 3-2 (continued)
COST OF TRANSPORTATION

SODIUM SULFATE (20%)	NO VOLUME REDUCTION-CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
NUMBER OF DRUMS REQUIRED	2880	458	575	450	933
AVERAGE DRUM WEIGHT (LB)	873	679	1140	840	660
MAXIMUM DRUMS/SHIPMENT	46	80	36	48	61
NUMBER OF SHIPMENTS	63	6	16	9	15
COST PER DRUM	$32.39	$18.75	$42.16	$31.18	$24.55

TABLE 3-2 (continued)
OPERATING COST SUMMARY

SODIUM SULFATE (20%)	NO VOLUME REDUCTION- CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
Container Cost $/Drum	$ 28.00	$ 100.00	$ 28.00	$ 28.00	$ 100.00
Binder Cost $/Drum	40.40	-0-	12.65	210.00	39.24
Disposal Cost $/Drum	88.11	88.11	88.11	88.11	88.11
Radiation Surcharge $/Drum	-0-	23.50	23.50	23.50	0.00
Transportation Cost $/Drum	32.39	18.75	42.16	31.18	24.55
Total Cost $/Drum	$ 188.90	$ 230.36	$ 194.42	$ 380.79	$ 251.90
Qty. of Drums Required	2880	458	575	450	933
Annual Cost	$544,039	$105,427.	$111,742.	$171,495.	$235,073.
Cost Comparison	$438,612	$-0-	$ 6,314.	$ 66,067.	$129,646.

TABLE 3-3
VOLUME REDUCTION ECONOMICS

WASTE TYPE	BEAD RESIN	
% CONCENTRATION	50 %	
DENSITY	63 lb/cu ft.	
QUANTITY/YEAR	4000 cu. ft.	
PRE-TREAT FACTOR	0.50	
LB. DRIED WASTE/DRUM		
NO VR-CEMENT	366 lb.	
VR-CEMENT	366 lb.	
VR-DOW	414 lb.	
VR-ASPHALT	217 lb.	
VR-HIC	364 lb.	
LB. BINDER/DRUM		
NO VR-CEMENT	362 lb.	
VR-CEMENT	210 lb. cement	152 lb. water
VR-DOW	168 lb.	
VR-ASPHALT	326 lb.	
VR-HIC	0 lb.	
BINDER COST ($/lb)		
CEMENT	.05	
DOW	1.40	
ASPHALT	.12	
DRUM/LINER SIZE	55 gal	7.34 cu. ft.
DRUM/LINER COST	28.00 $ each	
TRANS COST/TRIP	2850.00 $	
BURIAL COST	12.00 $/cu ft.	
RAD LEVEL/DRUM (no VR)	1200 mr/hr	

TABLE 3-3 (continued)
ENCAPSULATION OF BEAD RESIN WASTES

BEAD RESIN WASTES	NO VOLUME REDUCTION- CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
Volume of Waste Considered	4,000 ft^3	4,000 ft^3	4,000 ft^3	4,000 ft^3	4,000 ft^3
Pretreatment Factor	0.65	0.30	0.50	0.50	0.30
Wt Dried Waste (lb)	126,000 lb.	126,000 lb.	126,000 lb.	126,000 lb.	126,000 lb.
Total Weight after pretreatment	81,900 lb.	37,800 lb.	63,000 lb.	63,000 lb.	37,800 lb.
Wt. of "Dried" Waste/55 gal. drum (1)	366 lb.	364 lb.	366 lb.	414 lb.	217 lb.
Wt. of Binder/55 gal. drum	362 lb.*	----	362 lb.*	168 lb.	326 lb.
Total Wt. of Drum	728 lb.	364 lb.	728 lb.	582 lb.	543 lb.
Number of 55 gal. drums required	224	104	172	152	174
Volume Reduction Factor	1.0	2.15	1.30	1.47	1.28
Radiation Levels	12000 mr/hr	25858 mr/hr	15600 mr/hr	17646 mr/hr	15415 mr/hr

* Includes Weight of water for Cement Systems.

TABLE 3-3 (continued)
COST OF TRANSPORTATION

BEAD RESIN WASTES	NO VOLUME REDUCTION-CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
NUMBER OF DRUMS REQUIRED	224	104	172	152	174
AVERAGE DRUM WEIGHT (LB) (Weighted Average)	728	364	728	582	543
MAXIMUM DRUMS/SHIPMENT	55	80	55	69	74
NUMBER OF SHIPMENTS	54	8	6	5	7
COST PER DRUM	$51.41	$35.63	$51.41	$41.17	$38.43

TABLE 3-3 (continued)
OPERATING COST SUMMARY

BEAD RESIN WASTES	NO VOLUME REDUCTION- CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
Container Cost $/Drum	$ 28.00	$ 100.00	$ 28.00	$ 28.00	$ 28.00
Binder Cost $/Drum	18.10	-0-	10.50	235.20	39.12
Disposal Cost $/Drum	88.11	88.11	88.11	88.11	88.11
Radiation Surcharge $/Drum	136.51	207.64	136.51	136.51	136.64
Transportation Cost $/Drum	51.41	25.63	51.41	41.17	38.43
Total Cost $/Drum	$ 322.13	$ 431.38	$ 314.53	$ 529.00	$ 402.30
Qty. of Drums Required	224	104	172	152	174
Annual Cost	$ 72,084	$ 44,797.	$ 54,141.	$ 80,499.	$ 70,079.
Cost Comparison	$ 27,287	$ -0-	$ 9,344.	$ 35,703.	$ 25,282

TABLE 3-4
VOLUME REDUCTION ECONOMICS

WASTE TYPE	EDTA SOLUTION	
% CONCENTRATION	13 %	
DENSITY	72 lb/cu ft.	
QUANTITY/YEAR	8000 cu. ft.	
PRE-TREAT FACTOR	1.4	
LB. DRIED WASTE/DRUM		
NO VR-CEMENT	36 lb.	
VR-CEMENT	272 lb.	
VR-DOW	349 lb.	
VR-ASPHALT	233 lb.	
VR-HIC	218 lb.	
LB. BINDER/DRUM		
NO VR-CEMENT	750 lb.	
VR-CEMENT	226 lb. cement	141 lb. water
VR-DOW	233 lb.	
VR-ASPHALT	349 lb.	
VR-HIC	0 lb.	
BINDER COST ($/lb)		
CEMENT	.05	
DOW	1.40	
ASPHALT	.12	
DRUM/LINER SIZE	55 gal	7.34 cu. ft.
DRUM/LINER COST	28.00 $ each	
TRANS COST/TRIP	1500.00 $	
BURIAL COST	12.00 $/cu ft.	
RAD LEVEL/DRUM (no VR)	5 mr/hr	

TABLE 3-4 (continued)
ENCAPSULATION OF EDTA SOLUTIONS

EDTA SOLUTIONS	NO VOLUME REDUCTION-CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
Volume of Waste Considered	8000	8000	8000	8000	8000
Pretreatment Factor	1.0	1.4	1.4	1.4	1.4
Weight of Dried Wastes Processed	74880 lb.	74880 lb.	74880 lb.	74880 lb.	74880 lb.
Total Weight after pretreatment	74880 lb.	104832 lb.	104832 lb.	104832 lb.	104832 lb.
Wt. of Dried Waste/55 gal. drum	36 lb.	218 lb.	272 lb.	349 lb.	233 lb.
Wt. of Binder/55 gal. drum	750 lb.*	----	408 lb.*	233 lb.	349 lb.
Total Wt. of Drum	786 lb.	218 lb.	680 lb.	582 lb.	582 lb.
Number of 55 gal. drums required	2080	481	385	300	450
Volume Reduction Factor	1.0	4.33	5.40	6.92	4.62
Radiation Levels	5 mr/hr	22 mr/hr	27 mr/hr	35 mr/hr	23 mr/hr

* Includes Weight of water for Cement Systems.

TABLE 3-4 (continued)
COST OF TRANSPORTATION

EDTA SOLUTIONS	NO VOLUME REDUCTION-CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
NUMBER OF DRUMS REQUIRED	2080	481	385	300	450
AVERAGE DRUM WEIGHT (LB)	786	218	680	582	582
MAXIMUM DRUMS/SHIPMENT	51	80	59	69	69
NUMBER OF SHIPMENTS	40	6	7	4	7
COST PER DRUM	$29.19	$18.75	$25.29	$21.67	$21.67

TABLE 3-4 (continued)
OPERATING COST SUMMARY

EDTA SOLUTIONS	NO VOLUME REDUCTION-CEMENT SOLID.	VOLUME REDUCTION NO SOLID.	VR CEMENT SOLID.	VR DOW SOLID.	VR ASPHALT SOLID.
Container Cost $/Drum	$ 28.00	$ 100.00	$ 28.00	$ 28.00	$ 100.00
Binder Cost $/Drum	37.50	-0-	11.30	326.20	41.88
Disposal Cost $/Drum	88.11	88.11	88.11	88.11	88.11
Radiation Surcharge $/Drum	-0-	-0-	-0-	-0-	-0-
Transportation Cost $/Drum	29.19	18.75	25.29	21.67	21.67
Total Cost $/Drum	$ 182.81	$ 206.86	$ 152.70	$ 463.98	$ 251.66
Qty. of Drums Required	2080	481	385	300	450
Annual Cost	$380,235	$ 99.476.	$ 58,853.	$139,370.	$113,228.
Cost Comparison	$321,382	$ 40,623.	-0-	$ 80,517.	$ 54,376.

Topical Report 8019-001
ATCOR AVRS-80
Volume Reduction Process

CHAPTER 4

EQUIPMENT DESCRIPTIONS

4.0 EQUIPMENT DESCRIPTIONS

The following pages describe representative equipment which is used in the ATCOR/BN Volume Reduction Process. The actual equipment used may not be exactly the equipment described because of varying customer requirements or delivery constraints; however, the descriptions describe the functions provided by the equipment.

4.1 VOLUME REDUCTION EQUIPMENT

4.1.1 INTENSIVE DRYER/MIXER

The Dryer/Mixer is constructed of two horizontal cylinders each fitted with longitudinal shafts and lens-shaped mixing paddles, the inner walls of the cylinders are side by side circular major arcs of equal radii, intersecting to provide side-by-side interacting chambers. The rotating paddles cause longitudinal flow as well as flow through the opening between the intersection. The cylinders are electrically heated or steam jacketed for the drying section and water cooled for the mixing section. Drying is accomplished in the first 75% of the unit's length, and cooling and solidification matrix mixing in the final 25%.

The cylinders (barrel) are split horizontally and held sealed by swing-a-way bolts to provide easy access to the drying chamber. Extending through the cylinders and projecting beyond the end wall are the co-rotating mixing shafts positioned coaxially to the cylindrical chambers.

Positioned on the co-rotating shafts is an in-feed section containing a short length of solid feed screws, and immediately following, lens-shaped solid paddles stacked continually along the shafts. Depending on the required function, the configuration of the paddles can be easily adjusted in order to obtain an optimum result, i.e., forward motion, intensive mixing, hold back, etc.

The shape, size, and angular configuration of the paddles result in a self-cleaning action that overcomes the characteristics that borates and other salts exhibit, i.e., glassing, smearing, adhering, and plugging, when traversing their dehydration curve, while effectively exposing a homogeneous mixture of the wet salts to the available heat transfer surface. This continuous conditioning by the paddles results in efficient and effective dryer performance while handling difficult to dry waste products.

In order to facilitate rapid entrance to the equipment for maintenance, the inlets to the Intensive Dryer/Mixer are provided with quick disconnecting couplings whenever possible. The lines are normally sealed by means of a ram-seal type valve to ensure that a positive means exists to maintain the nozzle open in the event of unit shutdown. All valves are automatically placed in the safe position on loss of power.

A manually activated redundant drive can be provided upon request, in order to empty the inner chambers in case of failure of the motor drive or the power supply.

The design is such that the quantity of product contained in the apparatus during operation is small (less than 30% of the total volume) with virtually no dead space where dried residues might accumulate. A separate drain connection allows emptying of the cleaning or decontamination solutions.

The vapor stream is scrubbed of dried waste and entrained moisture by the Steam Purifier mounted on the Intensive Dryer/Mixer. The Steam Purifier is a packed column filled with varying finenesses of Inconel packing. A flushing connection is provided to clean the packing of encrusted particles when the pressure differential interferes with vapor flow.

4.1.2 CONDENSER

The condenser type is counter-current flow by contact. Cooling water circulates inside 304L tubes while the steam is condensed on the outside of the tubes. The condensate flows by gravity into the condensate tank, where it is held briefly to provide a measurement of the steam flow from the Intensive Dryer/Mixer. Level measurement in the condensate tank is discussed in Section 4.7. The non-condensable gasses released by the condensation of the vapor are released to the station ventilation. Optional HEPA filters can be provided prior to the station ventilation system if required by the activity of the waste being processed.

4.1.3 FILL PIPE AND SPLATTER SHIELD ASSEMBLY

The Fill Pipe is a telescoping design with a lexan plastic lining fastened to the inside pipe diameter. This lining behaves as a "slip surface" thus preventing wet wastes from sticking to the fill pipe internals. Based on actual operating experience, this design assures that the fill pipe internals remain free of wet cement. Normal fill pipe flushing is accomplished during the feeder flush cycle that is, no additional flush water is required to clean the fill pipe. The fill pipe is flange mounted directly to the mixer discharge valve. The container fill opening is covered by the splatter shield which is attached to the end of the fill pipe. An ultrasonic level detector is mounted directly to the splatter shield to continuously monitor the level of waste material inside the container. To facilitate removal of cement splatter, the underside of the entire splatter shield is covered with lexan plastic. As previously discussed, use of the plastic lining prevents cement from sticking to the surfaces. A series of spray nozzles are located beneath the splatter shield to enable remote decontamination cleaning with water. The advantage of the Splatter Shield design is that filling is performed under a gasket in a sealed and vented condition, thereby eliminating all splatter.

1. Materials of Construction: 304 Stainless Steel or equal

2. Closure and Seal Design: A stainless steel splatter shield with a rubber seal provides a dust-free, splatter-free environment. Sealing is accomplished by lowering the splatter shield onto the container opening.

3. Travel and Drive Mechanism: Pneumatic operated Cylinders.

4. Connections and Sizes: Fill Pipe is flange connected to the 8 inch Radwaste Mixer Discharge Valve (8 inch 150 lbs. ASA Flange). Flush connection is a single 1/2 inch socket weld and pipe connection.

5. Lubrication Requirements: None.

6. Travel Limit Switches: Part of Pneumatic Cylinders. Interlocks provided to assure filling cannot take place unless splatter shield is seated against the container opening.

4.2 WASTE TREATMENT EQUIPMENT

4.2.1 WASTE CONDITIONING TANK

This tank is custom designed for radwaste processing and is identical in design to the standard ATCOR Waste Conditioning Tank described in ATCOR Topical Report #ATC-132A. The tank is provided with an agitator to insure uniform discharge of waste product. The agitator has a three-blade propeller with all wetted parts fabricated from 304, or 304L Stainless Steel or Inconel as appropriate to the waste processed. The agitator drive is remotely located to facilitate maintenance and minimize personnel exposure. Also incorporated into the tank design is an ultrasonic waste level detector. This unit is constructed of compatible materials and is flange mounted in the top of the tank. The ultrasonic level detector (for determination of liquid level) is equipped with a water spray connection to provide remote cleaning. Level readout from this unit is incorporated on the main control panel. Fixed high and low level detector probes are mounted on the side of the tank. These probes signal their respective alarm points and activate the necessary system controls. A removable manhole cover assembly is provided for tank access.

Connections are provided in the tank for flushing, air sparge recirculation, and resin dewatering. The air sparge and dewatering connections are protected by screens.

Processing of evaporator concentrates requires that the tank be heated. This is accomplished using externally mounted "Chromalox" strip heater assemblies. This temperature is monitored using a temperature indicator/controller. The temperature probe is located in the tank, while the indicator/controller is located on the main processing control panel console.

Testing of the Waste Conditioning Tank conforms with API-650 and ASME Section 8 test requirements covering nonpressure (atmospheric) tanks.

Materials of Construction

Wetter Parts - 304, 304L Stainless Steel or Inconel as required by waste characteristics.

Supports & legs - Carbon Steel, ASTM-A36

4.2.2 COMBINATION WASTE METERING AND DEWATERING PUMP

The metering pump is a progressive cavity, positive displacement pump with a variable flow range of 0-3 gpm. It is constructed of compatible materials. The rotor is plated with hard chrome and turns within a stainless steel or inconel sleeve. The pump also comes equipped with a mechanical seal. This unit is mounted upon a structural steel baseplate with raised drip rim. The pump is driven by a 3 H.P. Reeves Vari-drive, TEFC, 3-Phase, 60-Cycle 460-Volt motor drive. Speed control is accomplished remotely from the main control panel. A tachometer readout which indicates pump flow is located on the main control panel. Flushing of this unit is easily and effectively cleaned by flushing with water. Special pump flushing flanges are incorporated into the standard pump design to permit direct internal flushing of the pump.

4.2.3 EMERGENCY WASTE RETURN PUMP

This pump will be identical to the above Waste Feed Pump description ecept it will run at a fixed speed of 450 RPM. Consequently the variable speed drive and remote speed control is not necessary. Pump is a Model IFF8. The pump is driven by a 7 1/2 HP, TEFC, Direct Drive Gear Motor.

4.2.4 SAMPLING SYSTEM

ATCOR has included in the system the capability to obtain waste samples to perform the process control program to provide positive assurance that the waste and binder will combine to form a solid, free standing product.

To obtain a waste sample, the waste is recirculated through the sampler. The air operated sample plunger withdraws a precisely measured amount of waste material with each stroke and gravity drain into the sample container. The sampler will be manually operated with a stroke plunger. Counting the number of strokes will determine the volume of the sample. The sampler withdraws a 10CC sample with each stroke. The recommended location for the sampler shall be outside of the cubicle containing the Batch Tank.

4.3 SYSTEM AUXILIARY EQUIPMENT

4.3.1 CONDENSATE METERING PUMP

The metering pump is a progressive cavity, positive displacement pump with a variable flow range of 0-3 GPM. It is constructed of 304 stainless steel wetted parts. The rotor is plated with hard chrome and turns within an abrasion resistant EPDM stator within a stainless steel sleeve. The pump also comes equipped with a mechanical seal. This unit is mounted upon a structural steel baseplate with raised drip rim. The pump is driven by a 1 H.P. Reeves Vari-drive, TEFC, 3-Phase, 60-Cycle 460-Volt motor drive. Speed control is accomplished remotely from the main control panel. A tachometer readout which indicates pump flow is located on the main control panel. Flushing of this unit is easily and effectively cleaned by flushing with water.

4.3.2 CHEMICAL ADDITION PUMP

This pump will be identical to the above described pump with the exception that the flow range is 1-1.5 GPM.

4.3.3 VALVES, BUTTERFLY

A butterfly valve is installed at the Waste Tank Discharge for shutting off or permitting flow of waste material into the Waste Metering Pump. The valve is remotely operated through a pneumatic rotary air-to-open and air-to-close actuator directly mounted to the Valve.

A solenoid valve and position indicating switches are provided with each valve. This valve is provided with a manual override to permit manual valve operation in the event of a power failure or loss of air.

4.3.4 VALVES, BALL

Ball valves will be used for flow control and shut-off of pump seal water and flush water to system components. Valve materials of construction are ASTM-A-351, Grade CF 8M, 304L S/S wetted parts. Valves will be remotely opened or closed by integrally mounted air operators. Valve position indicating limit switches and solenoid valves are furnished with each valve.

4.3.5 VALVES, PLUG

Plug Valves will be used throughout the Volume Reduction and Solidification System for flow shutoff of radioactive waste material and flush water through the system piping. Valve sleeves will be remotely opened or closed by air operators mounted on each valve. Valve position indicating limit switches and solenoid valves are furnished with each valve.

4.4 VOLUME REDUCTION AND SOLIDIFICATION SYSTEM MAIN CONTROL PANEL

The solidification process system is fully instrumented to monitor at the control panel the operating condition of system components, flow rates, and material levels. Interlocks are provided to prevent operation in an unsafe manner. For example, cemented product cannot be discharged unless a container is properly in place at the fill station. Product fill level is monitored to prevent overfilling, and waste processing will be automatically terminated if cement flow to the cement mixer is interrupted.

Functional automatic controls are provided in which the operator actuates controls sequentially. A pushbutton control can only be actuated if the previous pushbutton control operation has been completed and the system condition is satisfactory. The control system has been designed to simplify the operator's job and also preclude the possibility of making an error.

A manual control mode is also provided to individually operate any item of equipment for test purposes or special operation.

The control panel provides a complete graphic display of the sytem with running lights, pilot lights, and indicators to clearly show the operating condition (including valve positions) of the entire system. The running lights, readout devices and pushbutton starters for manual operation are located adjacent to the pertinent component illustrated in the graphic display. A NEMA 12 control cabinet will be provided to contain all relays, timers, etc., mounted and pre-wired internally to terminals. The CCTV monitors are located in the vicinity of the main control panel or may be located in the panel for convenience of the system operator.

Optional features such as the following can be provided.

a) Programmable Logic Controller (PLC) or microprocessor control of the system instead of relay logic.
b) Data Logging capabilities which will provide permanent records of vital process parameters such as input flow rates, and temperature.
c) Total automation of the process from the pretreatment through the mixing with binder.

The programmable logic controller portion of the system (PLC) is a modular industrial control system that is designed for controlling small to medium sized manufacturing processes that require both discrete and continuous process control. It can execute on/off control, as well as feedback loop control.

Discrete control is defined, in general industrial control terms, as being that portion of the application program that is describable in ladder diagram logic. It typically uses limit switches, push buttons, etc. as its inputs, and controls solenoids, lights, or motors as its outputs. This is often called programmable logic control. Feedback loop control is defined as that portion of the application that requires analog continuous control through standard analog feedback mechanisms, creating outputs that are either proportional to, an integral of, or derivative of the input value. It typically uses a temperature, pressure, or other analog signal as its input and controls a heater, valve positioner or other analog control mechanism as its output. This is generally called proportional, integral, and derivative loop control or PID control.

The PLC system combines both programmable logic and PID capabilities into one multi-processor micro-computer based control system utilizing both standard and custom designed micro processors.

In the areas of reliability, system security, and maintainability, the extensive use of microprocessors with the flexibility to perform a wide variety of tasks on a single chip, has allowed the system to be designed with a minimum of electronic parts therefore providing high reliability. The capability of the microprocessors also allows both on-line self diagnostics and off-line stand alone self testing. This gives high system security against undetected failures as well as making fault isolation and device replacement very simple.

The PLC hardware consists of:

1. Central processor unit

2. Power supply

3. Discrete I/O

4. Analog, BCD, and loop I/O

The PLC is capable of being programmed in EPROM (Erasable Permanent Read Only Memory) which requires no back-up power for memory retention.

4.4.1 TYPICAL SYSTEM INTERLOCKS

4.4.1.1. Fillhead In Place

Material transfer to solidification container cannot be started unless the fill head is connected as sensed by respective limit switches and lighting the RED FILLHEAD CONNECTED pilot light. If these limit switches are de-activated at any time during the transfer of material to the container, all valves associated with the transfer operation will close, all pumps will stop and the mixer will shut down. Resumption of any transfer operation or mixer operation will be locked out until the following conditions are satisfied:

a) Fill Head out of position is corrected.

b) Alarm is acknowledged.

c) Alarm is reset after abnormal condition is corrected.

This alarm condition cannot be overridden or defeated.

4.4.1.2. Container - Maximum Level

In the event of a maximum level condition which indicates that container overfill is eminent, all container fill operations (i.e. waste transfer, chemical addition and mixer operation) will be terminated and locked out. This alarm condition cannot be overridden or defeated.

4.4.1.3. Emergency Stop

Pressing the EMERGENCY STOP pushbutton removes all power and de-energizes all equipment except the dryer by stopping all motors and closing all waste valves. Flushing of the Intensive Dryer and waste feed lines is automatically initiated on the Emergency Stop and after the proper flush duration the Dryer is stopped. All automatic sequencing completed at time of failure will be "wiped out". Selector switches are not automatically returned to the OFF position and must be manually switched to the OFF position in order to return the system to a PRESTART condition. After an Emergency stop, the system reset button must be energized.

4.4.1.4. Interlock On-Off Selector Switch

When the INTERLOCKS ON-OFF selector switch is in the OFF position, all interlocks associated with non-critical equipment will be bypassed. The term "critical equipment" is defined as any device if operated under an alarm condition that would cause:

a) A radiological incident or area contamination.

b) Personal injury.

c) Equipment damage.

This function is designed for maintenance and emergency situations and is not intended to be a part of the normal operating process.

4.4.1.5. Container Off-gas Vent Blower

Container fill operation cannot be started unless the off-gas vent system is operating.

4.4.1.6. All Pumps are Protected by Three Interlock Methods

1. Valve line up which is determind by the valve position limit switches.

2. High pressure switches which protect pumps from damage by pumping against a closed head.

3. Low pressure switches in conjunction with a timer that protects pumps from damage by running dry.

4.4.1.7. Container Over Pressure

A pressure transducer located in the fillhead will signal an alarm upon sensing presure slightly above atmospheric and a container fill shutdown will be implemented.

4.4.1.8. Line Break Protection

Afforded by sensing rate of pressure drop in lines, e.g. waste, binder, promotor and catalyst extender, the respective pumps will stop, associated valves will close and terminate the mixing cycle.

4.4.1.9. No material can be added to any tank in the system if its high level has been reached.

The above options are selected based on the complexity of the system and on customer preferences and specifications.

4.5 TELEVISION CAMERA AND MONITORING SYSTEM

The TV monitoring system will have coverage over the entire Process Aisle Area. Mounting the required television cameras onto the overhead crane allows full visibility during emplacement for storage and retrieval of stored containers. Since the container will be suspended from the crane, a television camera system so located will always be in position to observe the operation in progress.

For viewing container filling and remote closure, a camera monitoring system will be specifically located to perform the aforementioned operations.

A system of power cable reels or festooned cable is required for the trolley mounted television cameras and the monitor (which is normally located adjacent to the system control panel). The following information and specifications describe typical circuit television cameras provided by ATCOR.

	Qty	Location
Storage & Grid Viewing	2	On Crane
Process Aisle	2	VR Product Fill Station and Smear/Decon Station
TOTAL	4	

4.5.1 REMOTE CONTROL MODULE, ST-1

The remote control module for the Model ST-1 Television Camera will allow the operator to remotely adjust the electrical camera controls and maintain a clear, bright picture. The module is a "rack-mount" style and is designed to mount in standard (19 inch wide) equipment racks. The module can also be custom mounted in the Customer's control panel.

The standard module is provided with the following controls: AC on/off beam, target, and electrical focus. The on/off beam is a dual function control. A pilot lamp and a front panel fuse are also included.

In addition to the above controls, the remote module with optical focus control includes a switch to remotely vary the distance between the lens and vidicon faceplate, thus changing the optical focus.

The module is 5-7/32 inches high, 4-15/64 inches wide, and 9-13/16 inches deep. The unit is finished in brushed aluminum and weighs approximately three (3) pounds.

4.5.2 ZOOM LENS, 20MM TO 100 MM

The lens is a 5:1 20 to 100 mm zoom with an F stop of 1.8. The lens offers quiet, smooth operation throughout its zoom range from the wide angle 20mm setting to the 100mm telephoto position. Precision, sound isolated motors provide smooth power transmission, and all drive gear functions are protected by factory set slip clutches.

The zoom lens uses a standard "C" mount arrangement to interface with the television camera. The focusing range of the lens is 79 inches to infinity. The unit is remote controlled, usually at or near the camera monitor. The control functions are zoom, focus, and iris.

4.5.3 PAN AND TILT, PT-550M

The pan and tilt mechanism is a ruggedly constructed, sealed, weatherproof unit and is designed to allow remote positioning of the DIAMOND ELECTRONICS' closed circuit television camera.

The pan mechanism turns horizontally through 355°. The unit incorporates externally adjustable limit switches should smaller movement angles be desired.

The tilt table (camera mounting surface) can be moved vertically through an angle of $\pm$ 90° from a normal level position. Vertical limit switch adjustments are made within the unit.

The pan and tilt unit is totally weathertight to protect the electronics and worm gears. The driving gear mechanisms minimize backlash and the dynamic braking prevents drift.

The unit incorporates electrical filtering to minimize electrical noise or interference. A multi-pin electrical connector will be provided on the base section of the unit and remains stationary as the unit moves. The unit requires seven (7) conductors between the pan and tilt and the remote pan and tilt control module.

4.5.4 SNA-14C MONITOR

The monitor is a cabinet style monitor with carrying handles on the top. The unit has a 14-inch (diagonally measured) rectangular kinescope with a bonded safety shield faceplate. It is fully transistorized and of modular design with quick disconnect-type circuit boards. Both the high and low voltage power supplies will be regulated. The monitor will provide a stable picture in size and brightness even though voltages may vary from 100 to 130 volts AC, 50 to 60 Hz; or 210 to 220 volts AC, 50 to 60 Hz. The maximum power requirement is 100 watts.

The video amplifier response will be 10 MHz $\pm$ 1db. The video input can be looped through with a termination switch for high impedance bridging or 75 ohm termination. The linearity of the system will be within 2 $^{o}/_{o}$ of the picture height. In the 60 field mode, the scan rate will be 525 lines per frame, assuring 800 lines center resolution and 700 lines corner resolution.

The normal front panel controls are recessed behind a panel door and easily accessible. The controls all include AC on/off, vertical hold, horizontal hold, height, contrast, brightness, width, and focus.

The unit is constructed of heavy gauge steel and weighs 55 pounds (25.0 kilograms). Dimensional data is as follows: the height is 13.38 inches (32.68 centimeters), the width is 13.81 inches (35.1 centimeters), and the depth is 18.63 inches (47.3 centimeters).

4.6 CEMENT HANDLING EQUIPMENT

4.6.1 BULK CEMENT STORAGE BIN

The Cement Bin is fabricated from 1/4 inch thick ASTM-A-36 or A-285 Carbon Steel. Connections to mate with the Vibrating Bin Bottom and Level Detectors are provided. The Bin Cover includes a Cement Fill Inlet Loading Adapter, in addition to a Flanged Vent Connection for the Automatic cleaning Bin Vent Filter, and a Pressure-Vacuum Manhole. For personnel safety, the Bin will be furnished with a caged safety ladder and guard rail. The Bin is provided with four (4) structural steel legs which will in turn be anchored to the floor. Typical Bin overall dimensions are as follows:

Diameter: 12 ft.
Overall straight side height: 8 ft.
Internal volume: 1000 cubic feet
Height from Top of Silo to Bin Activator Discharge: 17'

Moisture accumulation is prevented by using an air type absorption dryer system. This assures that a dry air environment is maintained within the cement storage silo automatically. The bin will be fitted with two eccentric 60 degree cones each fitted with Discharge Flanges for accepting 2" diameter Vibra Screw Inc., Bin Activators, for positive continuous flow of known density cement out of storage to the cement feeders.

4.6.2 CEMENT FILL STATION/INLET PANEL

The Cement Fill Station is designed to accommodate truckload delivery of dry cement and direct the cement to the Cement Bin. A limit switch is mounted on the Fill Connection of the Panel. When the driver connects the truck hose and energizes the switch with the truck Cement Fill Line, the Line actuates the limit switch. The limit switch sends a signal to start the Dust Collector flexing cycles, allows the alarm to sound on the Inlet Panel when the Cement Bin High Level is reached and illuminates the TRUCK CONNECTED light on the Main System Control Panel. With high cement level, the alarm sounds. Removal of the fill line automatically silences the alarm, and terminates the filling operation by stopping the Dust Collector.

The Panel will include a lockable cover of 10-guage steel construction; the interior will be fitted with a Kamlock with Limit Switch and Dust Cover.

The Cement Inlet Panel is connected to the Bulk Cement Storage Bin Inlet by schedule 4 inch diameter, 40 steel pipe, 2 Ducon Perma-Flow Abrasion Resistant Elbows, and all necessary couplers.

4.6.3 CEMENT DUST BIN FILTER ASSEMBLY

A Flex-Kleen Corporation Model 58BV-25 bin filter assembly is typically furnished to provide for dust-free operation. This unit is a standard automatic self-cleaning, bag-type filter with pre-wired electrical blow-back timer controls and pressure gauge. Purchaser is required to supply 6 cfm of clean, dry compressed air at 100 PSIG for automatic filter bag cleaning. The bag filter is provided with an additional air maze panel-type filter directly mounted to the bag filter exhaust. The additional exhaust filter has a cement dust retaining efficiency equal to the primary bag filters.

Filter Data:	183 Sq. Ft. Filter Area
Air Flow:	500 ACFM (Nominal)
Air to Filter Ratio:	12.7:1
Manufacturer:	Flex Kleen Corp.

4.6.5 CEMENT FEEDER CONVEYOR

The dry cement feeder conveyor is used for the precision metering of cement to the Intensive Dryer/Mixer. The cement in the feeder is preconditioned to a constant bulk density by the vibrating cement bin bottom to assure steady uninterrupted flow of material. When used with the vibrating bin bottom, the cement feeder meters the cement with an accuracy of $\pm$ 2%. The feeder is driven by a 1 1/2 HP motor with a variable speed drive control to give an output cement rate of 0-2 CFM. Speed control is accomplished locally at the feeder drive. The unit is made of carbon steel with all required surfaces protected with a corrosion-resistant paint.

The feeder/conveyor unit will penetrate the radiation shield walls. The unit contains a 10:1 variable speed drive with tachometer which will transmit a 0 to 100% speed signal to a speed indicator mounted remotely in the VR System control panel. Feeder size is normally 2". The feeder will contain an air operated slide gate on its inlet complete with limit switches and contains a zero speed switch on the driven shaft. Injection of the cement into the discharge section of the Intensive Dryer/Mixer is through a tangential penetration by means of an independent screw feeder. The independent feeder provides a positive means of preventing plugging of the cement feed port. The water provided for the solidification is typicaly provided from the water removed from the waste and is metered to a port on the Intensive Dryer/Mixer.

4.7 DOW BINDER HANDLING EQUIPMENT

4.7.1 BINDER TANK

The binder tank is a 6,000 gallon cylindrical horizontal tank with flanged and dished heads on each end. Its function is to provide storage for an adequate supply of Dow Binder. It is constructed of type 304L Stainless Steel and is equipped with an ultrasonic level detector for both continuous level indication and to provide signals for the tank high and low level conditions. It is also equipped with a flame arrester and vent as a safety precaution. The tank and its associated equipment is to be installed in an underground vault to ensure the binder is at the proper temperature.

The binder tank level sensing equipment is a continuous measurement ultrasonic level instrument. This is a single element sensor which gives a direct digital readout on the Main Control Panel. The device is used to monitor product level and signal high and low level conditions in the tank.

4.7.2 BINDER PUMP

The binder pump is a rotary gear type pump and is used to feed the binder from the storage tank to the solidificaton container. Its capacity is 65 GPM and is equipped with an explosion-proof 7 1/2 HP motor. It is installed in the underground vault with the storage tank. The pumps are equipped with John Crane mechanical seals and an integral relief valve. The pump casing and rotor are constructed of cast iron while the shaft and baseplate are carbon steel.

4.7.3 DOW ADDITIVES SKID ASSEMBLY

This skid will consist of the Catalyst, Extender and Promoter Storage and Feed Assemblies. The storage containers are the 55 gallon shipping drums equipped with low level indication. The Catalyst and Extender pumps will be tubular diaphragm type metering pumps with viton diaphragms. All other wetted parts will be stainless steel. The pumping capacity of these units is 0-18 GPH. The Promoter pump is a diaphragm type metering pump with a teflon diaphragm. All other wetted parts are stainless steel. The capacity of this unit is 2-8 GPH. Each pump will be equipped with capacity adjustment capabilities. Metering will be accomplished through the use of a pump stroke counter. The pumps are all motor driven. The skid will be pre-piped and pre-wired with a skid mounted junction box provided for an electrical interface.

4.8 INSTRUMENTATION

4.8.1 WASTE TANK & CONTAINER ULTRASONIC LEVEL SENSING EQUIPMENT

The radioactive waste product level sensing equipment is a continuous measurement instrument. It is a sonic echo ranging system which operates on the principle of elapsed time determination. It consists of a sonic transducer assembly which is mounted integral with the System Main Control Panel. A direct and continuous level measurement is displayed on the Main Control Panel. This device is used to monitor the product level and signal the full level condition. A dual ultrasonic level type unit is provided. The dual tube sensors, one a receiver and one a transmitter, act independent to each other and are not affected by the affects of splatter, vapor, etc. Operationally, the ultrasonic level unit provides reliable and accurate readings of waste and cemented waste.

4.8.2 FIXED LEVEL DETECTORS

The Fixed Liquid Level Detector consists of a float, mounted on a short float arm which is connected to a flexible shaft. The Level Detector operates on the change in force which results from the buoyancy of the float. The shaft transmits the float motion to a micro switch. Level Detectors are flanged mounted to a mating tank flange connection. All wetted parts are compatible with the waste processed. Normally the fixed detectors are used in the Waste Conditioning Tank and the Condensate Tank only.

4.8.3 MICRO MOTION MASS FLOW METER

The Micro Motion mass flow meter is a non-intrusive meter designed to measure the mass flow rate of any fluid, liquid, gas or slurry. It measures actual mass flow rate (lbs/min, gms/sec, etc.) independent of density, viscosity, temperature, pressure or other flow parameters.

The sensor is a rigid "U" shaped tube that is magnetically vibrated about an axis passing through the open end of the "U". The "U" tube is excited and foced to oscillate at its natural frequentcy (approx. 50HZ) depending upon the size of the tube and the density of the material within the tube. Although the natural frequency of the "U" tube changes as the density of the material is varied, the mass flow measurement is <u>not</u> determined by measuring this frequency.

Flowing the sensor tube causes a Coriolis/gyroscopic twist that is measured opticallly using two photo transistors. The mass flow rate is determined by measuring the "U" tube twist angle on the downward vibration stroke and by comparing this twist angle to that of the upward stroke. In a no-flow condition the twist angle will be constant for both the upward and downward vibration strokes. If flow exists in the sensor tube, the tube will twist in opposite directions during the upward and downward vibration strokes. This angular difference is measured optically and can be shown to be linear measurement of mass flow rate. This mass flow rate measurement is unaffected by two-phase flow or by changes in the effective tube diameter due to flow material deposition.

The mass flow meter offers the user excellent reliability since there are no electrodes to wear out, no bearings to deteriorate, no critical flow stream geometry and no requirement with respect to upstream/downstream piping.

The meter operates from either 115 V AC or 18-30V DC and incorporates a slide switch to change input modes. The output of the meter is provided in either or both of two output formats (1) analog output current of (2) a frequency output proportional to flow rate. The analog output is compatible with any 4-20 (0-20)ma control system and the frequency output has been designed to be compatible with any type of logic.

As an additional output, the meter provides the user with a square wave output signal at the pipe vibration frequency. Should the user desire to monitor the relative density of the flowing fluid, he may do so by monitoring the period of this square wave frequency.

4.8.4 CONDENSATE TANK INSTRUMENTATION

This system is equipped with a controller which adjusts the speed of the condensate pump in order to maintain the level at the pre-selected position. An indicator is provided on the main control panel in clear view of the operator.

4.8.5 CEMENT FEED INSTRUMENTATION

The cement is added in the final section of the dryer-mixer and the feed flow is adjusted by means of a Controller. The tachometer is calibrated in % of RPM, and the feed is directly proportional to the feeder screw speed. During start-up, the feeder is calibrated for the cement utilized. A curve of "% RPM vs lb/min" is generated and made part of the operating procedure. If desired the meter can be directly scaled to read in "lb/min" if the PLC Control options are purchased.

4.8.6 HEATING SYSTEM INSTRUMENTATION

The evaporator and the dryer are heated by means of electrical heaters or steam. A thermal sensor gives a signal to a controller which, through a SCR, adjusts the power fed to the electric heaters in order to maintain the selected temperature. For the steam heating option, the temperature sensor provides a signal to the steam inlet to adjust the dryer temperature. The temperature control equipment is provided separately for the evaporator and dryer.

4.8.7 MIXING METER INSTRUMENTATION

The flow of water required for solidification is added at the same time as the cement in the last section of the dryer/mixer and is controlled by a flow meter and a controller. A flow switch stops the pump in case of failure of the flow meter.

4.8.8 PRETREATMENT CONTROL

The drying of borate solutions requires the addition of lime. The amount of lime chemical pretreatment is adjusted to a value as low as possible, so as to not significantly increase the waste volume. In order to compute this adjustment, the waste feed flow meter produces a signal sent to a ratiometer which divides it by a preset value which is a function of the solid content in the feed flow.

The signal produced by a Ratiometer is sent to the chemical addition pump controller which compares this signal with the value coming from the reagent flow meter and adjusts the measured value to the value required.

The waste feed line and the reagent line are both fitted with a High and Low flow switches which stop the pumps in case of high or low flow.

4.8.9 DRYING CONTROL

The condensate flow signal is transmitted to a ratiometer which controls the feed pump.

The value of the ratio signal is proportional to the solid content in the feed. This insures a dry product discharge.

A chart will be supplied with values of the ratio conforming to the solid content of the feed.

4.8.10 MIXING CONTROL

We know the quantity of solids dried and coming into the mixing part of the mixer/dryer as a function of the feed flow rate and the known waste solids content.

The feed flow transmitter gives a value of the feed flow. This signal is used to calculate the value of cement needed to have a good product. The feed flow rate signal from the Waste Metering Pump is also sent to control the binder addition rates. The ratios given cover a range of solids content in the feed. Flow switches are provided to alarm in case of High or Low flow.

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CHAPTER 5

GENERAL ARRANGEMENTS

5.0 GENERAL ARRANGEMENTS

The arrangement of the equipment for the ATCOR/BN Volume Reduction Process depends on the space allowed within the station for the system. A typical arrangement drawing is included showing the equipment sizes and the physical relationship that each component skid will have with the others. The system is designed with the ALARA requirements in mind. Allowances for maintenance access is also a critical consideration when arranging equipment. Components are located such that access to lower radiation areas where maintenance must be performed does not require passage through zones of higher radiation. The main control panel and auxiliary control panels, for example, are located outside the tank and waste process areas. All operations are remotely performed from their respective control panels.

Skids, pumps, etc. are arranged to allow ease of component inspection and access for maintenance. Adequate shielding of high frequency access areas and during processing of high activity waste require about 3 foot thick concrete shield walls or equivalent. Areas of less frequent access require less shielding. Mobile systems are designed to the same objectives as the "in-plant" systems with the various equipment being more extensively skidded to facilitate installation, removal and transportation.

5.1 COMPLIANCE WITH "ALARA"

The system design and arrangement is in compliance with "ALARA" as specified in the USNRC Regulatory Guides 8.8 and 8.10. As shown on the attached layout drawings the system arrangement affords complete remote operation. All drum process, handling and storage equipment is operated from a remote shielded location using television cameras for full visibility of operation.

The system incorporates the following features which enhance the operability and maintainability of the system. All valves which do not contain waste are supplied on a common valve rack and located in a low radiation area outside the Waste Tank and Dryer/Mixer cubicles. All motors associated with waste and drum handling are located remotely from the equipment, when possible thus allowing maintenance without personnel exposure. The discharge valve from the waste tank is critical for waste return; therefore, it is supplied with a remote manual override. Should this valve fail to open, manual opening of

5.1 Compliance with "ALARA" (continued)

this valve combined with starting the pump will empty the waste tank of its contents. Additional emergency waste removal is accomplished utilizing a back up emergency waste return pump. If a problem occurs with the normal waste metering pump, the emergency return pump is provided for this service. Further, wherever critical to system operation, remote manual operation of equipment using air motors and conveyor motors is provided.

All waste bearing components and piping are provided with a complete remote automatic flushing capability to insure that the equipment is cleaned prior to servicing. Valves and components are selected to insure minimum leakage and spillage. All penetrations of shielding are designed to minimize exposure.

Drum and liner handling equipment such as conveyors, carts, cranes and smear and decontamination stations are designed to provide remote operating capability through the use of closed circuit television from the operating station(s). This equipment is discussed in ATCOR's topical report ATC-132A submitted to the NRC for review on April 17, 1978, and approved on September 3, 1981.

5.2 INTERFACE AND SCOPE OF SUPPLY

ATCOR's responsiblity is to provide the design, material procurement, fabrication, assembly, certification, delivery to job site, testing, and placing in commercial operation of the remotely operated volume reduction system.

Work Not Included - Performed by Purchaser

The following related work is not normally included in ATCOR's scope of supply:

1. Receiving, unloading and storage at the jobsite and erection labor.
2. Equipment foundations and anchor bolts.

Work Not Included - Performed by Purchaser (Continued)

3. Concrete shield walls.
4. Crane rails and supports.
5. Lighting of area.
6. Heat tracing and thermal insulation.
7. Electrical power for instrumentation, control and operating equipment.
8. All wiring, piping and ventilation ducts which are external to and which do not form an integral part of the equipment, components, panels and skids.
9. Electrical power connections for motors and heaters.
10. The utility services, including fire protection.
11. Ventilation for the solidification area.

C H A P T E R 6

CODES, STANDARDS, REGULATIONS

6.0 EQUIPMENT CODES, STANDARDS, AND REGULATIONS

Design of the ATCOR/BN System components conforms to the recommendations which appear in Table 1 in appendix to the "Branch Technical Position - ETSB 11.1 (Rev.1) - dated 11/24/75". A table summarizing the requirements is attached.

6.1 National Codes and Standards

6.1.1. American Society of Mechanical Engineers (ASME):

Section II: Material specifications - parts A,B,C:
Section III: Nuclear power plant components, General requirements;
Section V: Non-destructive examination;
Section VIII: Division 1 - Pressure vessels;
Section IX: Welding and brazing qualifications.

6.1.2. American Nuclear Standards Institute:

B 16.5: Steel pipe flanges, flanged valves and fittings
B 31.1: Power piping;

6.1.3. Other codes:

NEMA: National Electrical Manufacturers Association;
IPCEA: Insulated Power Cable Engineer's Association;
SSPC: Steel Structures Painting Council.

6.2. Code of Federal Regulations:

6.2.1. 10 CFR 20 - Standards for protection against radiation. The components used in radioactive service, as well as their arrangement in the various rooms of cells, comply with 10 CFR 20.

- 20.101 - Radiation dose standards for individuals in restricted area. As explained in sub-chapter 2.4 above, the operator exposure to radiation is below the permissible limits.

- 20.103 - Exposure of individuals to concentration of radioactive materials in a restricted area. The concentration values of radioactive products in the air are maintained below those given in Append:x B, Table I of 10 CRF 20.

- 20.105 - Permissible levels c radiation in unrestricted area. The equipment lay-out is such that the radiation doses are below those given in the present paragraph.

- 20.106 - Radioactivity in effluents to unrestricted areas. The activity values are in conformity with those given in the Appendix B, Table 2 of 10 CRF 20.

6.2.2. 10 CFR 50 - Licensing of production and utilization facilities. The following paragraphs have carefully been taken into account:

- 10 CFR 50 - 34a - Design objectives for equipment to control releases of radioactive materials in effluents of nuclear power reactors.
- 10 CRF 50 - 36a Technical specifications on effluents from nuclear power reactors.
- 10 CRF 50 - Appendix A - General design interim for nuclear power plants.

6.2.3. 10 CFR 61 - Disposal of low level radioactive waste and low activity bulk solid waste.

-61.86 - Waste form and packaging:

The products obtained after encapsulation comply with this paragraph; The resins are partially dehydrated before embedding; When encapsulating in cement, the matrix material used does not burn and does not suffer damage when exposed to a fire of 800^{o}C for half an hour.

-61.88 - Volume reduction:

The wastes obtained after processing conform to this paragraph, since the volume reduction ratio varies between 5 and 15.

6.2.4. 10 CFR 71 - Packaging of radioactive materials for transport and transportation of radioactive materials under certain conditions.

71.4 Definitions:

Low specific activity material.

The products obtained after solidification conform with the activities allowed in this paragraph.

Type A quantity and type B quantity.

The activities normally contained in the containers are below those of Type A quantity.

6.2.5. 49 CFR 173 - Code for Federal Regulations - Department of Transport Regulation.

No feature of the ATCOR/BN system is inconsistent with the Department of Transportation Regulations set forth in Title 49 of the Code of Federal Regulations with respect to the packaging, marking and shipment of radioactive material generated by the process.

Specifically, the following parts of this code are applicable:

Part 173.390: Transport Groups of Radionuclides:

The radionuclides present in the solid product produced will be the same as those present in the aqueous feed stream. Thus, the Transport Groups of the solid product isotopes will be the same as those applicable to the feed stream, primarily Groups III and IV.

Part 173.392: Low Specific Activity Radioactive Materials:

It is expected that all solid material generated by the system will qualify as "Low Specific Activity" material. Packaging, marking and shipping of waste containers will be consistent with the DOT regulations set forth in this section.

Part 173.397: Contamination Control:

All packages of LSA radioactive material generated will be decontaminated per the regulations defined in this section.

6.3 Nuclear Regulatory Commission Regulatory Guides.

6.3.1. Regulatory Guide 1.26: Quality Group Classification and Standards for Water, Steam and Radioactive Waste containing Components of Nuclear Power Plants.

It is planned to design and fabricate the hardware to Quality Group D standards per this regulatory guide.

6.3.2. Regulatory Guide 1.29: "Seismic Design Classification". It is expected that the hardware will not be designed as Seismic Category I. Thus, the hardware will not be designed to withstand the effects of the Safe Shutdown Earthquake (SSE). However, it is expected that the system will be housed in a Seismic Category I structure.

6.3.3. Regulatory Guide 1.42: Interim Licensing Policy on as Low as Practicable for Gaseous Radioiodine Releases from Light-Water-Cooled Nuclear Power Plants.

Radioiodine releases due to operation will be only a fraction of the 1 Curie per year allowed for each LWR at a site by this Regulatory Guide. In addition, it is expected that iodine releases will result in only a fraction of the allowable annual dose or dose commitment to the thyroid of an individual in an unrestricted area from all pathways of exposure. We understand that the allowable dose is 15 millirem.

6.3.4. Regulatory Guide 5.8: Design Considerations for Minimizing Residual Holdup of Special Nuclear Material in Volume Reduction Operations.

Special Nuclear Material (SNM) will not be processed by the volume reduction system. Thus, this Regulatory Guide is not directly applicable.

6.3.5. Regulatory Guide 5.25: Design Considerations for Minimizing Residual Holdup of Special Nuclear Material in Equipment for Wet Process Operations.

Special Nuclear Material (SNM) will not be processed in the sysrem. Thus, this Regulatory Guide is not directly applicable. However, design of the components is consistent with the design philosophy set forth in Section C of the Regulatory Guide.

6.3.6. Regulatory Guide 8.8: Information Relevant to Maintaining Occupational Radiation Exposure as Low as Practicable (Nuclear Reactors).

Equipment design will be consistent with the guidelines set forth in this Regulatory Guide so as to achieve "as low as practicable" occupational radiation exposure.

6.3.7. Regulatory Guide 8.10: Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Practicable.

The equipment conforms to the philosophy of Reg. Guide 8.10.

6.4 Nuclear Regulatory Commission

6.4.1. Section 11.1 - Source term.

6.4.2. Section 11.2 - Liquid Waste Management System.

Parts related to this section conform with the rules.

6.4.3. Branch Technical Position - ETSB 11.1: Design Guidance for Radioactive Waste Management Systems installed in Light-Water Cooled Nuclear Power Reactor Plants.

BI.b.2 All tanks do not have overflow piping; a high level safety detector closes the feed valve.

BIV.b. Some process pipes may have a diameter smaller than 3/4" in order to maintain certain flow characteristics. It is important for certain products or mixtures, to maintain a high velocity to avoid product accumulation in the piping.

6.4.4. Section 11.4 - Solid Waste Manyement System.

No remarks.

6.4.5. Branch Technical Position - ETSB 11.3 - Rev.1: Design Guidance for Solid Radioactive Waste Management Systems installed in Light-Water Cooled Nuclear Power Reactor Plant.

BI.2 Absorbants (such as vermiculite or calcium silicate) are not used in the encapsulated products.

BII.2. There is no contemplated method for detection of free water. The experiments carried out up to now and the control provided by the PCP will positively ensure a mixture solidifying without any residual free water.

6.5 I A E A Regulations

The waste material produced is consistent with the recently promulgated I A E A Regulations (1973) that will eventually become part of the Department of Transportation regulations covering the packaging and transportation of radioactive materials for burial. Specific positions in current regulations are as described in Section 6.2..

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C H A P T E R 7

QUALITY ASSURANCE PROGRAM

7.0 QUALITY ASSURANCE PROGRAM

ATCOR's Quality Assurance Manual has been reviewed and approved by the U.S. Nuclear Regulatory Commission.

The ATCOR Quality Assurance Program is applied throughout equipment and system design, fabrication, construction and test phases. The Quality Assurance Program, as applied, affords the planned and systematic action necessary to provide adequate confidence of a component, or system's ability to perform satisfactorily in service. ATCOR Subvendor Quality Assurance Programs are surveyed prior to contract issuance to assure conformance with the customer's specifications.

The Quality Assurance Manager, reporting directly to the President, is assigned complete control for the project. He is responsible for checking, auditing, inspecting, or otherwise verifying that an activity has been correctly performed as an independent, divorced from all activities concerned with design, planning, procurement, fabrication or testing of the components or systems.

Attachment 7-1 provides a general outline of the ATCOR Quality Assurance Program A-QA-001.

A system of checks and balances is used to assure design control. Each design is subjected to the following within the ATCOR system: review, approval and distribution prior to design acceptance. Once a design is completed and accepted, it is maintained current in engineering control files. Support drawings and specifications are similarly kept up to date. If, for any reason, a design change is required during construction, an approval by the Project Engineer is mandatory prior to implementation; thereby, design continuity is maintained.

Frequent inspections and quality audits are performed to assure quality compliance and program effectiveness.

As part of each system, ATCOR furnishes the following items:

1) Complete set of "As Built" equipment drawings.

2) Complete set of "As Built" electrical schematics.

3) Complete set of "As Built" installation drawings.

4) Quality assurance, fabrication and test records for non-standard equipment.

5) Preoperational system start-up test results.

Typical Q.A. data required by ATCOR for the major equipment within the Radwaste Solidification Systems are shown within TABLE 7-1.

ATTACHMENT 7-1

OUTLINE OF ATCOR QUALITY ASSURANCE PROGRAM A-QA-001

I. ORGANIZATION

A. Quality Assurance Manager

1. Reports directly to the President.
2. Primary duties are to assure that the requisite quality of the furnished end item is achieved.
3. The Quality Assurance Manager's authority shall be final.

B. Quality Control Coordinator

1. Reports to the Quality Assurance Manager.
2. Is responsible for maintaining the Quality Program.
3. Primary duties include:
   a. Schedule inspections and audits/evaluations.
   b. Liaison with customer and third-party inspectors.
   c. Controls inspections at vendor's facility.

C. Organizational Chart

1. See Figure 4-1.

II. QUALITY ASSURANCE PROGRAM

A. Assures adequate confidence that equipment will perform satisfactorily in service.

1. The program assures that all activities necessary to provide equipment which meets customer specifications are conducted in accordance with written and approved procedures.

B. Management

1. The Quality Assurance Manager has the responsiblity for implementing the Q. A. Program and assessing its effectiveness.
2. Internal audits are performed to assess the effectiveness of the program.
   a. Results of internal audits are distributed to the department managers and to the President of ATCOR.

C. Training

1. Personnel performing quality related functions are trained and qualified to perform those tasks.
2. Records of training and qualifications are maintained in Q. A. Files.

D. Goals and Objectives

1. To provide those mechanisms necessary to assure the requisite quality of all products furnished.

E. Disputes

1. Differences of opinion between QA/QC personnel and other departments that cannot be resolved on a managerial level shall be resolved in a staff meeting.

III. DESIGN CONTROL

A. Design Control Procedure assures that all design criteria as required by contract and specification are included within the design package. As a minimum the design requirements of REG. GUIDE 1.143 are imposed.

B. Responsibilities

1. Engineering:
   a. Initial interpretation of contract and specifications.
   b. Interfacing associated internal departments, purchasing and Q. A. included.
   c. Insuring all design considerations are included within the design package.
   d. Developing Test Procedures.
   e. Interfacing design requirements between vendors.

2. Drafting:
   a. Interfacing sub-assemblies within the design package.
   b. Interfacing design package within existing or proposed buildings.
   c. Maintaining drawing distribution records.

3. Quality Assurance:
   a. Review of design package prior to release for fabrication to assure applicable quality standards have been included.

C. Design Verification
   1. All designs are verified or checked for adequacy by either of the following:
      a. Formal project design review.
      b. Calculational methods.
      c. Formal testing.

D. Design Change
   1. Subject to the same control criteria placed on the original design.

E. Design Deficiencies
   1. Errors and design deficiencies that could adversely affect safety and operability shall be documented and corrective action taken to prevent reoccurance.

F. Purchased Materials
   1. The use of standard, readily available materials is encouraged.
      a. Off the shelf materials approved for a similar design must be reviewed for suitability to any new application.

G. Individual Design Review Responsibilities
   1. Project Engineer.
      a. Translates customer specifications into design specifications.
      b. Confirms that the accuracy of technical aspects, design specifications and that the design meets the customer requirements.
   2. Design Supervisor.
      a. Assures that all design specifications are properly translated into design drawings.

3. Design Draftsperson
    a. Produces design drawings and recording all transmittals.
4. Quality Assurance
    a. Confirms equipment meets customer quality requirements.
5. Engineering Manager
    a. Confirms the total design package meets the customer's requirements.

IV. <u>PROCUREMENT DOCUMENT CONTROL</u>

A. The procurement of materials, equipment and services is accomplished with a written Purchase Order.
   1. Purchase Order forms are controlled and in the possession of a limited number of individuals.
   2. Only those individuals are authorized to release Purchase Orders.

B. <u>Purchase Requisitions</u>
   1. All P.O.'s are written from purchase requisitions.
      a. The cognizant engineer is responsible for the technical content, scope, design requirements, identification, codes, standards, and test requirements.
      b. Quality Assurance is responsible for the inclusion of all applicable quality requirements including establishing witness and hold points, documentation requirements.

C. <u>Purchase Orders</u>
   1. The official P.O. is typed from the purchase requisition.
   2. The P.O. is reviewed by the cognizant engineer.
   3. The P.O. is reviewed by those individuals authorized to release P.O.'s.
   4. Evidence of review and approval is documented by signatures on the P.O.

D. <u>Purchase Order Changes</u>
   1. Changes are accomplished with a Purchase Order Change Notice, (P.O.C.N.)
   2. The P.O.C.N. is controlled in the same manner as the original P.O.

E. Spare Parts

1. P.O.'s for spare parts, replacement parts and miscellaneous parts are subject to the controls placed on the original equipment.

V. INSTRUCTIONS PROCEDURES AND DRAWINGS

A. Those activities affecting quality are accomplished in accordance with written instructions, procedures or drawings.

1. Appropriate quantitative or qualitative criteria are clearly defined within the instructions, procedures or drawings.

B. Preparation and approval of Instructions, Procedures, and Drawings.

1. Prepared by cognizant department.
2. Reviewed and approved by cognizant department manager and interfacing department managers.
3. Q. A. Reviews and concurs with inspection plans, calibration and special process procedures, drawings and specifications, and changes, revisions or alterations to the above.

VI. DOCUMENT CONTROL

A. The Document Control System provides a procedural means for the control of all documentation.

B. Document Preparation and Approval

1. All documents and their revisions are reviewed and approved by the originating department manager and Q. A. prior to implementation.
2. Approved changes are implemented promptly and all associated documentation is promptly revised.
3. Approval of changes are normally made by the same organization approving the original document, however, approval may be made by designated organizations familiar with the requirements.
4. Obsolete documents are destroyed or marked VOID.
5. Customers and or vendors are directed to delete the previously issued document.

C. Document Identification

1. All documents have an identification number and title.
2. Provisions are available to identify revision status, revision date, and revision approval.

D. Document Availability

1. All documents required to perform an activity are available at the location where such activity is to be performed prior to commencement of work.

E. Documentation Control List (D.C.L.)

1. A master list of all internal documents has been established.
   a. The list identifies the document title, identification number, and revision status.
2. Project Documentation Control Lists are generated for each project.
   a. The Project D.C.L. includes Purchase Order Control Book, Specification Control List, Drawing Log Book.
   b. The project D.C.L. identifies the document title, identification number, and revision status.

VII. CONTROL OF PURCHASED MATERIAL, EQUIPMENT AND SERVICES

A. Established measures assure that purchased items and services are clearly defined in the procurement document.

1. All items and services are furnished by vendors capable of meeting procurement document requirements.

B. Assessment of Major Vendor Capabilities

1. Vendors capabilities are determined through the use of audits or evaluations.
2. Audits and evaluations are performed and reviewed by Q.A. and Engineering.
3. Audit personnel are sufficiently trained in the areas to be audited.

C. Major Vendor Qualification

1. Vendor qualification is based on the vendors capabilities to meet one or more of the following: 10 CFR 71, Appendix E, 10 CFR 50, Appendix B, ANSI N-45.2, all requirements applicable to contract, satisfactory review of records and performance of vendors who have provided similar equipment or services, satisfactory results from a survey of the vendors Q. A. program.
2. Results of audits and evaluations are documented and kept on file for future reference and to assure that all required corrective action has been implemented prior to commencement of fabrication.

D. Inspection Requirements

1. Inspection requirements are determined prior to issuance of procurement documents.
   a. Requirements are based on the complexity and importance to safety and quality of the item to be furnished.
   b. Inspection requirements are clearly defined in the procurement document.
2. Inspection requirements include: visual, dimensional, packaging, identification, and testing.
3. Inspection records are documented and kept on file.

E. Documentation Requirements

1. The procurement document identifies the documentation requirements.
   a. Documents to be prepared and submitted.
   b. Documents to be retained.

F. Receipt Inspection

1. Receipt inspection assures that:
   a. Equipment is properly identified
   b. Documentation requirements have been fulfilled.
   c. Inspection status is identified prior to storage or use.

VIII. IDENTIFICATION & CONTROL OF MATERIALS, PARTS AND COMPONENTS

A. Established measures for the identification and control of materials, parts and components assure that only correct and accepted items are used, and that identification is evident at all times.

1. Identification shall be maintained on the material, part or component to the greatest extent possible.
   a. When this is not possible the equipment shall be segregated and control shall be maintained through established procedures.
   b. Identification shall be maintained in records traceable to the item.

B. Identification Requirements

1. Identification shall include job number, equipment number, and heat number as applicable.
2. Identification shall be permanent, legible, and shall not interfere with fabrication.
3. Identification shall be properly transferred to each part of an item when subdivided.
4. When material traceability is required the identification shall be traceable to the appropriate documentation.

C. Identification Verification

1. Identification shall be verified and documented prior to release for fabrication, assembly, and installation.

IX. CONTROL OF SPECIAL PROCESSES

A. Special Processes are accomplished in accordance with written and approved procedures.

1. Q.A. and Engineering review and approves special process procedures to assure compliance with applicable codes, standards, and specifications.

B. Procedure and Personnel Qualifications

1. All special processes are performed by qualified vendors and subvendors.

2. All procedures, equipment and personnel are qualified in accordance with applicable codes, standards, and specifications.
   a. Where no code, standard or specification exists, special processes shall be controlled through written procedures approved by ATCOR.

C. Qualification Records

1. Qualification records of all procedures and personnel are established filed and kept current.

D. Special Process Verification

1. When required, the performance of special processes is verified during in-process inspection.
2. A Certificate of Compliance is required from all vendors performing special processes.

X. INSPECTION

A. Inspections are accomplished through written procedures.

1. Inspections verify that activities affecting quality are accomplished properly and in accordance with written procedures.
2. Inspection personnel are appropriately trained and qualified.
3. Records of training and qualifications are maintained and kept current in Q.A. files.
4. Inspection personnel are independent and do not report to those who are responsible for the work being inspected.

B. Inspection Requirements

1. Inspection requirements are determined at the beginning of a project.
2. The requirements are outlined on the Inspection Point Program, (I.P.P.)
3. Witness and hold points are defined and shown on the I.P.P.
4. Work shall not proceed beyond a hold point until the requirement has been verified and documented.
5. Inspections shall include but not be limited to the following (as applicable):
   a. Visual Inspection
   b. Dimensional Inspection

c. Visual Weld Inspection

d. In-Process Fit-Up Inspection

e. Surface Preparation, Painting, and Preservation Inspection

f. Documentation Inspection

g. Packaging Inspection

C. Inspections

1. Inspection of processed items shall be performed as necessary to assure quality.
2. When inspection is disadvantageous indirect control shall be used (i.e. monitoring process methods, equipment & personnel).
3. Modifications, repairs and replacements are inspected in accordance with the original design and inspection requirements or acceptable alternatives.

XI. TEST CONTROL

A. The Test Control Program assures that all testing required to demonstrate that an item wil perform satisfactorily is identified, performed, and documented.

1. All testing is performed in accordance with written test procedures which incorporate or reference the requirements and acceptance criteria contained within the design and procurement documents.

B. Test Procedure Preparation and Approval

1. Test Procedures are prepared by the Engineering Department.
2. The procedures are reviewed and approved by the Engineering Manager and Q.A.
3. The procedures include:
   a. Acceptance criteria as described in design documentation.
   b. Test performance instructions
   c. Prerequisites
   d. Requirements for witnessing test performance
   e. Requirements for recording, documenting and reporting test results.

4. When required the vendor prepared test procedure shall be submitted and approved prior to use.
   a. The procedure submittal requirement is defined in the procurement document.

C. Test Requirements
   1. The procurement document identifies all tests which shall be performed and reported.

D. Test Results
   1. Actual test results are documented, signed by qualified test personnel, reviewed by Q.A. and Engineering prior to acceptance.
   2. Test results are maintained in Q.A. files.
   3. Modifications, repairs and replacements shall be tested in accordance with the original requirements or acceptable alternatives.

XII. CONTROL OF MEASURING AND TEST EQUIPMENT

A. All measuring and test equipment is provided, utilized and maintained by vendors.
   1. All equipment used for inspection testing and acceptance of an item shall be of the proper type, range and accuracy.
   2. Test equipment shall be used by qualified personnel only.

B. Equipment Accuracy and Calibration
   1. Accuracy shall be assured by identification, calibration stickers, and records traceable to national standards.
   2. In-house reference and transfer standards shall be traceable to national standards.
   3. Measures shall be established to assure that when test equipment is found to be out of calibration ATCOR Q.A. is formally notified and that the validity of inspections performed using defective equipment is documented.

C. Calibration Status

1. Records shall be maintained for all measuring and test equipment and shall include:

   a. Frequency of calibration

   b. Date of last calibration

   c. Date of next calibration required

   d. Present calibration status

D. Measuring and Test Equipment Verification

1. The above requirements shall be verified prior to vendor selection, and shall be under the surveillance of ATCOR Q.A.

XIII. HANDLING STORAGE AND SHIPPING

A. All activities associated with handling, storage, shipping, etc. are performed through the use of written procedures/instructions to prevent damage, deterioration and loss.

B. Handling, Storage, and Shipping Requirements

1. The Project Engineer shall establish and document the requirements for the above activities within engineering specifications and procurement documents.
2. Special procedures shall be prepared and adhered to for critical, sensitive, and high value articles.
3. All required shipping papers shall be prepared and maintained on file.

C. Vendors Capabilities

1. ATCOR Q.A. shall assure the vendor's capabilities to conform to the above requirements.
2. Compliance shall be verified during surveillance inspection.

XIV. INSPECTION, TEST AND OPERATING STATUS

A. Prior to vendor selection it shall be verified that the vendor has and implements documented measures to identify inspection and test status.

1. Measures shall assure that testing and inspections are performed as required, and the status is known throughout fabrication.
2. Non-conforming items shall be clearly identified.

B. Fabrication Status

1. The inspection and test status shall be maintained by status indicators.
2. The measures shall assure that only those items which have passed required inspections and tests are used, installed and operated.
3. The measures shall include controls for the use of the status indicators including the authority for the application and removal of the indicators.

C. Installation, Test and Start-Up Status

1. The facilities established tagging procedures shall be used.
2. The status of non-conforming, inoperative or malfunctioning equipment shall be identified to prevent inadvertant use.

D. Waiving Inspections and/or Tests

1. Bypassing inspections and tests shall be avoided to the greatest extent possible.
2. When bypassing becomes necessary, it shall be procedurally controlled.
   a. Those steps bypassed shall be documented and reviewed by Q.A. and Engineering.

XV. NON-CONFORMING MATERIALS, PARTS OR COMPONENTS

A. Prior to vendor selection it shall be verified that the vendor has and implements measures for the identification, segregation, disposition, and notification of non-conforming items

1. A planned procedure for action on non-conforminmg items shall be established by the vendor and approved by ATCOR.
2. Non-conforming items shall be tagged and physically segregated from other materials whenever possible.

3. When physical segregation is not possible another means of identification shall be provided.

B. Non-conformance Notification and Disposition

1. The vendor shall provide formal notification to ATCOR's Q.A. Manager.
   a. The formal notification shall include a complete description of all non-conformance, recommended disposition and justification.
   b. If repair or rework is required written procedures shall also be submitted.
2. The Q.A. Manager shall generate a Non-conformance Report (N.C.R.) and submit to Engineering for recommended dispostion.
3. When Engineering disposition is complete, the Q.A. Manager shall make the formal disposition.
   a. The vendor shall be formally notified of the required action to be taken.
4. The completed N.C.R. including formal disposition, shall be maintained in Q.A. files.

C. Inspection of Dispositioned Non-conformances

1. All non-conforming items requiring repair or rework shall be re-inspected and re-tested by a method at least equal to the original requirements.

XVI. CORRECTIVE ACTION

A. Measures have been established to assure that conditions adverse to quality and safety are promptly identified and corrected as soon as practicable.

B. External Corrective Action

1. When any adverse conditions occur, the Q.A. Manager shall document the condition, investigate the problem to determine the cause, determine required action to correct the problem at hand, and initiate the corrective action required to preclude repetition.

2. All of the above actions shall be documented, reported to management and maintained in project files.

C. Internal Corrective Action

1. Corrective actions required on a company level shall be documented, reported to management, maintained in Q.A. files, and verified during internal audits.

D. Corrective Action Follow-up

1. Corrective action required to preclude repetition shall be verified during subsequent inspections and evaluations.

XVII. QUALITY ASSURANCE RECORDS

A. Measures have been established to assure that sufficient records are prepared as work is performed to furnish documentary evidence of the quality of items and of activities affecting quality.

1. These records shall be consistant with the applicable codes, standards, specifications and contracts.
2. The records shall be adequate for use in management of the program.
3. The Q.A. Manager shall prepare a list of all required in-house and project records.

B. Inspection and Test Records

1. Shall identify the item being examined, the type of examination, date and results including acceptability.
2. The inspection/test records shall be signed, initialed or stamped by the inspector or data recorder.
3. Any deficiencies found shall be documented as well as the corrective action necessary to correct the deficiency including verification of re-inspection or re-test.

C. Record Identification

1. All Q.A. records are identifiable and retrievable.
2. A list of required records and their storage locations shall be maintained by Q.A.

3. All Q.A. records shall be avilable for review by the customer and/or his authorized representative.
4. Records shall be submitted to the customer as required by contract.

D. Record Retention

1. After shipment, the records shall be retained at a minimum of 5 years unless required by contract to retain the records for a greater length of time.
2. Records shall be retained in a suitable environment to minimize damage, deterioration and prevent loss.

XVIII. AUDITS

A. The audit system consists of planned internal and external audits and evaluations.

1. Audits and evaluations assure compliance with the Q.A. program and assess the effectiveness of the program.

B. Audit/Evaluation Frequency

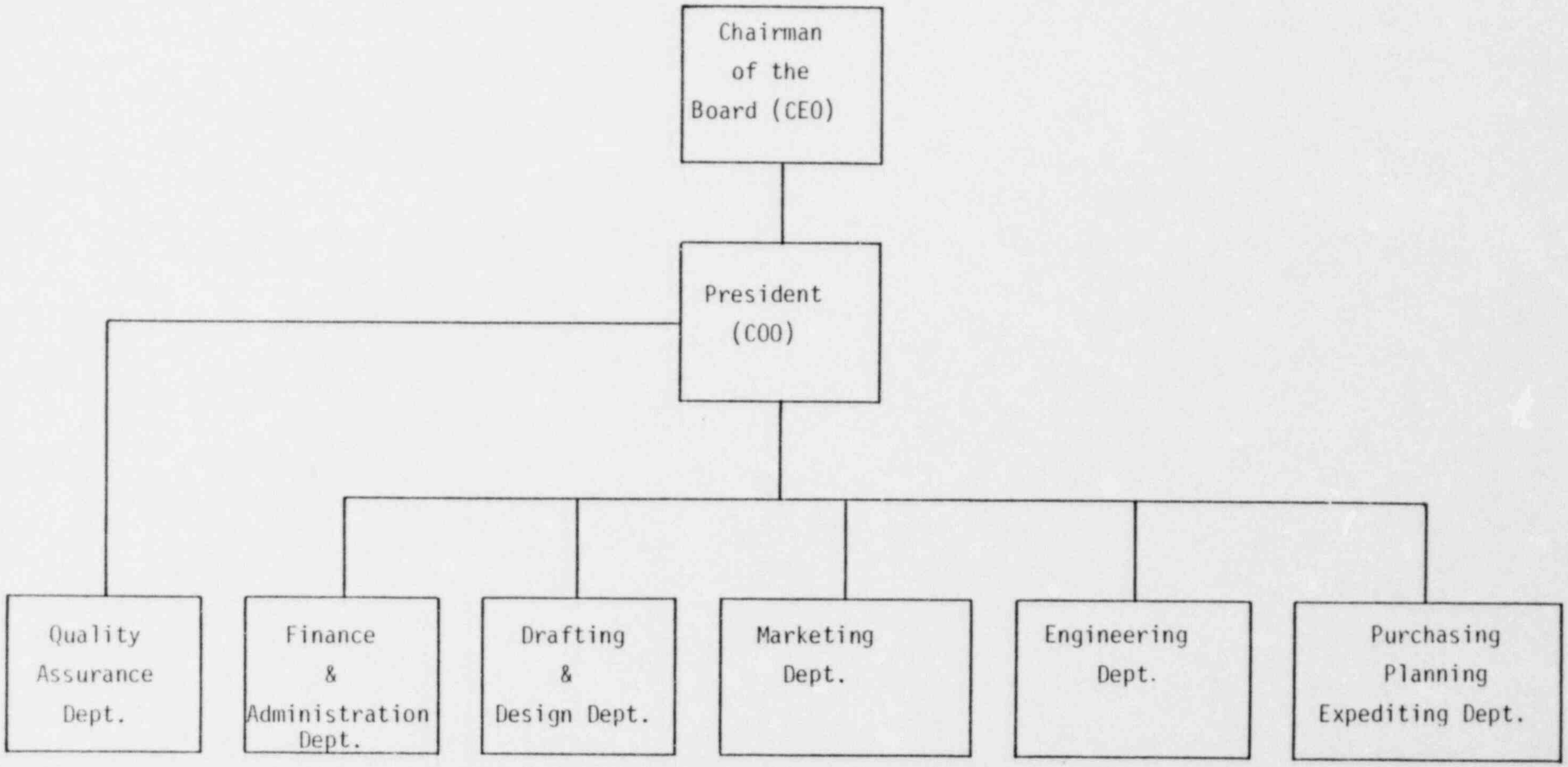
1. Audits/evaluations are conducted at periodic intervals based on the complexity of the activities being performed.
2. Internal audits are normally conducted once every 12 months.
    a. Unscheduled audits may be performed more frequently in specific areas.
    b. Internal audits are performed on a random, unannounced basis to assure effectiveness and prompt disclosure of deficiencies.
    c. Results are documented and reviewed with management.
    d. Deficiencies are documented as well as the corrective actions necesary to correct the deficiency.
    e. Results of vendor audit/evaluations are reviewed by ATCOR management to determine acceptability of the vendors capabilities.
4. Audits may be performed more frequently as deemed necessary by the Q.A. Manager.

C. Audit Personnel

1. All audits are performed by personnel not having direct responsibilites in the areas being audited.
2. Audit personnel shall have experience or training commensurate with the scope, complexity or special nature of the activities being audited.
3. When required, representatives from various departments may be called upon for technical advice or assistance.

ATCOR ENGINEERED SYSTEMS, INC.

ORGANIZATIONAL CHART



ATTACHMENT "A"

C H A P T E R 8

RESEARCH & DEVELOPMENT PROGRAM

8.0 RESEARCH & DEVELOPMENT PROGRAM

The research and development effort associated with the development of the ATCOR/BN Process is described in Appendix 3 - EXPERIMENTAL BASIS.

CHAPTER 9

OPERATING EXPERIENCE

9.0 OPERATING EXPERIENCE

9.1 ATCOR ENGINEERED SYSTEMS, A CHEM-NUCLEAR COMPANY

ATCOR has provided Radwaste Solidification and Processing Systems to nuclear power plants both in the United States and overseas. ATCOR systems have been designed to process and solidify wastes for both BWR and PWR plants. These projects have included system design, equipment fabrication, system integration, quality assurance, start-up supervision, system performance testing and complete system documentation, including installation, operation and maintenance manuals. A summary of ATCOR's experience in radioactive waste solidification systems is shown on Table 9-1.

ATCOR has been assigned patent #3883441 by the United States Patent Office for the ATCOR Solidification System. This patent, covering continuous in-line mixing of radioactive waste metered from a waste tank and cement metered from a cement bin, describes the basic inventions developed by ATCOR.

Operating experience of the ATCOR Solidification System in nuclear power plants has provided a solid demonstration of the validity of the ATCOR approach. ATCOR through these installations has gained experience and data covering a wide range of operating conditions. This data and plant operating experience has resulted in the constant improvement in equipment reliability and ease of operation that comes only with vast amounts of in-plant operating experience.

ATCOR's parent company, Chem-Nuclear Systems, Inc., Seattle, is a recognized leader in radioactive waste processing, transportation and disposal. Chem-Nuclear operates both radioactive and chemical waste disposal sites in the United States.

9.2 BELGONUCLEAIRE

Belgonucleaire was in charge on behalf of the Nuclear Study Center in Mol, Belgium (CEN/SCK), of the operation of the Mol Waste Treatment Station from the time it was opened in 1960 until 1980. During th is time Belgonucleaire was responsible for the design and installation of the radioactive waste processing systems installed at Mol.

The first bituminization unit was erected in Mol in the early sixties and it is still in operation for the daily needs of the station. It was basically built for the incorporation of filtercakes (obtained at the end of the low and medium level wastes process) into hot bitumen, the residual water contained in the cakes being evaporated by the heat transmitted through the bitumen. The process has a capacity of one drum every 8 hours.

Following the successful operation of this system, it was decided to redesign the system, introducing a volume reduction (VR) step prior to the encapsulation of the residues, to meet the requirement of limiting solidified product volumes. The construction of a "Pilot VR System" was initiated in 1969 and this was put into operation in 1971 for extensive testing of the design, its characteristics, efficiency and operational behavior. Practical solutions to the problems of borates, ion exchange resins, etc., were developed by refining the pretreatment, the drying technique and the process parameters. This Pilot System utilized the design principle of three separate process steps:

-pretreatment of the feed solutions;

-drying of the pretreated solutions (VR);

-incorporation of the dried solids in the solidification matrix.

This basic process has become the AVRS-80 System described in this Topical Report.

In 1974 an industrial bituminization unit was studied and built for an 800 MWe BWR power plant in Sweden. It utilized the same principles, general flow sheet and types of equipment supplied in the pilot unit tested in Mol. The commissioning test of this industrial unit with a capacity of 5 drums of conditioned product per working day was performed in 1979 - 1980.

As part of a continuing program of process improvements, a new research and development program was initiated. The complementary aims of this new program were:

-improvement in the drying technique with application to the miscellaneous waste types (to obtain a better efficiency and dried product quality) and testing of drying equipment from several potential manufacturers;

-investigation and comparison of the incorporation conditions and of the solidified products properties for a series of typical dried solids and the three main solidification matrix materials: cement, bitumen and polymer.

One of the major problems to be solved was the wide variety of dry solids content and characteristics to be handled while at the same time obtaining an acceptable evaporation capacity for a reasonable equipment size. The design proved effective in solving the problems mentioned above and in particular solved the problems associated with the "difficult to handle" nature of some of the solids as they go from "wet" to "dry".

In 1978, a VR and Solidification System contract was awarded to Belgonucleaire to study and construct for the TIHANGE 2 PWR power station (Belgium) a VR system using this technology. This plant is a direct application of the latest Volume Reduction Process for stationary combined volume reduction/solidification units. Start-up and operational testing is now scheduled for mid-1982. This plant uses cement as the binder.

Belgonucleaire acted as Architect - Engineer for the Eurobitum plant from the conceptual study up to the operational test. This plant bituminizes the medium activity wastes of the EUROCHEMIC fuel reprocessing plant and is now in industrial operation. The conceptual and detailed design of a similar installation in Japan has also been carried out.

Table 9-2 summarizes BN's experience.

9.3 THE ATCOR/BELGONUCLEAIRE VOLUME REDUCTION PROCESS

Based on the extensive experience ATCOR has had in solidification systems (18 Cement and one Dow) and the intensive research and development experience and capability as well as field experience at Belgonucleaire, a licensing and joint venture effort has been initiated to market this combined expertise. Work continues at the Pilot Facility at Mol, Belgium in the areas of continued testing of residues and, in particular, in process and equipment improvement and modifications. Testing is presently in progress on an improved mixer design and on an evaporator configuration that will reduce facility costs, improving materials handling and increase reliability.

The facility at Mol is available to our clients as a valuable tool to demonstrate the effectiveness of the combined ATCOR/BN VR Process. This facility contains industrial size equipment and is capable of full scale tests working with all types of simulated LWR effluents. The testing program includes an extended investigation of the detailed performance of the system and all its process parameters.

TABLE 9-1

ATCOR RADWASTE SOLIDIFICATION EXPERIENCE

SYSTEM DELIVERY	PURCHASER/PLANT	SYSTEM DESCRIPTION
1972	NORTHERN STATES POWER COMPANY (Monticello-548MWe-BWR)	Continuous In Line - Drum Filling Masonry Cement
1974	NORTHERN STATES POWER COMPANY (Prairie Island-1060MWe-PWR)	Continuous In Line - Drum Filling Masonry Cement
1974	WISCONSIN PUBLIC SERVICE COMPANY (Kewaunee-540MWe-PWR)	Continuous In Line - Drum Filling Masonry Cement
1974	BOSTON EDISON COMPANY (Pilgrim-670MWe-PWR)	Continuous In Line - Liner Filling Cement
1975	DUQUESNE LIGHT COMPANY (Beaver Valley-852MWe-PWR)	Continuous In Line - Liner Filling Masonry Cement
1975	SUMITOMO & TOKYO ELEC.PWR.CO. (Test Facility)	Continuous In Line - Drum Filling Cement
1976	CINCINNATI GAS & ELECTRIC CO. (Zimmer-810MWe-BWR)	Continuous In Line - Drum or Liner Filling - Masonry Cement
1976	TENNESSEE VALLEY AUTHORITY (Bellefonte-1213MWe-PWR)	Continuous In Line - Liner Filling Masonry Cement
1976	LONG ISLAND LIGHT COMPANY (Shoreham-820MWe-BWR)	Continuous In Line - Liner Filling Cement
1977	TAIWAN POWER COMPANY (Kuo-Sheng-1102MWe-BWR)	Continuous In Line - Drum Filling Cement
1977	WISCONSIN ELECTRIC POWER CO (Point Beach-497MWe-PWR)	Continuous In Line - Drum or Liner Filling - Masonry Cement
1977	OMAHA PUBLIC POWER DISTRICT (Ft. Calhoun-457MWe-PWR)	Continuous In Line - Drum or Liner Filling - Masonry Cement

TABLE 9-1 (cont'd)

ATCOR RADWASTE SOLIDIFICATION EXPERIENCE

SYSTEM DELIVERY	PURCHASER/PLANT	SYSTEM DESCRIPTION
1979	TEXAS UTILITIES (Commanche Peak-1150MWe-PWR)	Continuous In Line - Liner Filling Masonry Cement
1979	TAIWAN POWER COMPANY (Maanshan-1000MWe-PWR)	Continuous In Line - Drum Filling Cement and Lime
1980	KOREA ELECTRIC COMPANY (Units 5&6-1000MWe-PWR)	Continuous In Line - Drum Filling Cement and Lime
1981	N.I.R.A. ENEL, ITALY (Cirene-40MWe)	Continuous In Line - Drum Filling Cement and Lime
1980	FUERZAS ELECTRICAS DE CATALUNA Spain (ASCO,Unit 2-880MWe-PWR)	Continuous In Line - Drum Filling Cement and Lime
1980	CHEM-NUCLEAR SYSTEMS, INC. (Mobile Solidification Sys.)	In-Container Mixing for Liner DOW Media and Cement
1981	IBERDUERO SA (C.N. de Lemoniz-900MWe-PWR)	Continuous In Line - Drum Filling Cement and Lime
1981	NORTHEAST UTILITIES (Millstone-652/828MWe-BWR/PWR)	In-Container Mixing for Liner DOW Media
1981	FUERZAS ELEC. DE CATALUNA SPAIN (ASCO, Unit 1-880MWe-PWR)	Continuous In Line - Drum Filling Cement and Lime
1982	COMMONWEALTH EDISON (Quad Cities-800MWe-BWR)	In-Container Mixing for Liner DOW Media
1983	KOREA ELECTRIC COMPANY (Units 7&8-1000MWe-PWR)	Continuous In Line - Drum Filling Cement and Lime
1983	NORTHEAST UTILITIES (Millstone-1150MWe-PWR)	In-Container Mixing for Liners DOW Media

TABLE 9-1 (cont'd.)

ATCOR

REMOTE OPERATED HANDLING SYSTEMS EXPERIENCE

(CARTS, TURNTABLES, AND CONVEYORS)

SYSTEM DELIVERY	PURCHASER/PLANT	SYSTEM DESCRIPTION
1972	NORTHERN STATES POWER COMPANY (Monticello-548MWe-BWR)	Modification of a process aisle drum transfer cart
1974	NORTHERN STATES POWER COMPANY (Prairie Island-1060MWe-PWR)	Remote controlled drum process aisle and storage aisle conveyor system with automatic positioning
1974	WISCONSIN PUBLIC SERVICE COMPANY (Kewaunee-540MWe-PWR)	Remote controlled drum process aisle and storage aisle conveyor system with automatic positioning; a 35 Ton remote controlled cask Transfer Cart
1976	CINCINNATI GAS & ELECTRIC CO. (Zimmer-810MWe-BWR)	Remote controlled 7 1/2 Ton turntable for remote sequential fill and cap closure operations
1976	TENNESSEE VALLEY AUTHORITY (Bellefonte-1213MWe-PWR)	Remote controlled 5 Ton transfer cart system
1976	LONG ISLAND LIGHT COMPANY (Shoreham-820MWe-BWR)	Remote controlled 10 Ton process aisle tranfser cart system
1977	TAIWAN POWER COMPANY (Kuo-Sheng-1102MWe-BWR)	Remote controlled drum process aisle and storage aisle conveyor system with automatic positioning
1977	WISCONSIN ELECTRIC POWER CO (Point Beach-497MWe-PWR)	Remote controlled 5 Ton process aisle cart for sequential fill and cap closure operations of various size liners
1977	OMAHA PUBLIC POWER DISTRICT (Ft. Calhoun-457MWe-PWR)	Remote controlled 7 1/2 Ton process aisle cart for sequential fill and cap closure of liners or drums

TABLE 9-1 (cont'd)

ATCOR

REMOTE OPERATED HANDLING SYSTEMS EXPERIENCE

(CARTS, TURNTABLES, AND CONVEYORS)

SYSTEM DELIVERY	PURCHASER/PLANT	SYSTEM DESCRIPTION
1979	TEXAS UTILITIES (Commanche Peak-1150MWe-PWR)	Remote controlled 6 Ton process aisle transfer cart
1979	TAIWAN POWER COMPANY (Maanshan-1000MWe-PWR)	Remote controlled drum process aisle and storage aisle conveyor system with automatic positioning 5 Ton - 8 drum capacity remote controlled storage to shipping cart
1980	KOREA ELECTRIC COMPANY (Units 5&6-1000MWe-PWR)	Remote controlled drum process aisle and storage aisle conveyor system with automatic positioning
1980	FUERZAS ELECTRICAS DE CATALUNA Spain (ASCO,Unit 2-880MWe-PWR)	Remote controlled drum process aisle and storage aisle conveyor system with automatic positioning
1981	NORTHEAST UTILITIES (Millstone-652/828MWe-BWR/PWR)	Remote controlled 36 Ton capacity cask transfer cart
1981	FUERZAS ELEC. DE CATALUNA SPAIN (ASCO, Unit 1-880MWe-PWR)	Remote controlled drum process aisle and storage aisle conveyor system with automatic positioning
1983	KOREA ELECTRIC COMPANY (Units 7&8-1000MWe-PWR)	Remote controlled drum process aisle and storage aisle conveyor system with automatic positioning

TABLE 9-1

ATCOR

REMOTE OPERATED AUXILIARY SYSTEMS EXPERIENCE

(CAPPERS, DECON AND SMEAR STATIONS)

SYSTEM DELIVERY	PURCHASER/PLANT	SYSTEM DESCRIPTION
1972	NORTHERN STATES POWER COMPANY (Monticello-548MWe-BWR)	Remote drum decontamination System
1974	NORTHERN STATES POWER COMPANY (Prairie Island-1060MWe-PWR)	Remote drum capper - ring clamp/bolt closure system and a remote decontamination system
1974	WISCONSIN PUBLIC SERVICE COMPANY (Kewaunee-540MWe-PWR)	Remote drum capper - ringclamp/bolt closure system and a remote decontamination system
1975	DUQUESNE LIGHT COMPANY (Beaver Valley-852MWe-PWR)	Remote liner decontamination system; Remote liner cover closure device.
1976	CINCINNATI GAS & ELECTRIC CO. (Zimmer-810MWe-BWR)	Remote capper - ring clamp/bolt closure system for drums and liners
1976	TENNESSEE VALLEY AUTHORITY (Bellefonte-1213MWe-PWR)	Remote liner cover closure device
1976	LONG ISLAND LIGHT COMPANY (Shoreham-820MWe-BWR)	Remote liner capper - ring clamp/bolt closure system
1977	TAIWAN POWER COMPANY (Kuo-Sheng-1102MWe-BWR)	Remote drum capper - ring clamp/bolt closure system; remote decontamination and smear station systems
1977	WISCONSIN ELECTRIC POWER CO (Point Beach-497MWe-PWR)	Remote liner cover closure device
1977	OMAHA PUBLIC POWER DISTRICT (Ft. Calhoun-457MWe-PWR)	Remote capper - ring clamp/bolt closure system for drums and liners
1979	TEXAS UTILITIES (Commanche Peak-1150MWe-PWR)	Remote liner capper - ring clamp/bolt closure system

TABLE 9-1 (cont'd)

ATCOR

REMOTE OPERATED AUXILIARY SYSTEMS EXPERIENCE

(CAPPERS, DECON AND SMEAR STATIONS)

SYSTEM DELIVERY	PURCHASER/PLANT	SYSTEM DESCRIPTION
1979	TAIWAN POWER COMPANY (Maanshan-1000MWe-PWR)	Remote drum capper - ring clamp/bolt closure system; remote decontamination and smear station systems
1980	KOREA ELECTRIC COMPANY (Units 5&6-1000MWe-PWR)	Remote drum capper - ring clamp/bolt closure system; remote decontamination and smear station systems
1981	N.I.R.A. ENEL, ITALY (Cirene-40MWe)	Remote drum capper - ring clamp/bolt closure system
1980	FUERZAS ELECTRICAS DE CATALUNA Spain (ASCO,Unit 2-880MWe-PWR)	Remote drum capper - ring clamp/bolt closure system
1980	CHEM-NUCLEAR SYSTEMS, INC. (Mobile Solidification Sys.)	Crimp-a-Cap remote drum closure system
1981	IBERDUERO SA (C.N. de Lemoniz-900MWe-PWR)	Remote drum capper - ring clamp/bolt closure system
1981	NORTHEAST UTILITIES (Millstone-652/828MWe-BWR/PWR)	Crimp-a-Cap remote drum closure system
1981	FUERZAS ELEC. DE CATALUNA SPAIN (ASCO, Unit 1-880MWe-PWR)	Remote drum capper -ring clamp/bolt closure system
1982	COMMONWEALTH EDISON (Quad Cities-800MWe-BWR)	Crimp-a-Cap remote drum closure system
1983	KOREA ELECTRIC COMPANY (Units 7&8-1000MWe-PWR)	Remote drum capper - ring clamp/bolt closure system; remote decontamination and smear station systems
1983	NORTHEAST UTILITIES (Millstone-1150MWe-PWR)	Crimp-a-Cap remote drum closure System

TABLE 9-2
BELGONUCLEAIRE
RADWASTE SYSTEMS EXPERIENCE

SYSTEM DELIVERY	PURCHASER/PLANT	SYSTEM DESCRIPTION
1960	Belgian Nuclear Reasearch Ctr. Belgium	Asphalt Solidification of Filtered Flocculates
1962	Garching Nuclear Center W. Germany	Asphalt Solidification of Filtered Flocculates
1964	ISPRA EURATOM Nuclear Center Italy	Asphalt Solidification of Filtered Flocculates
1968	Zwierck Nuclear Center Poland	Asphalt Solidification of Filtered Flocculates
1970	Eurobitum & Eurostorage Belgium	Asphalt Extruder of Power Plant Waste Liquids
1974	PNC Reprocessing Plant Japan	Asphalt Extruder of Power Plant Waste Liquids
1980	Forsmark 1 & 2 Sweden	Evaporation to Solids, Solidification in Asphalt of BWR Waste Liquids
1981	Tihange 2 Belgium	Evaporation to Solids, Solidification in Cement of Waste Liquids

ATC-8019-1

ATCOR AVRS-80

Volume Reduction Process

C H A P T E R 10

POSTULATED ACCIDENT ANALYSIS

10.0 POSTULATED ACCIDENT ANALYSIS

The ATCOR AVRS-80 Volume Reduction System is designed to prevent the release of radioactive material to the radwaste processing building in the event of an abnormal situation. Furthermore, the selection and testing of the equipment has been influenced by the possible accident conditions described below to minimize the release of radioactivity and exposure of the operators required to recover from the accident.

10.1 LOSS OF POWER

Loss of electric power stops the processing capability of the volume reduction system by stopping the rotation of the intensive dryer shafts and stopping the addition of heat input for the drying process, the remainder of the process pumps are stopped. To ensure positive waste feed stoppage, the waste inlet is provided with a valve which shuts on loss of electric power. Automatic flushing of the feed lines is initiated on loss of power to prevent plugging ne lines by the waste slurry.

sting conducted at the pilot plant to simulate this condition has shown that e dryer can be restarted after the loss of power even when the dryer is filled with waste prior to the loss and when the mixing section is being used to solidify waste. The self wiping abilities of the dryer allow the dryer to re-start and break up any large aggregates of the dried product or solidified product which are present inside the dryer.

10.2 LOSS OF COOLING WATER

The effect of a loss of cooling water is to increase the pressure in the condenser and to allow the mixing section of the intensive dryer to heat up. Typically, the increase in system operating pressure is experienced prior to the effects of the increased mixing temperature to be detected. An alarm on the system operating pressure notifies the operator that cooling water flow has decreased. The operator can then decide either to re-establish flow or to stop processing waste in a controlled manner, if flow cannot be re-established.