THE DESIGN OF THE TRANSPORTABLE GROUT EQUIPMENT FACILITY AT HANFORD

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ABSTRACT

The U.S. Department of Energy and Rockwell Hanford Operations (Rockwell) have developed a grouting process for the immobilization of various low-level radioactive waste generated at the Hanford Site. This process has been demonstrated in a pilot facility and the program is now underway to implement it on a production basis. Associated Technologies, Incorporated (ATI) has been selected to perform the design, fabrication, and installation of part of such a facility to the standards and performance criteria established by Rockwell and the Department of Energy. SGN of France has been contracted by ATI to provide the benefit of remote maintenance experience.

INTRODUCTION

Large volumes of phosphate/sulfate waste (PSW) from N-Reactor operations presently exist or will be generated during future operations at the Hanford Site operated by the U.S. Department of Energy as part of its overall waste management program. The Department of Energy has selected a process whereby these LLW liquids with activity levels up to 0.5 Ci/liter of Cs 137 will be combined with grout-forming solids and disposed of in near-surface engineered vaults.

Rockwell is presently installing the necessary facilities to implement the grouting process on a production basis. Technical support to the project for grout formulations and performance evaluations is being provided by the Oak Ridge National Laboratory and the Pacific Northwest Laboratory.

The grout production facilities include the Dry Materials Receiving and Handling Facility (DMRHF), a one million gallon double-shelled, underground feed tank, the Transportable Grout Equipment (TGE) Facility and the disposal vaults. These facilities are located at the 200-East area of the Hanford Site. At this writing, the DMRHF and the new tank designated to feed the TGE are complete. Design and fabrication of the TGE is approximately 40% complete with preliminary site construction of the disposal vaults well underway. Completion currently is set for June 1, 1987.

The TGE Facility was purchased on the basis of a performance specification. Within the conceptual guidelines and design standards, Associated Technologies, Inc. (ATI) along with the advice and consultation of SGN of France were given responsibility for detailed design, fabrication and erection, and system safety and performance to the criteria established by Rockwell. At the time of contract award, it was clear that to meet the performance period leading to the pre-operational testing target, an expeditious and well-coordinated program would be necessary.

THE PROCESS

The grouting process has previously been described in the literature (1,2). For convenience, a brief description of the process follows in order to set the stage for the discussion of the system design. The flow diagram (Fig. 1) depicts the process as well.

At the DMRHF batches of the dry grout solids will be blended in the specified proportions designated for the particular liquid waste to be solidified. Table I lists the various constituents of the dry blended material. The blended solids will be delivered to the TGE Facility by means of bulk transport trucks. From an interim storage bin, the grouting solids are fed gravimetrically to the grout mixer.

In the mixer, the solid and liquid components are combined to form the grout slurry. The in-line, twin-screw mixer deposits the slurry in a surge tank at the inlet to the grout pump. The slurry mixture is then pumped to the disposal vaults at a rate ranging from thirty (30) to seventy (70) gallons per minute.

The additional equipment provide several auxiliary functions. These include process sample extraction from specified points, flushing and decontamination of all process lines, collection of the flush solutions and spent decontamination solutions, containment and collection of any potential leakage of inadvertant spills, and collection of liquids from all potentially radioactive drains. Finally, provisons will be made to receive any excess liquid returned from the disposal vaults.

Liquids will be collected from these various sources in a liquid collection tank. Here they will be homogenized, sampled, and adjusted for pH if required. At this point the liquids can be fed to the grout mixer or returned to the waste feed tank.

Along with these basic and auxiliary processes, the overall system will also perform the necessary supporting functions. Power supply and distribution controlled ventilation, dust collection, and safety systems will be addressed in later sections of this paper.

DESIGN CONCEPT AND CRITERIA

The design approach prescribes that the process and service functions of the TGE be accomplished in a system of interconnected modules. Each module has to be capable of being transported over public roads by standard flatbed trailers. Interconnections are quick-disconnect design where possible and site-specific characteristics are minimized. These features permit the processing facility to be relocated several times during its operational lifetime. The modular concept also permits the fabrication of a major share of the system off-site and minimizes field erection time.

The foundations for the transportable modules by contrast are permanent. These include the various slabs on grade and a reinforced concrete pit with cover blocks which serves as the foundation and provides shielding for the radioactive processing unit. Inter-connecting piping and wiring are run in pipe chases and conduit which are concrete-encased. These features will provide the stability necessary to maintain close assembly tolerances, minimize safety and maintenance problems associated with temporary connections, and provide the shielding necessary to limit surface exposure.

The TGE has a design life objective of ten years or fifty-thousand hours of operation. Ten individual processing campaigns, each consisting of up to twenty-one days of continuous, round-the-clock operation. Standard stock or catalog items are to be selected to the extent practical to meet overall design considerations.

During operations the process will be initiated and monitored by a single operator at the control console. Another outside operator will provide support for unloading trucks delivering the dry blend and other comsumables. Between the grouting campaigns the unit will be unmanned, except for routine inspections, requiring that the safety alarm systems be integrated with the site Computer Automated Surveillance System (CASS).

Other control considerations include the supply of a state-of-the-art electronic system with emphasis on reliability, ease of operation and one which permits automatic, safe, orderly shutdown on command or failure recognition. Redundancy in the control and process equipment is required at any point where a single-mode failure could prevent safe shutdown, permit an uncontrolled release of radioactivity or prevent recovery from a process upset. Additional design criteria include compliance with ALARA principles and conventional personnel and fire safety standards. Containment of liquid leaks or spills and airborne dust is required both in radioactive and non-radioactive areas. Particular attention is required to the decontamination capability of process lines and equipment internals and external surfaces which may be contaminated by leaks or airborne particles.

A major design requirement for the TGE system is the essential capability of simple, quick remote maintenance. Maintenance and repair activities will not be performed in the radioactive process module. Equipment must be accessible and removable through the use of a remotely operated impact wrench suspended from the hook of a standard 25-ton, motor crane and lifting bails installed on all individual components or components grouped as sub-assemblies. Interconnecting piping and electrical assemblies called "jumpers" utilize PUREX connectors specially designed for compatibility with this method of remote assembly and disassembly. Each unit must be balanced so as to maintain its appropriate orientation for assembly. Applications of this remote manipulation technology have resulted in several of the more ingenuous designs developed for the TGE. These criteria along with the specific system performance requirements and operations philosophy serve as the basis for the detailed TGE design. They influence the equipment selection and arrangement discussed in the following sections.

In all aspects of the TGE design, safety was of foremost concern, the objective being to supply a safe dependable system in which the potential for operator exposure during both operation and maintenance were minimized. In addition to a conventional failure modes and affects analysis, a detailed statistical dependability analysis was run on critical sections of the plant. Based on results of these studies, process design, equipment selection, redundancy and placement, module configuration and control philosophy and program were all optimized to minimize if not eliminate the possibility of a safety related mishap and to minimize potential for operator exposure during all circumstances.

TGE FACILITY DESIGN

Preliminary design decisions led to the identification of eight functional modules. These include:

(1) Dry Blend System	(5) Electric Equipment Module
(2) Decon and Additive Module	(6) Electrical Substation
(3) Liquid Collection Tank/Mixer Module	(7) Stand-by Generator
(4) Control Room Module	(8) Filtration Module

These individual units range from specialty fabrications to customized modular buildings to conventional skid-mounted equipment. The arrangement of these modules at the site is shown in Fig. 2. In addition to these TGE Facility modules Rockwell is providing a Change Room/Lunch Room building for TGE operators to complete the overall facility.

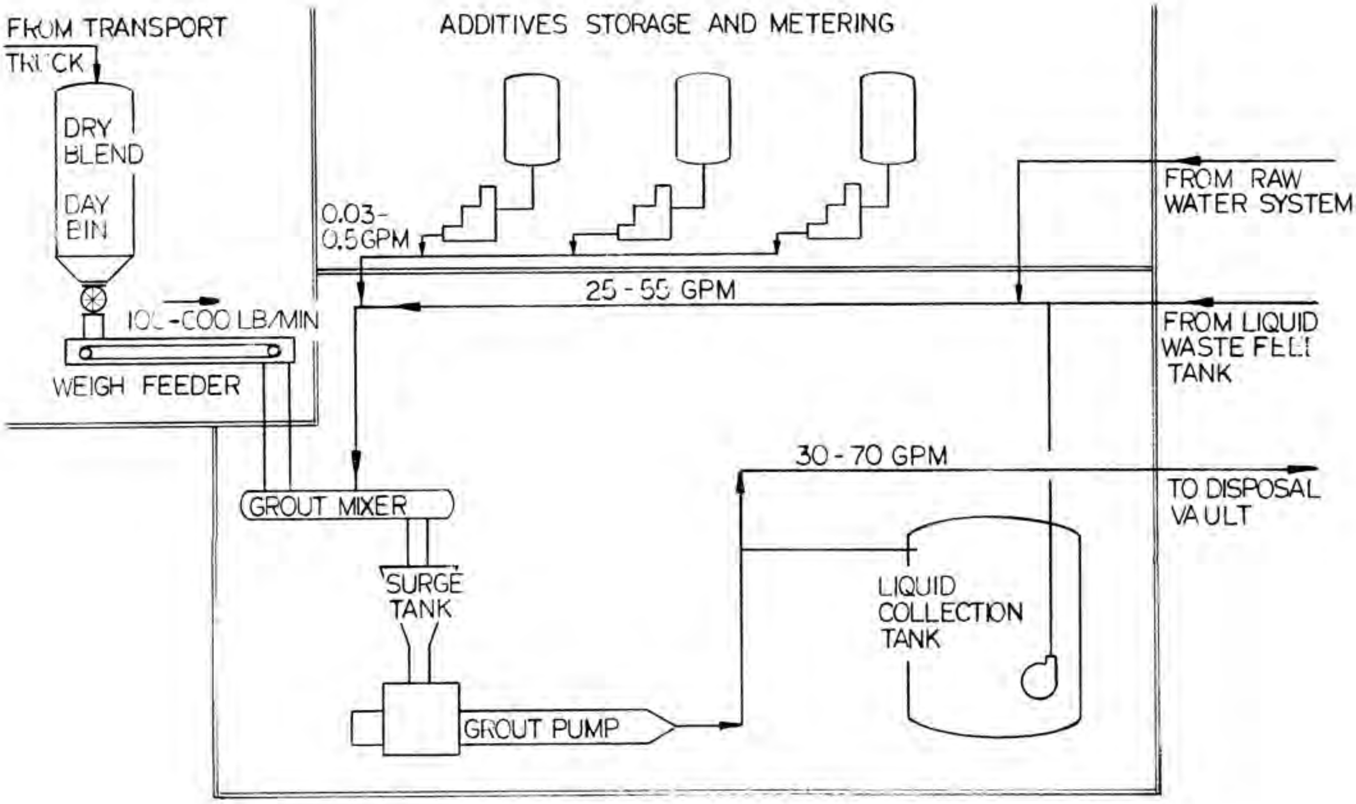

Fig. 1. Flow Diagram.

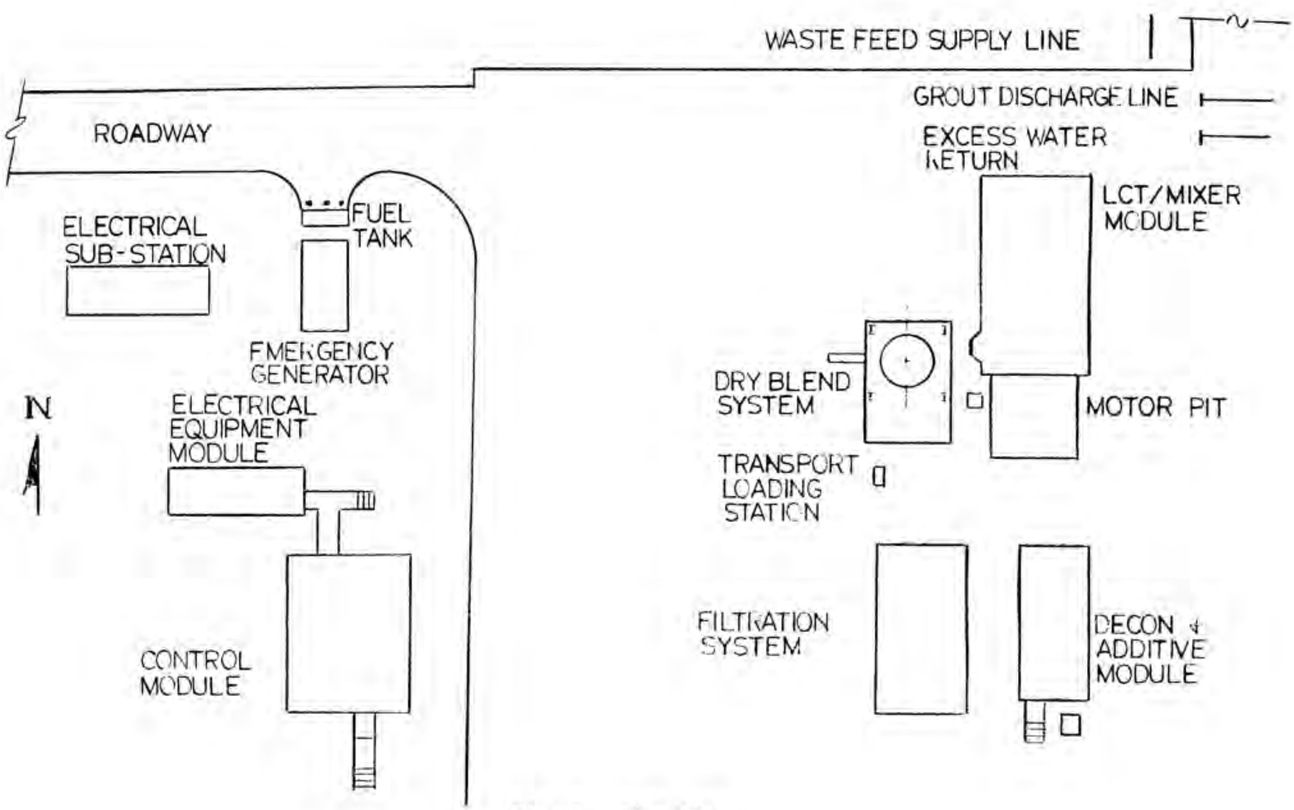

Fig. 2. Site Plan.

DRY BLEND SYSTEM

The head end of the grouting process begins at the Dry Blend System. This module is a field-erected steel structure which includes equipment to pneumatically off-load the dry blended grout material from the delivery trucks and transport it to the dry storage bin, the weigh feeder and the discharge system to the grout mixer. A baghouse filter which receives air exhausted from the surge tank at the mixer discharge is also located on the module. Components are "stacked" on this structure which reaches a height of over seventy-five feet from grade.

The pneumatic conveying system is designed to pressurize and off-load a 1,000 cubic foot truck (27 tons at 54 pounds per cubic foot) in 30 minutes. A bin vent filter mounted on top of the day storage bin collects dry blend dust and returns the collected material by pulse jet cleaning to the bin.

The day storage bin is a straight-sided bin which transitions to a 60^0 hopper bottom which interfaces with the bin activator. It provides 1700 cubic feet of dry material storage and is designed for mass flow to prevent classification, ratholing, and bridging. To prevent moisture condensation inside the bin, a circulating fan and dryer circulate dried air through the bin.

Dry blended material is discharged from the day storage bin through a vibrating bin bottom and a variable speed rotary valve, which discharges onto the weigh feeder. The weigh feeder measures the gravimetric flow rate and provides the input which controls the speed of the rotary valve to deliver the desired flow rate of dry blend material. The weigh feeder discharges the dry blend to a diverter which feeds the vibrating screen during normal operation, or to the transfer conveyor in the event that the contents of the day storage bin must be returned to the truck. The vibrating screen removes tramp material, discharging the tramp material into a 55-gallon drum. The screened dry blend is discharged into a chute which feeds the grout mixer located in the Liquid Collection Tank/Mixer Module.

The Dry Blend System is capable of delivering material to the grout mixer at a controlled rate adjustable from 100 pounds per minute to 600 pounds per minute. This rate is key the process parameter from which feed rates of waste and any liquid additives are proportioned in accordance with the selected grout formulation.

Though residence time in the day storage bin during process campaigns will be relatively short, the system is designed to store the blended material for up to 30 days without segregation. Two automatic samplers, one on the inlet to the bin and one at the discharge to the vibrating screen provide representative samples of the material. Table I lists the types and ranges of dry blend constituents and basic properties.

TABLE I

Dry Blend Constituents

a. Portland Cement, 20-50 wt%, ASTM C 150, Type II, Type III

b. Fly Ash, 30-80 wt%, ASTM C 618

c. Attopulgite Clay, API 13A, 0,5-20 wt% Bulk density, 40 pounds per cubic foot

d. Red Pottery Clay, 0,5-10 wt% Bulk density, 67 pounds per cubic foot

e. Calcium hydroxide 0,5-20 wt%, ASTM C 911-79 Particle Size 0.2 to 150 Micron Bulk Density 41 - 69 lb. per cubic foot

Local controls for truck unloading are provided adjacent to the truck access roadway. This control function is performed by an outside operator away from the Control Room and can take place while grout production is in progress.

Key decisions affecting the Dry Blend System include the selection of the continuous belt weigh feeder and the employment of rotary valves. The former provides accurate delivery over the range of material bulk densities, while the latter provides positive protection against flooding the grout mixer with dry product.

DECON AND ADDITIVE MODULE

This module houses additional process support equipment, but no radioactive service components. Located within the Decon and Additive Module are five stainless steel tanks, three for process additives, one for decontamination solutions, and one for caustic solution used to adjust the pH of liquids received in the Liquid Collection Tank, and the associated pumping equipment and interconnecting piping. Raw water for producing non-radioactive grout and system flushing is provided by way of the decontamination solution feed line. Table II lists these tanks and their capacities. The compressed air system with redundant compressors and associated aftercoolers, dryer system, and receiver tank is located in this module, as is the grout line clearing pump and drive motor and an I/O cabinet for the various instrumentation and control functions.

TABLE II

Decon and Additive Tanks

Fluidizer	1000 gallons
Tributyl Phosphate	500 gallons
Set Regulator	250 gallons
Decontamination Solutions	500 gallons
Caustic (30% Sodium Hydroxide)	200 gallons

This module is completely shop-fabricated and assembled for installation on a concrete slab foundation. Its structural steel framework is sided and roofed over. An integral floor sloped to drain provides spill containmet within the unit. To conserve space, overall module dimensions are only 13 feet by 28 feet, the three additive tanks are horizontal with the two smaller tanks stacked above the largest. The various feed lines from the Decon and Additive Module run in an underground pipe chase to the heart of the grout production system.

LIQUID COLLECTION TANK LCT/MIXER MODULE

Early in the design process it was decided to include all radioactive service functions within a single module. This unit which is another completely shop-fabricated module contains the grout mixer, grout surge hopper, grout pump, a valve skid and the liquid collection tank. A structural steel exoskeleton provides support and rigidity. The inner containment flooring and sides are made up of stainless steel plate continuously welded to provide leak-tight construction. Gasketed, removable roof panels, also stainless steel, complete the containment integrity when the unit is operating. The entire unit is placed in the previously mentioned concrete pit and finally covered by two tiers of interlocking concrete shielding blocks. External to the LCT/Mixer Module and at its south end is the motor pit. Topped by a metal sided and roofed building, the grout mixer and grout pump motors and transmissions are housed here for maintenance access.

Inside the LCT/Mixer Module the dry blend material is mixed with the radioactive waste stream in a twin-screw variable speed in-line mixer. (Liquid process additives are metered into the waste stream just prior to its entry into the mixer). Mixer internals are designed to be self-wiping such that grout build-up does not exceed 1/8".

The mixed grout slurry is deposited in a surge tank which provides a constant supply of material for the grout pump. During tests conducted on smaller models of the mixer significant amounts of dust were observed emanating from the mixer discharge. To prevent the contamination of this dry blend dust it has been necessary to design a dust collection system at this point. By maintaining a negative pressure in the surge tank head and back through the mixer body and dry blend feed system the dust is pulled out of the surge tank and collected in a baghouse located at the Dry Blend System. The system is designed to prevent moisture condensation caused by the 180^{0}F waste stream entering the mixer and to remove entrained air in the dry blend plus any air that may have leaked into the system.

The negative pressure condition in the mixer and dry blend feed system provides an operating condition which can be monitored for fluctuations indicative of plugging conditions. Loss of the desired negative reading automatically shuts down the waste feed to prevent backflow of radioactive material into the dry blend feed system.

The grout pump is a progressive cavity style pump capable of delivering over 500 psig. Continuous operation is 350 psig with higher pressures being necessary to overcome the gel strength of the grout when restarting with the discharge line full. This pump will deliver grout in the range of 30 to 70 gpm.

All wetted materials in the LCT/Mixer Module are selected for resistance to abrasion and the corrosive properties of the waste and decontamination solutions. Elastomers, such as the pump stator, are EPDM based on findings in the pilot scale testing.

The nominal 850 gallon liquid collection tank (LCT) serves as the catch-all for any contaminated liquids which are not incorporated in the grout. This includes any spills or leakage collected in the sump, spent flush and decontamination solutions from either internal or external system clean-up, and excess liquid pumped back to the TGE from the disposal vaults. Contents of the tank can be homogenized and sampled. Sample lines recirculate the contents to the sampling station located at the motor pit. Provisions are incorporated to adjust the pH by the addition of a caustic solution. From the LCT these solutions can be fed directly to the grout mixer inlet or they can be pumped back to the waste feed storage by way of the waste feed line.

Notable in the design effort of the LCT/Mixer Module is provision for remote maintenance. In addition to utilizing existing PUREX connector designs, remotely maintainable flanges have been designed for the grout line high pressure applications at the grout pump discharge and the module containment wall. Also, the dry blend feed chute jumper serves as a remotely removable, pressure-tight connection between a ten-inch diameter feed pipe and the 10-inch-by-13-inch rectangular mixer inlet.

Other features incorporated in the LCT/Mixer Module design are two ceiling mounted radiation-resistant CCTV cameras with full pan, tilt, and zoom lens capability, plus three additional stationary standard cameras directed on specific components through viewports in the containment walls. A high-intensity lighting system illuminates the module interior for the CCTV's. A directional microphone is being mounted on one of the movable cameras to permit monitoring of noise emanating from the equipment. These features plus a great deal of process monitoring instrumentation enable the system operator to closely monitor the system performance.

FILTRATION MODULE

This module is a specially designed equipment skid, shop-fabricated and assembled for rapid field installation. Weather protection is incorporated but this unit is basically designed for outdoor service. It includes both the supply air intake filtration and exhaust air discharge systems for the LCT/Mixer Module. Both supply and exhaust systems provide dual flow capability so that processing may be maintained with proper ventilation during filter element changeout.

The supply air drying system includes redundant air drying systems and HEPA filtration trains. The exhaust system draws air from the LCT/Mixer Module and the baghouse dust collection system which ventilates the grout surge tank through dual HEPA filtration trains by means of redundant exhaust fans and discharges the filtered air to a stack for monitoring and release. The system provides for 850 s.c.f.m. of air flow for frequent air changes in the processing module.

CONTROL ROOM MODULE

The Control Room Module is a customized unit consisting of two trailer sections joined together to make a single control room with overall dimensions of 24 feet by 28 feet. The module contains the control console, instrument test bench and office facilities for the operators.

The control console itself consists of four sections arranged in an L shape. The principal controls and monitors are located directly in front of a seated operator. On the left of the operator are the subsidiary controls and monitors.

The control philosophy is to provide an optimum balance of automatic control and operator initiated control. Fixed sequences of operation such as alignment of valves and proper sequencing of motors for start-up are automated in the control system. Selection of sequences is an operator function.

Complete information on the status of the process including the state of on/off devices and the values of process parameters, such as temperatures and flows, are displayed to the operators.

All the process control is performed by a programmable logic controller (PLC). This PLC controls on/off devices such as valves, does the interlocking to prevent an improper action, and performs the automatic sequencing. In addition, modulating control is performed via the PLC through PID algorithms within the PLC itself.

The operator interface with the control system consists of a set of keyboards and CRT monitors. Control actions are initiated by the operator via the keyboard. Monitoring of the process takes place via the CRT's. In addition the CRTs provide menus to assist the operator in performing the control actions and in selecting different screens for monitoring different portions of the process. There are approximately 20 different process screens which the operator can select. These vary from an overview of the entire process to detailed screens providing information on specific subsections of the process.

Alarms are displayed to the operator on an alarm summary screen and are printed out on a printer. In addition the most recent alarm is displayed on the bottom of the graphic screen which is being displayed currently on another monitor.

Redundancy is employed within the control system and the operator interface to assure availability of control and monitoring under all conditions. The PLC has redundant processors with automatic changeover in case of a failure. There are three identical sets of operator interface hardware and software to provide redundancy and also to allow the operator to view more than one screen at a time. The PLC and the operator interface equipment are powered from an interruptible power system which is backed up by a diesel generator set; therefore, both short term and long term power outages can occur without affecting the availability of the control and monitoring system.

Alarms and events are logged onto hard disks within the computerized control system. Events consist of all discrete process changes such as a valve opening or a motor turning off. Various historical reports based on logged alarms and events can be selected by the operator and printed out on one of the redundant printers.

The control console section at the operator's left contains a closed circuit television (CCTV) monitor and its associated controls, and a radiation monitor. The CCTV monitor, via multiple cameras in the LCT/Mixer Module, provides the operator with visual information on the internal status of the Module.

In addition to the CCTV and the radiation monitoring equipment, this console section contains a set of emergency controls. The emergency controls are selector switches and indicators which allow the operator to control those valves and motors which are essential to flushing grout from the system and for shutting it down in an orderly fashion. This provides additional assurance beyond the redundant control system that the process can be prevented from stopping with grout remaining in pipelines or equipment for any significant period of time. Thus under all failure situations the TGE system can be cleared of grout to prevent equipment damage.

At the operator's right, space is allocated for an additional control console section for controlling and monitoring the filling of vaults with radioactive grout produced by the TGE.

ELECTRICAL EQUIPMENT MODULE

This unit is also a customized modular building. Located in this 12 foot by 28 foot "single wide" are various electrical components including the motor control center, variable speed drive controllers, the uninterruptible power supply, the automatic transfer switch for bringing the stand-by generator on-line, control voltage step-down transformers and the power distribution panel. A self-contained HVAC system is included to remove heat loads imposed by this concentration of electrical equipment. Raised access flooring permits interconnecting wiring to be run beneath the floor.

ELECTRICAL SUBSTATION AND STAND BY GENERATOR

These two modules are straightforward equipment skids routinely supplied for outdoor service. In this application the 1000 KVA substation transformer takes a 13.8 KV primary feed and provides 480/277 volt power feed to the balance of the system. In case of loss of primary power the standby generator set, rated at 650 KW continuous standby duty is available to provide 480/277 volt power.

REFERENCES

1. D. G. HUIZENGA, W. T. FARRIS, R. L. TREAT, A. H. MAKIN, "Sensitibity Analysis of the Long Term Performance of the Grout System for the Disposal of a Low Level Radioactive Waste Stream at Hanford", Proceedings, Waste Management '86, Tucson, Arizona.

2. R. A. KALDOR, E. W. MCDANIEL, R. L. TREAT, "Immobilization of Selected Low-Level Hanford Wastes in Grout", Proceedings, Waste Management '85, Tucson, Arizona.

3. S. A. WIEGMAN, R. D. WOJTASEK, H. E. MCGUIRE, S. L. STEIN, "The Hanford Waste Management Plan", Proceedings, Waste Management '85, Tucson, Arizona.