FINAL DESIGN AND START-UP OF THE TRANSPORTABLE GROUT EQUIPMENT FACILITY AT HANFORD

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ABSTRACT

The U. S. Department of Energy and its Hanford operations contractors have designated certain low-level radioactive liquid wastes to be immobilized by means of a grouting process. The process is now being implemented on a production basis under the management of the Westinghouse Hanford Company (WHC). Associated Technologies, Incorporated (ATI) has completed the design, fabrication, and installation of the Transportable Grout Equipment (TGE) Facility, the waste processing unit of the overall storage, treatment and disposal system. SGN of France under contract to ATI assisted with remote maintenance design considerations and field start-up support.

The TGE Facility provides for the remotely-operated mixing of the selected liquid wastes with the dry grout solids and delivery of the resulting slurry to the disposal vaults where solidification occurs. TGE includes the processing module and all necessary control and supporting systems for safe, self-contained operation.

All processing and support modules have been fabricated, delivered, and installed. The objective of transportability was demonstrated through the actual highway shipment of the assembled modules to Hanford from their various points of origin. Completion of field interconnections permitted the commencement of the Acceptance Test Program (ATP) in the fourth quarter of 1987. This paper discusses salient features of the final design and start-up experiences.

INTRODUCTION

The Hanford Grout Disposal Program is being implemented by the U. S. Department of Energy and its Hanford Site operations contractor, Westinghouse Hanford Company (WHC). Low-level liquid radioactive wastes will be incorporated in a cementitious grout matrix and permanently disposed in near-surface concrete vaults. Candidate waste streams include the low-level fraction of radioactive liquid wastes presently stored in underground double-shell tanks, phosphate and sulfate wastes from reactor containment decontamination and spent fuel pool filtration operations, and other low-level wastes from operations at the Hanford Site. Environmentally-safe disposal of these grouted wastes is an important element of the overall site waste management plan.

Westinghouse Hanford Company is managing the completion of the grout facilities and will ultimately operate the systems. Technical support for grout formulations and performance evaluations have been provided by the Oak Ridge National Laboratory and the Pacific Northwest Laboratory.

The individual facilities located at Hanford's 200-East Area which will comprise the complete grouting system include:

Facility	Function
Dry Materials Receiving & Handling Facility (DMRHF)	Bulk Storage & Blend-materials.
Double-shell Tank (one million gallon capacity)	Staging of liquid waste feed.
Transportable Grout Equipment (TGE) Facility	Production of grouted slurry and delivery to disposal facility.
Near-surface disposal Vault(s)	Permanent repository solidified waste.

The DMRHF, waste feed tank including feed line to the TGE, and the first vault are complete. The TGE Facility completed construction in November, 1987 and is presently undergoing its Acceptance Testing Program (ATP).

Associated Technologies, Incorporated (ATI) was selected to provide the Transportable Grout Equipment (TGE) Facility on a turn-key basis in accordance with the conceptual guidelines and performance requirements established by the U. S. Department of Energy and its Hanford contractors. SGN of France was contracted by ATI for consultation in design, particularly in the area of remote maintainability, and start-up assistance.

TGE FINAL DESIGN

At the project's outset, the basic processing requirements were prescribed based on the laboratory development of the grouting process and limited quarter-scale demonstration of mechanical components. Conceptually, the equipment to perform the process was to be self-sufficient and capable of being transported in modules suitable for movement over public roads. Finally, these processing and support functions were to be performed in accordance with Hanford's standards for safety and minimized radiation exposure.

Other major design criteria impacting the final design included:

1. Design life objective of ten (10) years (50,000 hours of operation;
2. Use of standard catalogue components to the extent feasible;
3. Remote disassembly/reassembly capability in the radioactive process module;
4. System initiation and monitoring by a single operator;
5. Self-monitoring capabilities to permit unmanned stand-by between campaigns;
6. Redundancy in control and equipment where a single-mode failure could prevent safe shutdown, permit an uncontrolled release of radioactivity, or prevent recovery from a processing upset;
7. Decontamination of all process lines and internal and external equipment and containment surfaces;
8. Containment/collection of liquid leaks or inadvertent spills and airborne particulate (radioactive and non-radioactive) to meet permissible environmental release standards; and
9. All necessary HVAC and other environmental control measures to accommodate Hanford's climatic conditions.

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.

The design effort resulted in the construction of eight (8) modules, exclusive of an operator Change Room/Lunch Room trailer being provided by WHC. In addition to the TGE modules a module whose purpose is to monitor the grout slurry as it is deposited and cured in the disposal results has been designed and integrated with the TGE controls. These modules provide for the remote waste mixing and pumping and all necessary process support and control. They are arranged to permit access for inspection and maintenance, including remote maintenance activities in the radioactive processing unit. Interfaces are limited to primary electrical power, raw and sanitary water supplies, sanitary sewer, and waste feed and grout discharge lines.

The concept of transportable modules permitted a substantial amount of fabrication, component assembly, and some initial testing to be performed prior to site delivery. The individual modules include a range of construction from relatively conventional outdoor service equipment skids and customized trailers to specialty, process-specific fabrications. They include:

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

Each unit and its approximate arrangement on the site are shown in Fig. 1.

By contrast the foundations for the modules 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 LCT/Mixer Module. Inter-connecting piping and wiring are run in pipe chases and conduit which are concrete-encased. These features 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.

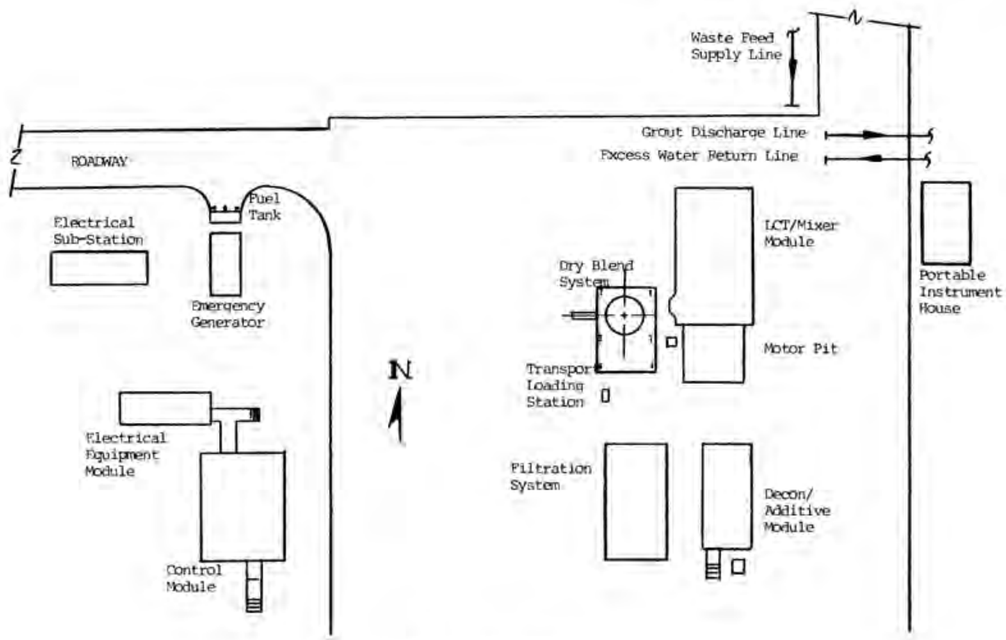

Fig. 1. Site Plan.

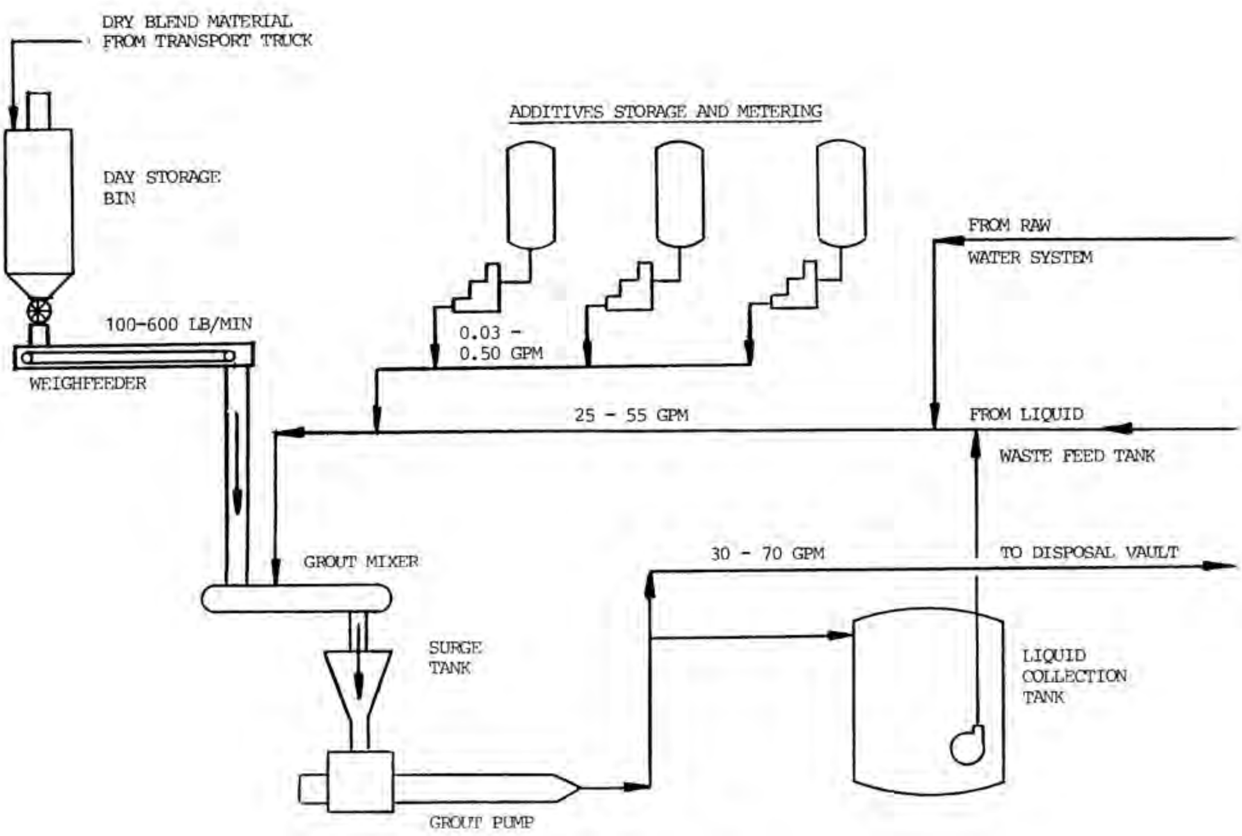

Fig. 2. Flow Diagram.

Both the grouting process and basic TGE component design have been described in earlier works (Refs. 1, 2, 3). The following discussion reviews each module and its process or support function along with key design features. Refinements and additions developed as the system neared completion are highlighted. The basic process is shown in Fig. 2.

Dry Blend System

The dry grout-forming solids, consisting primarily of Portland Cement (ASTM C 150, Type II, Type III) and Fly Ash (ASTM C 618) plus additives, are prepared at the DMRHF and loaded into bulk transport trailers for delivery to the TGE's Dry Blend System. This module, (see Fig. 3), is a shop-fabricated, field-bolted, steel structure which includes the pneumatic conveyor to off-load the dry blended grout delivery trucks and transport the dry grout to the day storage bin, the storage bin complete with a system for circulating dried air and bin vent filter, the weigh feeder and the discharge system to the grout mixer. A baghouse filter which receives air exhausted from the surge tank at the grout 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.

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.

The day storage bin provides 1700 cu. ft. of interim storage and is designed for mass flow to prevent classification, ratholing, and bridging. Dry blended material is discharged from the day storage bin through a vibrating bin bottom and a variable speed rotary valve onto the weigh feeder. The weigh feeder measures the gravimetric flow rate and provides the input signal which controls the speed of a 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. The vibrating screen diverts any tramp material and discharges the screened dry blend 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 to 600 pounds per minute. This rate is the key process parameter from which feed rates of waste and any liquid additives are proportioned in accordance with the selected grout formulation.

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 and associated pumps and piping, three for process additives, one for decontamination solutions, and one for caustic solution used to adjust the pH of liquid received in the Liquid Collection Tank. Table I lists these tanks and their capacities. Raw water for producing non-radioactive grout and system flushing is provided by way of the decontamination solution feed line. The compressed air system with redundant compressors and associated equipment is also 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.

The Decon and Additive Module was *completely* shop-fabricated, assembled, and transported to the site for installation on a concrete pad foundation. Its structural steel framework is sided and roofed over. An integral floor sloped to drain provides spill containment 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 Motor Pit and on to the LCT/Mixer Module.

Liquid Collection Tank/Mixer Module

This specially-designed unit houses the radioactive process functions of the TGE facility. The module was completely shop-fabricated and assembled. Prior to shipment many of the remote maintainability features were demonstrated. The fully-assembled module was transported by truck across country with no damage and only minimal readjustments required at the site, (see Fig. 4).

TABLE I

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

Fig. 3. The Assembled Dry Blend System.

Fig. 4. The LCT/Mixer Module In-Transit to Hanford.

Fig. 5. Setting the LCT/Mixer Module (Right-Partially Assembled Dry Blend System).

One day was required to unload the unit, set it on its prepared foundation and shim it to its design elevation.

The unit is located in a below-grade concrete pit which will be routinely covered with removable interlocking shielding blocks, (see Fig. 5.). 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. Within the LCT/Mixer Module containment are located the driven components of the grout mixer and grout pump, the surge hopper, the liquid collection tank (LCT), valve and instrument skids, and interconnecting piping and electrical conduit. 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 provide visual inspection and observation capabilities. A high-intensity lighting system illuminates the module interior for the CCTV's.

External to the module at its south end is the Motor Pit. Originally planned to house and provide maintenance access to the drive motors and transmissions for the grout mixer and pump, the Pit is also the location for a sophisticated Sampling Cabinet. The sampler, a remotely-cycled, fully-shielded Isolok unit by Bristol Engineering, is positioned in a recirculation loop for the LCT. The unit is completely maintainable by means of a Sargent Industries double-breech can assembly for contamination control.

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, (see fig. 6.). (Liquid process additives are metered into the waste stream just prior to its entry into the mixer.) The mixed grout slurry is deposited in a surge tank which provides a constant supply of material for the grout pump. 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.

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 Sample Cabinet in the motor pit. 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 tank by way of the waste feed line.

The components of the LCT/Mixer Module can be disassembled for maintenance and re-assembled using a remotely-operated impact wrench suspended from the hook of standard 25-ton motor crane. Interconnecting piping and electrical assemblies called "jumpers" utilize PUREX connectors specially designed for this

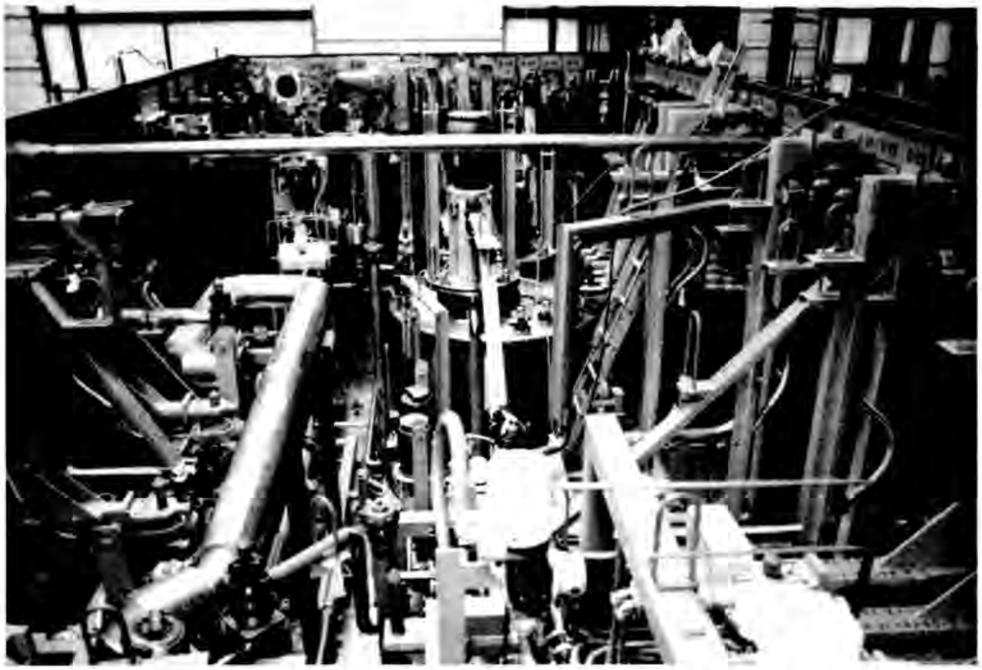

Fig. 6. A View of the Compact Interior of the LCT/Mixer Module.

methodology. Components or groups of components are mounted on structural frameworks equipped with lifting bails and balanced to permit only minimal orientation changes when lifted to facilitate removal and re-installation. 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 and for the dry blend feed chute jumper which serves as a remotely removable, pressure-tight connection between the ten-inch diameter dry material feed pipe and the 10-inch-by-13-inch rectangular mixer inlet.

A late addition to the design is the construction of an accessible pipe chase interconnecting the LCT/Mixer Module and the Motor Pit. Originally, the interconnecting lines were to be run underground and encased in concrete. The pipe chase will allow repeat access for pipe inspections and maintenance, installation of additional lines, when and if required, and has facilitated additional time for design and construction of the Sample Cabinet with minimal impact on other work.

Filtration Module

The Filtration Module is a specially designed equipment skid, shop-fabricated and assembled for rapid field installation. Once transported to the site and set on its prepared foundation, the unit was pressure tested for any leaks, then heat traced and insulated as appropriate. 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 system includes redundant 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.

Electrical Substation, Electrical Equipment Module, and Stand-by Generator

The primary and back-up electrical power service are provided by these three units. The substation and generator consist of skid-mounted components set on their respective concrete slab-on-grade foundations. Components are weatherized or otherwise protected for outdoor services. The Electrical

Equipment Module is a customized, trailer-mounted modular building, complete with a self-contained HVAC system. It houses control equipment in support of the process (motor control centers and variable speed controllers), as well as power supply components.

The 1000 KVA Substation transformer takes 13.8 KV primary feed and provides 480/277 volt power to the Electrical Equipment Module where the main power distribution panel and further control voltage step-down transformers are located. In the event of a primary power loss an uninterruptable power supply automatically picks up powering the

Facility's vital functions while the Stand-by Generator start-up cycle is initiated. The generator is capable of powering the Facility during a safe,orderly shutdown sequence and maintaining the Facility in stand-by condition until primary power is restored.

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 TGE control philosophy is to provide an optimum balance of automatic control and operator initiated control. Selection of sequences is an operator function. Fixed sequences of operation such as alignment of valves and proper sequencing of motors for start-up are automated in the control system. All the process control is performed by the 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. 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. In addition the CRT's 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, (see figs. 7 and 8).

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. Three identical sets of operator interface hardware and software provide redundancy and allow the operator to view more than one screen at a time during normal operations. The PLC and the operator interface equipment are powered from the uninterruptible power system which is backed up by the 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 consists 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. Alarms are also 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. Between campaigns when the system is unmanned, all safety alarm systems are integrated with the site Computer Automated Surveillance System (CASS).

The control console itself consists of five sections arranged in a "U" shape. The principal controls and CRT's are located directly in front of a seated operator. The control console section at the operator's left contains a closed circuit television (CCTV) monitor, 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. This section also contains a set of emergency controls 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 halted and cleared of grout to prevent equipment damage.)

At the operator's right is the interface control for the Portable Instrument House(s) (PIH), which monitors grout filling conditions at the disposal vault. PIH controls and interlocks have been fully integrated with the TGE for enhanced process control and safety.

Portable Instrument House

To monitor the disposal vault filling cycle, a trailer-mounted monitoring station, the Portable Instrument House, has been designed and built. Its programmable controller/computer designed with redundancy and uninterruptible power is similar to that provided for the TGE but has no closed-loop controls. The functions of up to three of these units have been fully integrated into the TGE control design, requiring the additional console section for additional hardware and necessary software additions. The first unit has been delivered and is being functionally tested along with the TGE components.

The PIH instrumentation is cabled to the TGE control console and to CASS. Parameters being monitored, alarmed, and/or logged during the vault filling cycle are grout level, grout temperature, water leakage to the leachate collection sump and pump pit, excess water return flow to the LCT, and radiation levels from the area, continuous air, and vault exhaust monitors. Two radiation-hardened closed-circuit television cameras are supplied to inspect the geo-textile vault liner for flaws or leaks prior to filling and to determine grout surface conditions as filling operations proceed.

Fig. 7. View of Control Console (LH Section) During Installation.

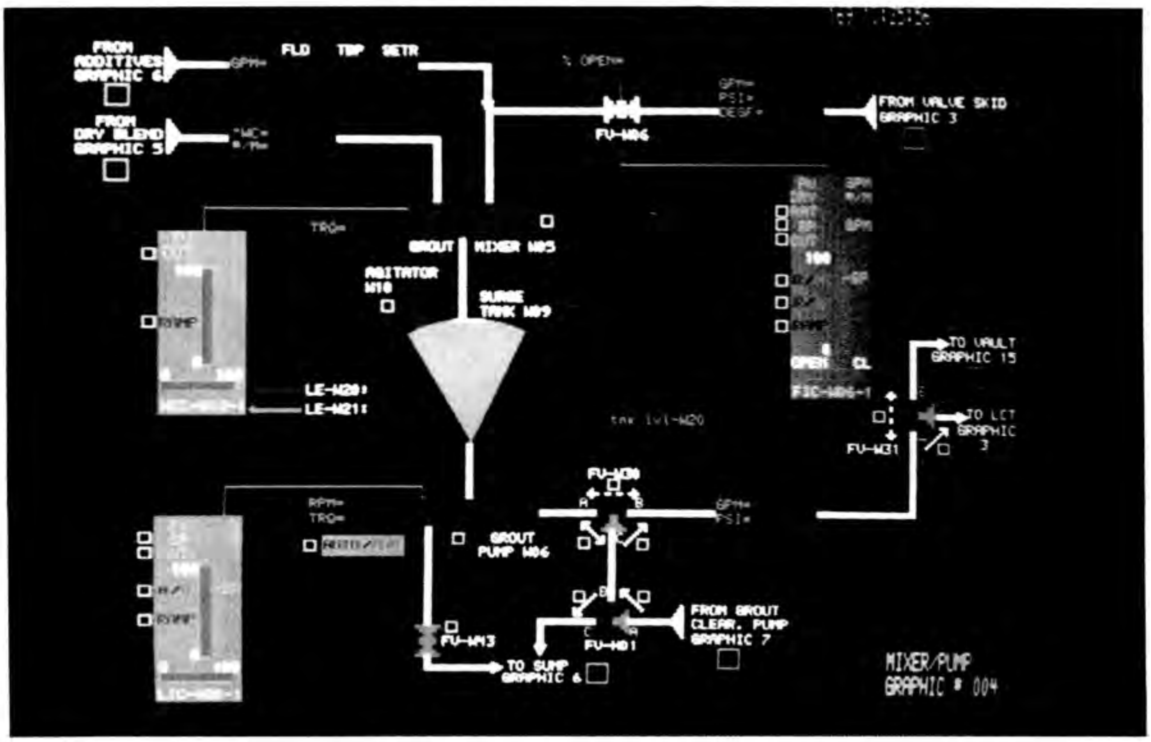

Fig. 8. Example of One of Many Process Graphics.

The PIH has its own power supply sources in the permanent underground electrical duct system. All control, instrumentation and power connections are made by quick-disconnect fitted portable cables from the field to the trailer. A communication cable link is provided in the underground duct system for PIH/TGE connection at any trailer location.

At the conclusion of activities at one vault the PIH will be moved to its next designated location. Only the vault temperature probes and level sensing elements remain in place.

ACCEPTANCE TEST PROGRAM

Site construction began with Phase I excavation and concrete work in January, 1987. Phase II including steel erection, module installation, and interconnecting piping and electrical work proceeded through the third and into the fourth quarter. The design change incorporating the accessible pipe chase impacted construction somewhat. Nevertheless, TGE construction was substantially complete by November 30, 1987.

Even before the completion of construction, ATI and Westinghouse initiated the Acceptance Test Program (ATP). To facilitate expenditious performance of this program, the ATP was also divided into two phases. Phase I, the Pre-Acceptance Test checkout was successfully completed on January 6, 1988 and is discussed here.

Phase I verified the proper installation and operability of all process system components. Components and instruments were calibrated and tested for repeatability over their full operational ranges. Installation of the control system permitted the cross-checking of operational functions and instrument readings with console indicators and graphic displays. For example, actual physical conditions such as valve positioning, pump operation, and tank levels were verified to be accurately represented at the controls.

A number of events which might typically be routine for facilities of permanent construction demonstrated the successful execution of the modular construction concept. For the first time the driven components of the grout mixer and grout pump in the LCT/Mixer Module were coupled to their respective drive units located outside the module on the opposite side of a thirty-three (33) inch shield wall in the Motor Pit. Jack shafts running through sleeves in the concrete wall and the Module containment wall connect the drivers and driven members. The units were successfully run, demonstrating that demanding tolerances could be achieved with transportable equipment. Likewise, the LCT/Mixer Module and the Filtration Module were sealed and pressurized to demonstrate their leak-tight capabilities.

Other essential functions demonstrated and verified were the operation of the PLC-controlled variable speed/positive displacement metering pumps for process additives, the high pressure grout line clearing pump, and operation of the remote CCTV systems. Also, a loss-of-primary-power situation was simulated and the coordinated transfer first to the uninterruptible power supply followed by the automatic transfer to the diesel generator back up was verified. The accomplishment of these and a multitude of less notable detailed checks prepared the system for actual integrated performance testing.

CONCLUSION

Phase II of the ATP requires complete demonstration and verification of all control logic and the ability to produce grout with raw water. The initial grout production took place on January 25, 1988. The completion of the ATP is in progress at this writing. Final test program results and operational experiences will be reported in future works.

The Grout Disposal Program will be the first production operation for the permanent disposal of Hanford's defense double shell tank wastes. The completion of the TGE Facility will enable the Department of Energy and WHC to implement a major piece of the Hanford Waste Management Plan.

DISCLAIMER

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