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Design of the Demonstration Bulk Vitrification System for the Supplemental Treatment of Low Activity Tank Waste at Hanford - 8310

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ABSTRACT

In June 2004, the Demonstration Bulk Vitrification System (DBVS) was initiated with the intent to design, construct, and operate a full-scale bulk vitrification pilot-plant to treat low-activity tank waste from Hanford Tank 241-S-109. The DBVS facility uses In-Container Vitrification™ (ICV™)[1] at the core of the treatment process. The basic process steps combine liquid low-activity waste (LAW) and glassformers; dry the mixture; and then vitrify the mixture in a batch feed-while-melt process in a refractory lined steel container. Off-gases are processed through a state-of-the-art air pollution control system including sintered-metal filtration, thermal oxidation, acid gas scrubbing, and high-efficiency particulate air (HEPA) and high-efficiency gas adsorber (HEGA) filtration.

Testing has focused on development and validation of the waste dryer, ICV, and sintered-metal filters (SMFs) equipment, operations enhancements, and glass formulation. With a parallel testing and design process, testing has allowed improvements to the DBVS equipment configuration and operating methodology, since its original inception. Design improvements include optimization of refractory panels in the ICV, simplifying glassformer addition equipment, increasing the number of waste feed chutes to the ICV, and adding capability for remote clean-out of piping,

In addition, the U.S. Department of Energy (DOE) has provided an independent review of the entire DBVS process. While the review did not find any fatal flaws, some technical issues were identified that required a re-evaluation of the DBVS design and subsequent changes to the design.

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[1] In-Container Vitrification and ICV are trademarks of AMEC, Inc.

A 100 percent design package for the pilot plant will be completed and submitted to DOE for review in early 2008 that incorporates process improvements substantiated through testing and reviews. This paper provides a description of the bulk vitrification process and a discussion of major equipment design changes that have occurred based on full-scale testing over the past two years and DOE reviews.

INTRODUCTION

The Hanford Site, located in southeastern Washington State, has been a United States Government installation since 1943. The Site has served, national needs, first as part of the Manhattan Project and later in the Cold War era. Today, the DOE is responsible for the site, and its mission is environmental cleanup. Within DOE, the Office of River Protection is charged with retrieving radioactive waste from the Hanford tanks and treating it for its eventual disposal.

CH2M HILL Hanford Group, Inc. (CH2M HILL) is the Office of River Protection's prime contractor and is responsible for storing and retrieving more than 200 million liters (53 million gallon.) of highly radioactive and hazardous waste. This waste resulted from nuclear fuel reprocessing and is currently stored at 18 tank farm locations in 177 underground tanks.

Current plans call for the tank waste to be retrieved from the aging tanks and partitioned to separate the highly radioactive constituents from the large volumes of chemical waste. These highly radioactive components will be vitrified into glass logs in the Waste Treatment Plant (WTP), temporarily stored on the Hanford Site, and ultimately disposed of as high-level waste in the offsite national repository. The less radioactive chemical waste, referred to as LAW, is also planned to be vitrified and then disposed of in approved onsite trenches.

In 1989, the Washington State Department of Ecology (Ecology), the U.S. Environmental Protection Agency (EPA), and DOE entered into an agreement (HFFACO 1996, known as the Tri-Party Agreement [TPA])[1] to ensure that federal regulations concerning Hanford Site cleanup were followed.

To help ensure milestones are met, the Supplemental Treatment Project was undertaken. The project, managed by CH2M HILL, involves the testing, evaluation, design, and deployment of supplemental LAW treatment and immobilization technologies. Applying one or more supplemental treatment technologies to the LAW has several advantages, including providing additional processing capacity, reducing the planned loading on the WTP, and reducing the need for double-shell tank space for interim storage of LAW. As an outcome of the supplemental Treatment Project, the bulk vitrification process was recommended for further evaluation.

The bulk vitrification process is based on AMEC Earth and Environmental, Inc.'s ICV process and involves batch melting in a disposable, refractory-lined, steel container [2]. It is a robust, relatively simple treatment technology that results in a glass product with excellent durability, high-waste loading, and significant waste volume reduction. This technology has been used commercially by AMEC in the United States and internationally. The container size and configuration of the process varies depending on project requirements.

As a next step, the DBVS facility was initiated in FY 2004 to design, procure, assemble, and operate a full-scale bulk vitrification pilot-plant to treat up to 757 m^3 (200,000 gallons) of low activity tank waste from Hanford Tank 241-S-109 under a *Permit for Dangerous and or Mixed Waste Research, Development, and Demonstration* (Ecology 2004) [3]. The project will provide a full-scale bulk vitrification demonstration facility that can be used to assess the effectiveness of the bulk vitrification process under actual operating conditions. The demonstration pilot-plant is scheduled to commence construction in 2009.

PROJECT STRUCTURE AND OBJECTIVES

The DBVS facility will result in the production of up to 50 full-scale containers of immobilized tank waste to further research and develop systems, designs, and operating philosophies envisioned for the production bulk vitrification system and to confirm the effectiveness of the bulk vitrification process in treating a wider range of tank wastes.

During operations of the DBVS facility, a number of operational and equipment parameters will be varied to evaluate the response of the bulk vitrification process on the treatment of actual LAW from Tank 241-S-109. In addition, responses to variations in the feed composition will be evaluated to confirm the effectiveness of the bulk vitrification process for treating a wide range of low-activity tank wastes at the Hanford Site.

Glass waste form qualification work combined with a wide range of tests and analyses to help assess the effectiveness of the bulk vitrification process will be carried out over the life of the project. Key objectives of the DBVS facility include:

- Support the joint decision between DOE, Ecology, and EPA regarding Supplemental Technology;
- Determine impacts of waste treatment operations on the equipment and support systems;
- Gain valuable waste form qualification data to support full-scale production operations;
- Validate equipment size, throughput, and technical viability;
- Evaluate the effectiveness of new process equipment;
- Gain operational and maintenance experience with equipment;
- Validate system technical viability and size; and
- Validate system throughput capabilities and refine life-cycle cost estimates.

PROCESS DESCRIPTION

The DBVS facility is comprised of a number of subsystems including:

- Liquid Waste Receipt System,
- Dry Material Handling System,

- Waste Dryer System,
- Dried Waste Handling System,
- In-Container Vitrification System,
- Main Off-Gas Treatment System, and
- Secondary Waste System.

A simplified process flow diagram for the DBVS facility is shown in Fig. 1. In summary, waste is received from Tank 241-S-109 and analyzed to ensure it is within the composition parameters for which DBVS is designed. Low activity, sodium bearing liquid waste is metered into a waste dryer where it is mixed with glassforming materials (see Dry Material Handling System section) and the water is removed. Dried material is transferred from the dryer to the ICV box where power is applied through electrodes to vitrify the material. Dried material is added in semi-continuous mechanical augers (i.e., the augers deliver a quantity of material as needed by the process). The vitrification process is started at the bottom of the ICV box and progresses upwards as material is added. Once filled, a top-off soil layer is added to provide in-place shielding and to meet void space requirements. The filled ICV box is stored at the DBVS facility before permanent disposal at the Hanford Site. Off-gases from the process are treated at the DBVS facility, while secondary liquid waste is collected and sent to the Hanford Effluent Treatment Facility.

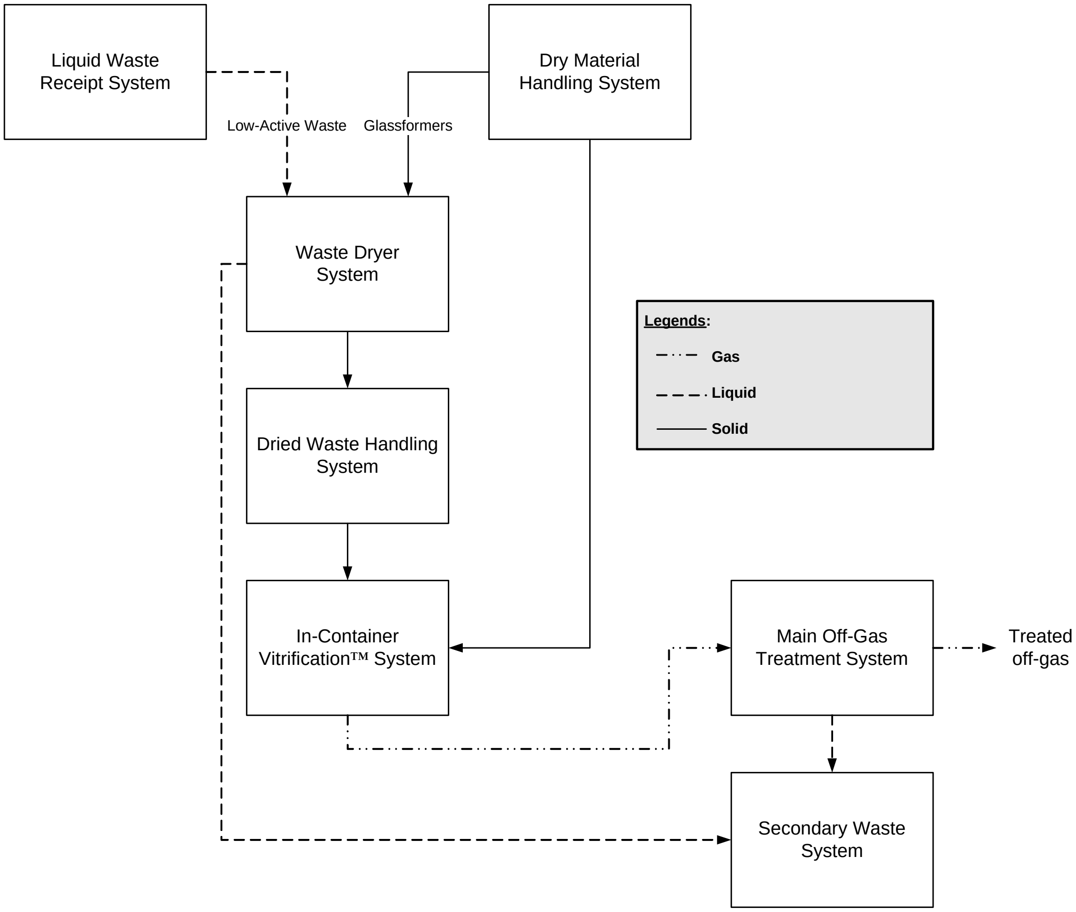

Fig. 1. Process Flow Diagram for the Demonstration Bulk Vitrification System.

Liquid Waste Receipt System

For the DBVS facility, the solid waste in Tank 241-S-109 will be retrieved by CH2M HILL by adding water to dissolve salts and pumping out the resulting 5 molar sodium. The liquid stream will be conditioned to remove solids to avoid sending insoluble transuranics with the LAW stream. The liquid waste will be pumped to the DBVS facility and received in one of three waste receipt tanks. Liquid waste from Tank 241-S-109 is routed through the DBVS Waste Transfer Pump Skid where it is sampled before being stored in one of the three waste receipt tanks. If analysis of the sample indicates the liquid waste is outside the DBVS processing envelope, the liquid waste is pumped from the receipt tank by the Waste Transfer Pump Skid back to the 241-SY-Tank Farm.

The Liquid Waste Receipt System consists of a waste transfer pump skid and three liquid waste staging tanks. The primary functions of the Waste Receipt System are to receive, sample, and transport waste to the Waste Dryer System. The Waste Receipt System will receive batches of waste from the Hanford tank farm and route it to one of three liquid waste staging tanks for storage until it is needed for processing. The waste transfer pump skid draws waste from a liquid waste staging tank and transfers it to the dryer in a recirculation loop where a portion is fed into the dryer in a semi-continuous manner. Waste not fed into the dryer normally returns to the liquid waste staging tank of origin.

The continuous feed method does not use differential between flow meters to determine the amount added to the dryer. Total waste volume added is totalized using the flow measured at the outlet of the dryer feeding pumps, which are different from those in the waste transfer pump skid. This method of using a continuous liquid feed into the dryer was first evaluated in small-scale dryer testing and then verified in the Integrated Dryer and Melt Test (IDMT) [4]. The waste transfer pump skid provides a flowmeter, which in conjunction with a dryer flowmeter, will be used to determine a gross total waste volume added to the dryer as a confirmation method. Total waste volume added to the dryer is also determined by the change in waste staging tank liquid level. A sampler on the recirculation loop collects samples to characterize the waste for process material balances.

Other system functions include containment of waste to prevent waste from leaking into the environment. The waste transfer pump skid and the liquid waste staging tanks have leak detection in secondary containment sumps to ensure the timely detection and removal of leaked waste.

Dry Material Handling System

The Dry Material Handling System serves two functions in the process: (1) delivers glassformers to the Waste Dryer System for mixing with liquid waste and (2) delivers top-off soil for addition to the ICV box at completion of the melting process. The glassformers are added as a premixed blend of hematite, rutile, kyanite, olivine, wollastonite, boron oxide, zircon, and cellulose. In the original DBVS design [5], the glassformers consisted of Hanford soil, boron oxide, and zircon; however, testing (at laboratory, engineering, and full-scale) demonstrated that a premixed blend of raw chemicals, with cellulose, resulted in better ICV processing characteristics and final product characteristics [4, 6]. This design change had some minor impacts to the DBVS process including the removal of glassformer storage tanks located above the dryer and a change from lose-phase to dense-phase pneumatic handling.

Delivery of the glassformer mixture is accomplished using a dense-phase, positive pressure pneumatic transfer system. The glassformer mixture is received at the DBVS facility in bulk bags (target size is for batches between 900 and 1,400 kg) that will be handled using a commercial bulk bag unloader station. When required by the Waste Dryer System, measured quantities of the glassformer mixture is pneumatically transferred to a filter/receiver unit located above the Waste Dryer System. Glassformers are then gravity fed from the receiver unit through an airlock assembly into the dryer. The purpose of the airlock assembly is to maintain isolation of the dryer from the Dry Material Handling System, thus eliminating contamination of a clean system.

Once an ICV box is filled with vitrified waste, a layer of clean top-off soil is added. This layer provides two benefits: (1) provides shielding to workers who must disconnect the ICV box from the process lines and (2) minimizes void space before long-term burial. Top-off soil is added from a Blower Truck that pneumatically transports soil to two locations: (1) three filter/receiver units located in the Melt Area Enclosure and (2) The filter/receiver unit located above the waste dryer. Each of the filter/receiver units in the Melt Area Enclosure will monitor the weight of top-off soil and gravity feed the material into the ICV box through an airlock assembly (three feed points are used to ensure distribution of material in the ICV box). Soil is added through the waste dryer to "flush" out the contents of the dryer and to take advantage of the two Dried Waste Transfer Feed chutes to increase top-off soil coverage in the ICV box. The soil is local Hanford soil consisting primarily of silica and alumina with an average moisture content of approximately 5%.

Waste Dryer System

The Waste Dryer System is a major component of the DBVS facility. The primary function of the waste dryer is to provide a blended and dried feed product suitable for vitrification. The dryer will receive glassformers, recycle dust from the off-gas SMF, and feed waste from the liquid waste staging tanks. Material is mixed and dried to meet pre-established dryness criteria. Once the dryness criterion is met, a portion of the dried waste is discharge to the Dried Waste Handling System for transport to the ICV box. Vapor removed during the drying process is condensed and transferred to the Secondary Waste System. Noncondensable species are directed to the Main Off-Gas Treatment System. Dryer support systems, such as steam supply and chilled water, are also included as part of this system.

Heat and vacuum are used to dewater the liquid feed and glassformer mixture. Heat is applied to the dryer wall via a steam jacket. The dryer mixes its contents with rotating plows under a vacuum of approximately 660 mm mercury (26-in); at this pressure the evaporation temperature is 60 ºC (140 ºF). During IDMT [4], the observed temperature in the dryer was relatively constant as liquid waste was continuously fed into the dryer and did not increase until liquid was no longer being added. The vacuum facilitates the dewatering process by promoting evaporation at lower temperature, and withdrawing the vapor from the dryer headspace. As the vapor is produced in the dryer it is pulled through a SMF to remove particulates before the vapor reaches the condenser unit. The particulates captured in the filter are returned to the dryer drum via back-pulsing the filters with compressed air. Condensables are captured through cooling the exiting gases in the condenser unit. The remaining exhaust is directed to the Main Off-Gas Treatment System.

The original waste drying operation was a batch process, in which eight full dryer-loads were required for each ICV box and were transferred into the ICV box once a full-dryer load batch was complete. The revised operating strategy for operation of the waste dryer is to process a full dryer load batch and transfer the entire batch to the ICV box to initiate the vitrification process. The dryer is then loaded with glassformer material and liquid waste is added until a target composition and final moisture content are reached. Once these targets are achieved, a portion of the dryer content is transferred to the Dried Waste Transfer System by breaking the vacuum in the dryer and opening a valve located on the bottom of the dryer near the center. The arrangement of the plows in the dryer is such that the waste is mixed by directing it from the ends of the dryer toward the center. Once the discharge is complete, the valve is closed and vacuum re-established. Glassformer material is added to the mixture that remains in the dryer and the process is repeated. This approach allows better control of the overall processing of an ICV box by providing greater flexibility of how often material is made available for feeding into the ICV box and not creating a situation where a downstream process is waiting on a feed stream [7].

Moisture levels in the dryer are typically maintained at less than 6-wt% water during processing as determined by material balance with internal waste temperature as a primary indicator. Moisture content is tracked (as a basis to add additional increments of feed) from the mass balance based on the weight of additives and a load cell on the dryer confirms condensate evaporated. Dryer temperature provides a secondary means of confirming moisture content. As the soil and feed dries, and the evaporative duty goes down, the dryer temperature will begin to rise.

The dryer can act as a storage vessel until the Dried Waste Handling System can transfer the dried waste to the ICV box. Typically, the strategy is to discharge waste when it reaches the target dryness level and volume and as the vitrification process requires.

Dried Waste Handling System

The Dried Waste Handling System transports the dried waste mixture from the waste dryer to the ICV box for processing. Dried waste is gravity fed from the waste dryer, through a discharge valve located on the dryer, to the Dried Waste Handling System hopper located beneath the dryer. Based on full-scale testing results, the interface from the dryer to the Dried Waste Handling System hopper is a straight chute instead of the original design that used a rotary valve to meter material to the hopper [7]. The straight chute eliminates potential accumulation/plugging points between the dryer and hopper. The hopper is sized to provide some lag storage capacity that allows the dryer to discharge a fraction of its contents, and then continue processing new material, when the ICV box is not ready to receive dried waste.

The Dried Waste Handling System hopper feeds two parallel auger trains; each train is comprised of a vertical auger and a horizontal auger. To prevent material bridging in the hopper, and distribute material evenly to each auger train, the hopper is equipped with an agitator located near the bottom of the hopper. Each horizontal auger discharges at a point located in the Melt Area Enclosure such that dried waste is gravity fed to the ICV box through chutes. Each of the chutes is comprised of an airlock assembly and straight sections; the purpose of the airlock assembly is to provide isolation of the ICV box when needed.

The dried waste is discharged from the dryer by opening the dryer discharge valve located directly beneath the dryer. The waste feed from the dryer is controlled by the discharge rate of the discharge rotary airlock. The dryer discharge valve remains open during the entire discharging sequence. This does not cause discharge chute plugging because the dryer plow action directs the waste to the opening, but does not force the waste into the opening.

As the discharge chute rotary valve rotates, the waste is discharged into a hopper. The waste is transported to the dry waste receivers through a rotary auger. The dried waste falls by gravity into the ICV box via the dome valve airlock assemblies. Use of two dry waste receivers and two entry points into the ICV box provide additional distribution.

The Dried Waste Handling System was a pneumatic-based system in the design package that was completed in 2006 [6]. Comments received on the design questioned whether there was sufficient information known about the material produced by the waste dryer to design a pneumatic transfer system. In addition, concerns were expressed about erosion in the piping and the ability to recover from loss of power (i.e., dried waste that dropped out in piping during loss of power might not be recovered upon restart of the system). A Value Engineering session was held and recommended that a mechanical-based auger system be further evaluated; the recommendation based on technical information that showed a mechanical system would be less sensitive to variability in material properties [8]. During IDMT [4], a non-prototypic mechanical auger system was successfully used to transfer material from the waste dryer to the ICV Box. The system tested at IDMT [4] did not have any lag storage capacity beyond what was normally held in the augers. This limited when material could be added to the ICV Box because it required that material be ready in the waste dryer. For the revised DWHS design, the hopper beneath the waste dryer has been increased to provide lag storage that will assist in management of the ICV Box cold cap. Note that such lag storage did not exist in the pneumatic-based system (it was designed to transfer material from the dryer to the ICV Box with no material hold up).

In-Container Vitrification System

The ICV System is designed to receive a waste and soil mixture, contain the bulk vitrification process, and serve as the final disposal container for the product. This system will provide primary confinement for dried waste being received from the dryer, the molten glass during processing, and then the final waste product.

The melt container is prepared in the box preparation building by lining the container with layers of sand and castable refractory panels. . Earlier full-scale testing demonstrated shortcomings in the refractory design. Significant changes were made and validated in subsequent testing including the removal of insulating boards, less sand, thinner castable refractory panels, addition of metal catch sumps, lap joints between panels, and mortar between panel joints.

When the lining is in place, a mixture of graphite flake and glass cullet (50/50 by volume) is positioned in the bottom of the container. The mixture provides the initial pathway for the electrical current to flow between electrodes. Next, the hood (lid) and two electrodes are installed on the container such that the two electrodes are in contact with the mixture of graphite flake and glass cullet at the bottom of the container. The hood includes a series of flanged openings along its top for the subsequent addition of dried waste mixture through two ports, clean soil addition through three ports, and Main Off-Gas Treatment System exhaust connection.

The prepared box is then moved with an air pallet system into position at the melt station. Connections are made for electrical power and instrumentation. An enclosure referred to as the auxiliary waste transfer enclosure (AWTE) is lowered in place and secured to the top of the hood. The AWTE provides confinement when connecting and disconnecting the off-gas piping and waste feed addition ports.

Connections from feed hoppers for the dried waste mixture and clean soil are made to the flanged connections on the top of the hood within the AWTE. Cameras are moved into position, one at both ends of the ICV box, and the ICV box is grounded to the structural steel. One dryer batch of dried waste is added to the box before starting the melt. The melting process is initiated using the starter material at the bottom of the ICV container and the application of power through the electrodes. Power levels are increased gradually during startup, with the joule-heating process requiring high voltage because of the resistance of the starter material. As material is heated and melts, the resistance decreases and high current (low voltage) is required to achieve the desired power level. Indication of the melt's progress is provided by the installed thermocouples, ratio of voltage to current (indication of resistance) and power level (determined by the product of voltage and current). Startup will follow a power ramp-up schedule to a target nominal operating level. Both the startup schedule and target nominal operating level are anticipated to be test specific parameters defined by individual test campaign plans.

Once the melt is initiated, waste is fed in at appropriate increments. With the design changes to the Dried Waste Handling System and the operational changes with the dryer, there is significant improvement in the control of waste feed to the ICV box. This allows for better cold-cap management, which has a direct impact on process and glass characteristics. One of the objectives of recent testing was to demonstrate this cold-cap management technique [4].

When all of the waste material in the container has been melted, electrical power to the melt is shutoff and the melt begins to cool and solidify within the container. Clean soil is then conveyed into the container through clean soil feed ports within the AWTE to fill the void in the container and to provide radiological shielding at the top of the container. Feed ports are then disconnected within the AWTE, the flanged connections on the top of the hood are closed, and the AWTE is retracted.

The container is then moved with the air pallet from the melt station to the box storage area for cooling, eventual sampling, and storage.

A completed ICV box contains approximately 44 metric tons of vitrified product, which includes 63 metric tons liquid waste, 37 metric tons of glassformers and cellulose, and 2 metric tons of a clean glass layer. The ICV box is topped off with 5 metric tons of soil.

Design changes to the ICV box are based on recent testing. The addition of cellulose to the glassformers has changed the characteristics of the process, resulting in a much more combustible feed and higher off-gas flow rates. A valve on the inlet air addition to the box has been added to help control vacuum in the ICV box when off-gas generation fluctuates.

The glassformer compositional changes also impacted the ability of the dryer to produce palletized dried waste feed. At times the waste feed from the dryer consisted mostly of powdery material. This resulted in a significant amount of particulate entrainment. The original design of the OGTS exhaust ducting used a small diameter (5-in.) duct to maximize off-gas velocity. The assumption being that the higher velocity would keep particulate entrained in the off-gas until it reached the downstream filters. The increased amount of particulate carryover resulted in plugging of this small diameter duct. The off-gas ducting has been redesigned to provide a velocity that will minimize the potential for particulate carryover for very fine light dust.

Main Off-Gas Treatment System

The purpose of the Main Off-Gas Treatment System is to filter, scrub, and chemically treat the ICV process off-gas, dryer exhaust, and storage tank vent streams before the exhaust air fans discharge them through a monitored exhaust stack to atmosphere. The off-gas flowrate exiting the ICV ranges from 1,000 to 1,600 m^3/hr (600-950 acfm) at a nominal temperature of 121°C (250°F). The system is designed for a particulate loading of 3.2 kg/hr and an oxide of nitrogen concentration ranging from 15,000 to 80,000 ppmv. Organic and acid gas concentrations are minimal, typically less than 50 ppmv while cesium-137 and strontium-90 account for the highest radionuclide concentration exiting the ICV at 3.97E-2 and 6.14E-3 Ci/hr.

Gas discharge from the ICV box is first conditioned by two stages of SMFs to remove particulate that may be entrained in the gas stream. Both stages are rated for 99.97 percent removal efficiency for 0.3 μm particulate. The first stage is comprised of two filters in parallel; this allows for one filter to be taken out of service when discharging collected solids back into the ICV box, while the other continues to condition gases. The collected solids return to the ICV box through a gravity feed to the Dried Waste Handling System horizontal auger discharge. The original design only had two SMFs in series. The design change was made to address two concerns identified from design reviews and full-scale testing: (1) original concept to return solids to the process via pneumatic transport to the waste dryer had unresolved technical issues and (2) collection of solids in the Main Off-Gas Treatment System piping during full-scale testing required redesign of the interconnecting piping from the ICV box to the SMF units [4, 9]. The second stage SMF is a single unit that is not expected to see significant quantities of solids or to be exposed to large particles. As a result, the transfer of any collected solids back to the waste dryer is expected to pose limited technical risk; this will be verified as part of startup testing for the DBVS facility.

The filtered off-gas stream from the SMFs is fed into a nitrogen oxide thermal oxidizer where a reducing atmosphere is used to reduce nitrogen oxide compounds to elemental nitrogen. The function of the thermal oxidizer unit is to treat nitrogen oxide in a reduction chamber and to treat organics in a re-oxidation chamber. An intermediate cooling chamber reduces the temperature to prevent the reformation of nitrogen oxide in the re-oxidation chamber. The thermal oxidizer unit has been added to the DBVS design and replaces a Selective Catalytic Reduction (SCR) Unit [8]. This change addressed two areas of concern with the original design: (1) the SCR was located at the end of the Main Off-Gas Treatment System because of temperature limitations, required dilution air to reduce the concentration of nitrogen oxide compounds to acceptable concentrations, and required treatment to remove acid gases that would foul the catalyst and (2) organic destruction removal efficiency relied on the vitrification process and collection in the HEGA filter skid.

The inlet to the nitrogen oxide thermal oxidizer is the sum of the off-gas from the SMF and the dryer exhaust, which adds an additional 255 m^3/hr (150 acfm) to the off-gas flowrate. The nitrogen oxide thermal oxidizer has three separate zones; a reduction chamber, a cooling chamber, and an re-oxidation chamber. In the reduction chamber, propane is used to convert nitrogen oxide compounds to nitrogen by supplying a full, rich environment. The cooling chamber uses water recycled from the quencher and scrubber unit described below to cool the temperature of the gas before entering the re-oxidation chamber. Excess air is added to the re-oxidation chamber to complete the combustion of any residual organics. The air drawn from the vents of the liquid waste staging tanks, secondary waste tanks, and dryer enclosure is used to supply this re-oxidization air.

The treated off-gas stream from the thermal oxidizer is fed into a quencher and scrubber unit. A filtered, water-fed quencher unit reduces the temperature of the gas stream from the thermal oxidizer. The quencher is a venturi style and provides intimate contact with the liquid to ensure saturation. The discharge of the quencher unit is passed through a condenser to recover liquid that is fed back into the Quencher unit with a slip stream used for the thermal oxidizer cooling chamber. Using the condensate reduces the fresh water requirements for the two systems. Acid gas components are removed from the gas stream in a scrubber unit that uses a sodium hydroxide solution. Purge streams from the quencher and scrubber units are sent to the Secondary Waste System. The scrubbed off-gas stream is passed through a heater to reduce the relative humidity before entering the HEPA and HEGA filter skids. The quencher and scrubber unit represents a minor change to the original design, which contained a wet scrubber unit that also had a function to remove particulate [8]. With the elimination of this function, the new quencher and scrubber unit has a lower pressure drop that enables the use of smaller main exhaust fans in the redesigned Main Off-Gas Treatment System.

The heated off-gas is filtered through two HEPA filters (in series) in parallel HEPA banks and is then drawn through the HEGA filter skid, which consists of parallel carbon filter and polishing filter trains. The carbon filter bank is used to remove any residual radioactive iodine and organics from the off-gas stream. The purpose of the polishing filter bank is to capture any “break-up” of the carbon filter media and prevent it from being released out the stack to the atmosphere.

The HEPA and HEGA filter skids have redundancy, with the off-gas stream passing through one set of filters and adsorbers, while the second set of filters and adsorbers are on stand-by.

The treated off-gas from the HEGA filter skid is discharged through the exhaust stack by one of two parallel off-gas exhaust fans (one operating and the other on stand-by). Changes to the design of the Main Off-Gas Treatment System have allowed the size of the fan to be decreased from 300 kW to approximately 60 kW (400 hp to 75 hp). Before being discharged to the atmosphere, the Off-Gas Stack Monitoring System will sample the off-gas stream to measure the discharge flow, temperature, and nonradioactive contaminants present, such as particulate, nitrogen oxide, sulfur oxide, carbon monoxide, hydrogen chloride, chlorine, and total hydrocarbons being exhausted to the atmosphere. Analysis of the off-gas stream for radioactive contaminants is also performed at stack for iodine and particulate, beta and gamma radiation, and carbon-14. With the removal of the SCR unit from the design, the off-gas temperature entering the stack is much lower. This allows the use of standard monitoring equipment at the stack compared to the original design that required some sampling to occur before the SCR because of excessive temperature.

The Main Off-Gas Treatment System maintains the ICV box at a negative pressure relative to atmospheric. This is accomplished by providing sufficient flow capacity to handle a range of off-gas generation rates from the ICV box. In the event of an upset condition, either in the ICV box itself or an event in the Main Off-Gas Treatment System, which causes a reduction of flow through the ICV box (and subsequent loss of vacuum), the flow from the ICV box is switched from the Main Off-Gas Treatment System to the Off-Gas Bypass System.

The Off-Gas Bypass System operates one of a pair of bypass exhaust fans for the entire duration of the ICV box loading, processing, and cool down. Ambient air is drawn through an inlet HEPA filter to meet the minimum flow requirements of the bypass exhaust fans. The ambient air is heated to lower air stream humidity before entering the Off-Gas Bypass System inlet HEPA filtration unit to prevent condensation buildup and wetting the inlet and exhaust HEPA filters. The bypass is then routed from the HEPA filter directly to the stack.

Secondary Waste System

The Secondary Waste System provides for the storage of the secondary waste, liquid effluents, and the load-out of these effluents into trucks for transfer to an onsite treatment facility. The two effluent streams generated during normal operation are the dryer condensate and off-gas quencher and scrubber solution bleed. Two tanks for each effluent stream provide capacity to support operations and sampling activities.

Functional aspects of this system include:

- Liquid effluent receipt and interim storage;
- Fluid conveyance to the recycle system or effluent disposal tanker truck;
- Containment of leaks from the storage tanks or the pump skid and hose-in-hose-transfer lines; and
- Ancillary and support equipment for equipment installation, and operations and maintenance activities.

The secondary waste pump skid transfers the liquid effluent from the storage tanks to tanker trucks or recirculates waste through the selected storage tank.

PROJECT STATUS

The DBVS facility is currently nearing the submittal of CD-3. The design is scheduled to be completed in the Spring of 2008 with construction scheduled to start in 2009. Construction and commissioning of the facility will occur through 2010.

A series of tests with simulants will then follow to confirm that operator training is complete, operating procedures are validated, and the equipment is operating properly before conducting tests with actual LAW. The first radioactive test will involve approximately 3.8 m^3 (1,000 gallons) of actual LAW solution combined with approximately 45m^3 (12,000 gallons) of simulated non-radioactive waste solution.

ACKNOLEDGMENTS

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