2014-LTR-1014

Attachment 16

[Permit Attachment QQ]

Process Engineering Description for GasVit Building (to be changed to MWTH)

ATTACHMENT ~~6~~QQ

Process Engineering Description
For ~~GASVIT™~~MWTH Building

MIXED WASTE FACILITY
RCRA/TSCA PERMIT

PFNW-R
RICHLAND, WASHINGTON

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~~**Non-Confidential Version**~~

~~Text shown italics is business confidential information and has been omitted from the non-confidential version of this attachment.~~

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ACRONYM LIST

AC	Alternating current
ATS	Automatic-transfer switch
~~AWFCO~~	~~Automatic waste feed cut-off~~
BTU	British Thermal Unit
CAM	Continuous air monitoring
~~CBI~~	~~Confidential Business Information~~
cfm	Cubic feet per minute
~~CHW~~	~~Chilled water~~
DC	Direct current
DOE	Department of Energy
~~EOG~~	~~Emergency Off-Gas~~
E-Stop	Emergency stop
~~FSCP~~	~~Firefighter's Smoke Control Panel~~
fpm	Feet per minute
~~GASVIT™~~	~~Gasification/vitrification~~
gpm	Gallons per minute
HEPA	High-Efficiency Particulate Air
HP	Horse power
~~HX~~	~~Heat exchanger~~
~~Lbm~~	~~Pounds mass~~
LDR	Land Disposal Restrictions
LFL	Lower flammability limit
LLMW	Low-level mixed waste
HAZMAT	Hazardous materials
HEME	High-efficiency mist eliminator
MCC	Motor control center
MMI	Man-Machine Interface
MWIP	Mixed Waste Integration Program
PCW	Process cooling water
psi	Per square inch
~~PNNL~~	~~Pacific Northwest National Laboratory~~
PPE	Personal protective equipment
ppm	Parts per million
psig	Pressure per Square Inch Gauge
RCRA	Resource Conservation & Recovery
~~R.O.~~	~~Reverse osmosis~~
TSCA	Toxic Substances Control
~~PLC~~	~~Programmable logic~~
~~GVB~~	~~GASVIT™ Building~~
MPC	Main process control
PLC	Programmed logic controller
~~PID~~	~~Proportional-Integral-Derivative~~
P&ID	Piping and installation drawings
STB	Stabilization building
TCLP	Toxicity Characteristic
VFD	Variable frequency drive
WAP	Waste analysis plan
WC	Water column

1. OVERALL PROCESS DESCRIPTION

The evaporation process reduces the volume of the hazardous wastewaters and concentrate hazardous waste constituents (e.g. metals) and inorganic materials into residues for additional treatment at the MWF or to dispose off-site. This process will be located in the MWTH Building.

~~The gasification/vitrification (GASVIT™) process treats and stabilizes a wide variety of low-level mixed wastes (LLMW). Materials treated may contain both organic and inorganic matter without regard to their net heating value or their exothermic contribution to the treatment process. The process is designed to accomplish three main functions: 1) destroy toxic and non-toxic organics; 2) reduce the waste volume; and 3) vitrify the inert and radioactive residues from the destruction process. The GASVIT™ process product is a vitrified glass- or rock-like material, which is highly durable and leach resistant. The process by-product is a fuel gas, referred to as synthesis gas, or "syngas," that is converted to water and carbon dioxide, a stable form, before being discharged to the atmosphere.~~

1.1 PROCESS OVERVIEW

Evaporation process and ancilliary equipment will be installed in the MWTH Building to evaporate non-dangerous wastes and low-level mixed waste. The evaporation system (TP-16) will include the following operations:

- Inspection of incoming wastewaters in tanker trucks
- Unloading into one of the four storage tanks after the incoming wastewater passes the acceptability criteria outlined in the WAP (Att. CC)
- Pumping from storage tanks to evaporators
- Pumping residues from the evaporators into a sludge/residue storage tank. Periodically sludge which may settle in the storage tanks may also be fed to the evaporators.
- Pump residues from the sludge/residue storage tank into containers for further on-site treatment at the STB or disposed of off-site.
- Handling, treatment, and disposal of secondary waste generated from the evaporation process

~~The GASVIT™ system encompasses all of the subsystems needed to ensure safe and reliable operation of the process. The system will be installed in a building referred to as the GASVIT™ building. A listing of the subsystems included in the GASVIT™ building and key reference documents are presented in Table 1.1. A brief description of the subsystems is contained in Section 1.3.~~

~~The GASVIT™ process accomplishes two distinct operations simultaneously, gasification and vitrification. In the gasification operation, organics in the waste are gasified in the absence of oxygen (reducing environment) to produce a fuel gas called "syngas." In the vitrification operation, inert wastes (metals and minerals) are melted and incorporated into a leach-resistant vitrified product. Unlike a combustion process that produces heat, the gasification and vitrification process absorbs heat (an endothermic process) and thus requires an outside heat source.~~

~~In the GASVIT™ system, a plasma-arc is generated to provide the outside source of heat to process primarily organic wastes. In addition, the GASVIT™ primary chamber utilizes joule heating to maintain the temperature of the molten bath. The thermal energy from the plasma converts the organic waste into light organics and primary elements. Steam is introduced into the chamber allowing the gasification (or steam reforming) reaction to take place. In some input wastes there is sufficient water within the matrix so that additional steam is not required.~~

~~The combination of plasma and joule heating processes the waste materials into the gas and glass products. The molten glass product is withdrawn and cooled to form a monolith in the receiving canister. This product is stable and highly leach-resistant. Glass forming additives are periodically introduced into the process chamber to control glass chemistry.~~

~~The syngas by-product discharged from the process chamber is a mix of hydrogen, carbon monoxide, steam, acid gases, particulates, and low-temperature vaporized metals. This mixture is discharged from the process chamber at temperatures of approximately 1000°C (1800°F), although the reaction zone is much hotter. The syngas is then treated, cleaned and converted to the stable form of water and carbon dioxide in a flameless oxidizer.~~

~~A three stage process filters out nearly all of the syngas impurities prior to converting the purified gas into water and carbon dioxide. A first stage filter removes particulates larger than 1 micron using a high-temperature filter. A second stage scrubber, mist eliminator, and High-Efficiency Particulate Air (HEPA) filter removes acid gases (such as hydrochloric acid and hydrogen sulfide), low vapor pressure metals, and particulates in a primary set of HEPA filters. In the third stage, the scrubber gas is oxidized, converting the syngas to water and carbon dioxide. The thermal energy released during syngas oxidation is used to generate steam for plant use. The water and carbon dioxide is cooled in a quench tower and then filtered through a secondary bank of pre-filters, HEPA filters, and activated carbon filters. After carbon filtration, the gases are discharged through the building stack along with the building ventilation exhausts. Building stack radiation monitors measure critical parameters.~~

~~As a means of treating LLMW, the GASVIT™ system has several inherent health, safety, and environmental protection features. These are listed immediately below.~~

~~The endothermic GASVIT™ process eliminates the need for fossil fuel fired burners. These burners add considerable mass to the process gas stream in the form of combustion gases from supplemental fuel and air. By eliminating those gases, the GASVIT™ process reduces by-product gas volumes by 80 to 90 percent, allowing the use of smaller off-gas treatment equipment. A smaller off-gas system is not only less expensive, but is simpler to operate and maintain and is inherently safer since less gas resides in the system at any given time reducing the risks from postulated accidental release scenarios.~~

- ~~The GASVIT™ process produces a ceramic/glass-like product and a metal product that is stable and highly leach-resistant.~~
- ~~The highly reducing atmosphere within the process chamber, combined with a rapid water quench to below 200° Fahrenheit, minimizes the formation of polycyclic aromatic hydrocarbons.~~
- ~~The absence of oxygen in the by-product gas nearly eliminates the reformation of toxic chlorinated organics, such as dioxins and furans.~~
- ~~Halogen gases existing in the syngas stream remain in their hydrate acid form due to the reducing environment. This acid form is much easier to separate in the scrubber than the elemental gas form (e.g. hydrochloric acid instead of chlorine gas).~~
- ~~NO_x formation is negligible in the reducing process chamber atmosphere.~~
- ~~The high temperatures in the process chamber plenum ensure complete disintegration of hard-to-treat organics such as benzene, toluene and styrene rings.~~

1.2 ~~GASVIT™ CHEMISTRY~~MWTH Building Description

The MWTH Building is an enclosed structure with an approximate floor area of 13,500 square feet. The evaporation system will be located in Room MWT-01 within the MWTH Building. The floor is comprised of concrete with an eight (8) inch high concrete curb at the walls. The entire evaporations process equipment will be provided with its own secondary containment consisting of concrete floors and an eight (8) inch high curb.

~~The GASVIT™ system gasifies organic or carbon-based, waste constituents and vitrifies inorganic waste constituents. The chemistry of gasification has been used commercially since the 19th century to produce municipal power from coal.~~

~~The commercial use of vitrification is more recent, primarily driven by disposal requirements for hazardous and radioactive wastes. The chemistry of vitrification is closely related to the chemistry used to manufacture glasses, ceramics, and metals.~~

~~High-temperature chemistry guided the development of the waste acceptance criteria, the design and selection of equipment, and the development of operating procedures for the GASVIT™ system. Five general categories of reactions were considered in the development of the GASVIT™ system. These categories are:~~

- ~~gasification;~~
- ~~vitrification;~~
- ~~acid gas formation and removal from the synthesis gas stream;~~
- ~~toxic metal removal from the synthesis gas; and~~
- ~~syngas conversion.~~

~~1.2.1 Gasification Chemistry~~

~~The gasification of organic material is accomplished in a two-step process. First, the material is allowed to decompose to its elemental form, primarily carbon, in the presence of intense heat from the plasma torch. Second, carbon is allowed to react with water (steam) to produce carbon monoxide. By using bound oxygen in steam as the oxidant rather than air, the process chamber atmosphere remains highly reducing.~~

~~Hydrogen and carbon monoxide are the primary products of gasification and the primary components of the fuel gas leaving the chamber. These gases are formed by the following reaction:~~

$$\cancel{C + H_2O \rightarrow H_2 + CO}$$

~~If an excess of water, in the form of steam, is present, the reaction will proceed further to yield additional hydrogen and carbon dioxide.~~

$$\cancel{CO + H_2O \rightarrow CO_2 + H_2}$$

~~Other components of the syngas include steam, methane, acid gases, particulates and volatile and semi-volatile metals. Methane formation is governed by the following reaction:~~

$$\cancel{C + 2\,H_2 \rightarrow CH_4}$$

~~Other minor components of the syngas are produced from waste constituents. For example, hydrochloric acid is produced from waste constituents by way of typical reactions 1, 2, and 3 listed below:~~

~~**1. Hexachlorbenzene (C_6C_{16})**~~

~~C_6C_{16} + steam + heat → hydrogen + carbon monoxide + hydrochloric acid~~
~~$C_6C_{16} + 6\ H_2O \rightarrow 3\ H_2 + 6\ CO + 6\ HCl$~~

~~**2. Trichlorobenzene ($C_6H_3C_{13}$)**~~

~~Trichlorobenzene + steam + heat → hydrogen + carbon monoxide + hydrochloric acid~~
~~$C_6H_3C_{16} + 6\ H_2O \rightarrow 6\ H_2 + 6\ CO + 3\ HCl$~~

~~**3. Methylene chloride (CH_2Cl)**~~

~~Methylene chloride + steam + heat → hydrogen + carbon monoxide + hydrochloric acid~~
~~$CH_2Cl + H_2O$ + heat → $2H_2 + CO + HCl$~~

~~Methane is produced from diethyl phthalate according to reaction 4 as follows:~~

~~**4. Diethyl phthalate ($C_{12}H_{14}O_4$)**~~

~~Diethyl phthalate + steam + heat → carbon monoxide + methane~~
~~$C_{12}H_{14}O_4 + H_2O \rightarrow 7\ CO + 5\ CH_4$~~

~~When more water is added as steam, methane reacts to form hydrogen and carbon monoxide according to reaction 5 listed below.~~

~~**5. Methane (CH_4)**~~

~~Methane + steam + heat → hydrogen + carbon monoxide~~
~~$CH_4 + H_2O \rightarrow 3H_2 + CO$~~

~~Wood and paper, which are primarily cellulose, produce large volumes of the gaseous products hydrogen and carbon monoxide as shown in reaction 6 below.~~

~~**6. Cellulose ($C_6H_{10}O_5$)x**~~

~~Cellulose + steam + heat → hydrogen + carbon monoxide~~
~~$C_6H_{10}O_5 + H_2O \rightarrow 6H_2 + 6CO$~~

~~Within the process chamber, some compounds spontaneously decompose to carbon monoxide and water as shown in reaction 7 below.~~

~~**7. Methanol (CH3OH)**~~

~~Methanol → hydrogen + carbon monoxide~~
~~$CH_3OH \rightarrow 2\ H_2 + CO$~~

~~In all of the above reactions the process is controlled by the amount of heat and steam added to the process chamber. Control of these reactions is generally independent of the composition or the energy value of the feed material. Thus very little knowledge about the characteristics of the feed material is required for process control.~~

~~Another factor controlling the reaction is the heat supplied to complete the reaction. Although steam reforming reactions are known to start at temperatures as low as 480° Celsius (900° Fahrenheit), much higher temperatures (e.g. 1,100° Celsius or 2,000° Fahrenheit or higher) are needed to achieve a complete reaction of the hard-to-destroy compounds such as styrene, toluene and benzene.~~

~~1.2.2 Chemistry of Vitrification~~

~~Inorganic material such as metals and minerals can be introduced in virtually any form for molten processing in the GASVIT™ system. After entering the process chamber, metals and minerals partition between the ceramic/glass phase in the bottom of the process chamber and a small fraction exit the chamber with the syngas.~~

~~Materials that partition into the ceramic/glass phase are discussed below while the fraction of volatile metals leaving the chamber with the syngas are discussed in a later section.~~

~~Metals and minerals with high boiling points collect in the chamber bottom and a portion melts into the ceramic/glass phase, and a portion is removed as metal. Adding glass-forming additives controls the molten bath chemistry. Ceramic/glass phase diagrams and composition models are used to estimate the amount of glass forming necessary to assure product quality. Glass forming additives are utilized to increase the durability of glass product or bring the composition into the glass forming region.~~

~~Lime and silica are glass forming additives typically used for most waste streams expected to be processed. This mixture produces ceramic/glass phase that has a desirable viscosity and electrical conductivity throughout the operating temperature range. A ceramic/glass phase with the desired viscosity promotes homogeneity and improves the performance of the molten material tap. The electrical conductivity must be within certain boundaries to allow practical joule heating of the melt.~~

~~Depending on the oxidation state of the ceramic/glass phase, some metals may remain reduced and separate as a molten metal pool.~~

~~A typical reaction during vitrification is as follows:~~

$$\cancel{SiO2 + CaO \rightarrow CaSiO_3}$$

~~This reaction takes 3-4 minutes to complete. Glass formation from the silicates takes a much longer time, which depends on the operating temperature, glass composition and grain size of the inorganic materials.~~

~~1.2.3 Volatile Metals Formation and Removal Chemistry~~

~~Metals introduced with the feed material leave the GASVIT™ system in five products or by-product streams: 1) the vitrified product or tapped metal; 2) the solids collected from the high-temperature filter; 3) scrubber secondary liquid waste residues; 4) the primary HEPA filters; and 5) the HEPA/charcoal filters in the syngas processing subsystem. Because of multiple processing and clean up steps, the release of metals to the atmosphere is nearly eliminated. In which of the five products or by-products streams the volatile or semi-volatile metals partition, depends on the form and the vapor pressure of the metal or metal compound. The fate of the most abundant or significant forms of each of the 12 hazardous and 2 radioactive surrogate metals included in the Demonstration Test Plan is discussed below. A brief discussion of overall predicted toxic metal partitioning in the GASVIT™ system is presented below:~~

~~**Partitioning in Vitrified Product or Tapped Metal:** In the absence of large quantities of halogens, or other compounds with which metals could react in the process chamber, metals with boiling points~~

~~greater than the temperature of the bath (1,400°-1,650° Celsius [2,500°-3,000° Fahrenheit]), partition into the melt and exit the system in the vitrified product or tapped metal. In the presence of chloride, metals chlorides are formed in the process chamber. Of the various metal chlorides that could form in the process chamber, only two (silver and cerium) have boiling points greater than 1,400° Celsius (2,500° Fahrenheit) and will be present in the process chamber as solids that blend with the melt.~~

~~**Partitioning in Syngas:** Metals exiting the process chamber occur in at least two forms, free metals and reduced chloride salts. Just as thermodynamic considerations dictate that molecular hydrogen leaves the chamber, those same considerations dictate that metals chemically related to hydrogen leave the chamber in elemental or free form. Several of the elemental metals, or at least a fraction of their mass, exit the process chamber as vapors. These metals are arsenic, cadmium, mercury, thallium, stenium, and cesium. When halogens are present, some of the metals react with the halogens to form salts, such as silver chloride. The formation of the metal salts is analogous to the formation of hydrogen chloride from molecular hydrogen discussed earlier.~~

~~**Partitioning in First Stage Syngas Process Filter Residues:** Some of the metals and metal chlorides in the syngas are removed by the high-temperature filter of the first stage syngas processing system and discharged as solid residues. These residues are either stabilized or returned back to the process chamber for processing. Some of the metals and metal chlorides that exit the process chamber as vapors with the syngas are captured in the high-temperature filter after the syngas is cooled by steam to 760° Celsius (1,400° Fahrenheit). As the syngas cools, vaporous and metal compounds with boiling points greater than 760° Celsius condense onto particulates that are captured by the high-temperature filter. A partial list of the metal and metal chlorides that leave the process chamber as a vapor that have a boiling point greater than 760° Celsius are: cadmium, cadmium chloride, chromium chloride, lead chloride, and cesium chloride.~~

~~**Partitioning in Scrubber Secondary Waste Residues:** Acid gases and metals and other impurities removed by the secondary syngas processing system are collected in the secondary waste system. The scrubber secondary waste and residues from mist elimination are concentrated and stabilized to meet LDR requirements before being sent to a disposal site. Several metals and metal chlorides exit the high temperature filter as vapors. These metals and metal chlorides include the four metal elements: arsenic, mercury, thallium, cesium, and the six metal chlorides: antimony chloride, arsenic chloride, barium chloride, beryllium chloride, mercury chloride, and thallium chloride. With one exception, these metals and metal chlorides vapors condense in the scrubber water quench, which cools the syngas to 95° Celsius (200° Fahrenheit). The exception is barium chloride which remains as a vapor and boils at 36° Celsius (98° Fahrenheit). As some of the metals and metal chlorides cool down and condense in the scrubber, they form a fine particulate. The scrubber system is designed to remove a majority of these particulates. However, a small amount of particulates could escape with the syngas exiting the scrubber and are expected to be captured by the high efficiency mist eliminator and HEPA filter banks (see below).~~

~~**Partitioning in Primary HEPA Filters:** Metals and metal chlorides in particulate form and barium chloride, which remains as a vapor due to low boiling temperature of at 36° Celsius (98° Fahrenheit), escaping the scrubber and HEME will be retained by a primary HEPA filter bank mounted at the discharge from HEME.~~

~~**Partitioning in Final HEPA Filters:** Although the final HEPA filters are not a part of the GASVIT™ process line, they provide additional safeguards for ensuring that the release of any toxic metals to the atmosphere is nearly eliminated. To this end, any metal vapor (e.g., the gaseous barium chloride) or particulate that may escape the primary HEPA filters discussed above will reach the syngas converter/boiler and be converted into oxides which help and is captured by the final HEPA filter~~

~~units. Table 1.2 shows that with the exception of cesium, the boiling point for an oxide form of a metal is higher than the boiling point of a chloride form. Therefore, all of the metal oxides, including barium, are present as particulates after the converter/boiler exhaust is quenched. This implies that a metal or metal compound reaching the final HEPA filter will be in particulate form. These particulates are removed by the building confinement HEPA and carbon filters just prior to the stack.~~

~~**Treated Spent HEPA Filters:** Some of the spent final HEPA filters will be returned to the process chamber for processing. In this case, all but four of the metal oxides accumulated on the filter and returned to the process chamber with the spent HEPA filter partition primarily into the melt. Only four of the metal oxides (arsenic, mercury, thallium, and cesium) have a boiling point less than the melt temperature range. The boiling point of the oxide of cadmium (1,560° Celsius [2,840° Fahrenheit]) is less than the high end of the melt temperature range (1,650° Celsius [3,000°F]).~~

~~The above consideration of the boiling points of the most abundant forms of the metals in the syngas explain why the bulk of the metals are removed from the gas stream prior to the stack. Metals, however, are frequently present in the syngas in other forms as well, some of which are volatile at room temperatures. A small fraction of metals present in these volatile forms do pass out the stack with the exhaust gas. Potentially, a very small fraction of the volatile metal (mercury) and the semi-volatiles (antimony, cadmium, lead and compounds derivatives of arsenic) could pass through the multi-stage syngas processing system and exit with the stack gases. The demonstration test plan will determine the significance of the emissions of these volatile metals and metal derivatives.~~

~~Major radioactive nuclides of concern in one of the waste streams, Hanford site, designated for processing by the GASVIT™ system are: ^{3}H, ^{14}C, ^{129}I, ^{239}Pu, ^{238}U, ^{235}U, ^{137}Cs, ^{106}Ru, ^{99}Tc, and ^{90}Sr. Actual testing and pilot studies have been performed by the Pacific Northwest National Laboratory (PNNL) and vitrification system suppliers on surrogates that are substituted for radioactive metals. In addition, actual testing with radioactive species was conducted by PNNL to determine the fate of the radioactive species upon processing in a direct current (DC) arc plasma processing system. A list of the nuclides and the designated surrogate materials and their similar radioactive counterparts are presented below. The selection of the radionuclide surrogates is based on information from the Department of Energy (DOE) Mixed Waste Integration Program (see DOE/MWIP-15, prepared for the U.S. Department of Energy by Martin Marietta Energy Systems, Inc., Oak Ridge, TN, January 1994).~~

~~Surrogates:~~	~~Cs, Ru, Sr~~	~~for~~	~~^{137}Cs, ^{103}Ru, ^{90}Sr~~
	~~Ru~~	~~for~~	~~^{99}Tc~~
	~~Ce~~	~~for~~	~~^{239}Pu, ^{238}U, ^{235}U~~
	~~Co~~	~~for~~	~~^{60}Co~~
	~~I~~	~~for~~	~~^{129}I~~

~~The pilot tests demonstrated that Ce, the surrogate for ^{239}Pu, ^{238}U, and ^{235}U, is captured in the glass phase of the melt. Cs (the surrogate for ^{137}Cs, ^{103}Ru, and ^{90}Sr) was captured in the scrubber water and was removed with the evaporator bottoms. These results agree with the descriptions of the chemistry of the two metals presented earlier in this section.~~

~~1.2.4 Acid Gas Formation and Removal Chemistry~~

~~Acids may be present in the original waste or may be formed from chemicals present in the feed material, especially halogens such as chlorine. Three of the most common forms of acid forming precursor elements are described below.~~

~~**Halogens:** The gasification reactions depicted above demonstrated how hydrochloric acid is formed from halogenated hydrocarbons. In all reactions where halogenated material is processed, halogens~~

~~preferentially react with the hydrogen to form hydrated acids. The most common halogen in the feed material, chlorine, gives rise to hydrochloric acid. Hydrochloric acid is stable at processing temperatures, and the abundance of hydrogen in the process gas promotes the formation of hydrochloric acid. Chlorinated organic compounds are rarely detected in the syngas, and when detected are present only at very low concentrations. Virtually all of the chlorine reacts with hydrogen to form hydrochloric acid. Halogen acids are relatively easy to neutralize in a wet scrubber, with solutions of lime or sodium hydroxide forming stable salts. Wet scrubbers achieve common removal efficiencies of 98-99 percent. In the GASVIT™ system, halogens are separated in the scrubbers by the addition of caustic solution according to the following typical reaction:~~

$$HCl + NaOH \rightarrow NaCl + H_2O$$

~~**Nitrogen:** Due to lack of free oxygen in the process chamber and the highly reducing environment, the nitrogen purge gas used in the GASVIT™ system will not form NO_x and hence, no nitric acid (HNO_3) will be formed in the process chamber. The most common scenario for forming nitric acid in the GASVIT process is an air leak. If sufficient air is leaked into the process chamber, the chamber will be converted from reducing to oxidizing environment and it is likely that oxides of nitrogen will be formed. The nitric oxides or acid generated by small air leaks is quickly destroyed. The abundance of hydrogen and carbon monoxide in the gas phase virtually ensures that nitric acid, as an oxidizer, will react quickly. Even various oxides of nitrogen (NO_x), are quickly reduced to elemental nitrogen by the carbon, hydrogen and carbon monoxide. The GASVIT™ process chamber includes several features that minimize the introduction of air into the chamber.~~

~~**Sulfur:** When sulfur is present in feed material, it follows three possible paths: 1) reaction in the process chamber with hydrogen to form hydrogen sulfide; 2) absorption in glass in the process chamber; and 3) entertainment as a particulate in the syngas and filtering out in the high temperature filter. It is unlikely that sulfur will react with oxygen to form oxides of sulfur (SO_x) since it must compete with hydrogen, carbon, and carbon monoxide in the syngas. Hydrogen sulfide exiting the process chamber with syngas is removed from the gas stream in the scrubbers according to the following reaction:~~

$$H_2S + 2NaOH \rightarrow Na_2S + 2H_2O$$

~~**1.2.5 Syngas Conversion Chemistry**~~

~~The syngas from the GASVIT™ process is a fuel gas very similar to the "water gas" derived from reacting hot coal with steam. The syngas is expected to have a British Thermal Unit (Btu) content varying from 300 to 400 Btu per standard cubic foot. The Btu content is primarily contributed by hydrogen and carbon monoxide. In the GASVIT™ system the syngas is converted to the stable form of water and carbon dioxide. The energy generated during the conversion process is used to produce steam for plant use.~~

~~Conversion reactions are as follows:~~

$$2H_2 + O_2 \rightarrow 2H_2O$$
$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$
$$2CO + O_2 \rightarrow 2CO_2$$

1.3 ~~Overall System Description~~Waste Staging & Storage

Incoming tanker trucks of hazardous wastewaters will be staged for inspection at the tanker truck unloading station equipped with a sampling platform or ports. If the incoming load passes inspection and

fingerprint analysis as per the WAP, it will be unloaded into one or more storage tanks (T-101 through T-104). The feed pipe to each storage tank extends from the tank roof to close to the side-wall bottom to prevent splashing during loading and, hence, reducing working loss emissions from the tanks. Each storage tank will be rotationally-molded, cone-bottom, high density cross-liniked polyethelene one piece seamless construction with a design capacity of 10,950 gallons. Containerized inorganic liquids from WSB can also be loaded into the storage tanks using the unloading pump for tanker trucks.
~~The GASVIT™ system encompasses all of the subsystems needed to ensure safe and reliable operation of the process. The system will be installed in a building referred to as the GASVIT™ building. A listing of the major subsystems and the related documentation is included in Table 1.1, located in the back of this attachment. A brief description of the various subsystems is presented below.~~

~~**Feed Preparation Subsystem (GV-01):** This subsystem receives waste containers from outside of the GASVIT™ building and prepares them for feeding into the GASVIT™ process chamber. Operations conducted by this system are receipt, inspection, unloading, sorting, size reduction, interim storage, and bagging/canisterization. The inspection operations conducted in this subsystem are subject to the permit requirements pursuant to the Waste Analysis Plan (WAP).~~

~~**Feed Subsystem (GV-02):** The feed subsystem introduces feedstock and additives into the process chamber at a predetermined feed rate. The following four different types of feeder are used: 1) a feed tank/pump assembly is used to feed liquid/sludge wastes; 2) a continuous screw feeder equipped with an airlock hopper assembly is used to introduce solids; 3) a redundant set of batch feeder mechanisms are used to feed pre-packaged waste canisters; and 4) glass former additives are metered into the continuous solids feeder by a gravimetric feeder which introduces the material into the process chamber.~~

~~**Process Chamber Subsystem (GV-03):** The process chamber subsystem is the heart of the GASVIT™ system, where feed materials are processed producing synthesis gas, a ceramic/glass product, and metal. Two sources of energy are utilized to process the feed: the DC arc plasma zone, and the alternating current (AC) joule-heated zone. The DC arc plasma is created by applying a DC potential across the three 6 inch diameter graphite arcing electrodes with a single electrode at one polarity and the other two electrodes at the opposite polarity. A stable plasma arc is then formed between the molten bath and arcing electrodes. The second source of energy to the process chamber is supplied directly to the molten glass by way of three 6 inch diameter graphite joule-heating electrodes submerged in the melt. A three-phase AC potential is placed across the joule-heating electrodes which results in current flow through the glass. The molten glass acts as a resistor such that power is supplied directly to the molten glass. Organic constituents which are subjected to the DC plasma arc and joule heating are pyrolized and steam reformed producing CO, H_2, HCl, and H_2S. Inorganic constituents decompose oxides and dissolve into the glass phase~~

~~**Product Handling Subsystem (GV-04):** The GASVIT™ system product handling subsystem consists of a bottom freeze valve and an overflow drain valve attached to the process chamber. These two discharge points are used to remove molten product out of the chamber. The molten product is poured into disposal containers and allowed to cool to a solid form. The solid form is sent to a burial site for final disposal.~~

~~**Syngas Processing (GV-05, GV-06, and GV-07):** The syngas processing subsystem employs three process stages to remove metal vapor and acid gas impurities in the syngas and convert the purified syngas to a stable form (i.e., water and carbon dioxide). The first processing stage is a high-temperature filter. This filter takes out solid particulates leaving the process chamber. The second stage consists of a scrubbing train, a mist eliminator, and primary HEPA filter banks. This train removes acid gases, metal vapors, and particulate and discharges the gas into the third stage syngas processing subsystem. The third stage converts the syngas into a stable form of water and carbon dioxide and filters any remaining~~

~~particulate. The third stage consists of a syngas converter and a final HEPA/charcoal filter train. The exhaust for the third stage is released to the atmosphere.~~

~~**Syngas Sampling Subsystem (GV-08):** This subsystem extracts a continuous stream of syngas which is analyzed for CO and CO_2. Signals from the continuous sampler are used to control the rate of steam addition (at a stoichiometric ratio) with respect to feed rate of organic material.~~

~~**GASVIT™ Process Vent Subsystem (GV-09):** Fugitive emissions are controlled by the GASVIT™ process vent subsystem. The subsystem collects gases from vent lines on various process hoods and enclosures where there is a potential for generating fugitive emissions. The vent gases are first filtered, if necessary, to remove dust and particulates. After initial filtration, the vent gases are sent to a carbon filter bank to remove any organic vapor constituents. The exhaust from the carbon filters are sent to the building ventilation ducts.~~

~~**Main Process Control Subsystem (GV-10):** This subsystem ensures compliance with the Resource Conservation and Recovery Act (RCRA)/Toxic Substances Control Act (TSCA) operating limits imposed on feed rate control and automatic waste feed cut-off (AWFCO) requirements. Centralized computer controls and the programmed logic controller (PLC) along with local instruments are provided to implement the controls.~~

~~**Secondary Waste Treatment Subsystem (GV-11):** Scrubber secondary waste is collected in a tank and processed through an evaporator unit. The distillate from the evaporator is recycled back to the scrubber for reuse. The concentrates from the evaporator are filled into a drum and sent to the stabilization building where it is stabilized and sent to burial sites for disposal.~~

~~**Caustic Addition (GV-12):** This subsystem includes a bulk storage tank which receives concentrated bulk caustic from incoming tank truck or bulk containers. Bulk caustic is pumped to a day tank where it is diluted and fed to the scrubber units.~~

~~**Utility Subsystems:** The GASVIT™ system employs several utility subsystems to provide ancillary service for proper operation of the system. Utility subsystems include: service/instrument air (GV-13); nitrogen supply (GV-15); process water supply (GV-16); reverse osmosis water supply (GV-17); steam (GV-18); process cooling water (GV-19); and chilled water (GV-20). These subsystems have a set of monitors and alarms that measure various parameters regarding the availability and condition of utility services and supply. These monitors and alarms are annunciated in the main process control panel for operator action.~~

~~**Confinement Subsystem (GV-22):** The GASVIT™ building ventilation subsystem, referred to as the "building confinement subsystem," maintains a negative pressure inside the GASVIT™ building (GVB) while providing approximately 7-10 air changes per hour. The GASVIT™ system exhaust is discharged into this system. Before release to the atmosphere, the building exhaust is passed through a set of pre-filters, HEPA filters and charcoal filter banks.~~

~~**Electrical Power Distribution (GV-23):** Power distribution includes transformers, motor control centers, emergency generators, and an uninterruptible power supply for smaller critical load which cannot be off-line for the 10 second generator start time (i.e., MPC/PLC and control room).~~

~~**Main Process Control Panel (GV-24):** The GASVIT™ system uses a centralized main process control (MPC) subsystem encompassing computers, programmable logic controllers (PLCs), Proportional-Integral-Derivative (PID) controllers and other devices to monitor, control and alarm system parameters relative to operating limits specified in the permit.~~

~~**Building Exhaust Monitors (GV-25):** The confinement system exhausts to outside the GVB and is equipped with radiation monitors and flow meters.~~

~~**Building Containment Subsystem (GV-26):** Secondary containment is included in the GVB to collect any potential liquids spilled during the handling and processing of material in the GVB. The secondary containment is described in other sections of the permit application.~~

~~**Area Monitors (GV-28):** Radiation air sampling stations are provided at strategic locations in the GVB.~~

1.4 ~~GASVIT™~~ System ~~Permit Operating Limits~~Description Summary

The MWTH Building will incorporate all systems, subsystems, and ancilliary equipment needed for safe and reliable operaion of the evaporation process designated as Treatment Line 500. A brief description of equipment, system, and subsystems included for this treatment line is described below:

Treatment Line 500: This treatment line will use the evaporation system (TP-16). Equipment for the evaporation system consists of unloading pumps, basket filters, four storage tanks, evaporation feed pumps, two evaporators, residue pump to transfer residue/sludge to the residue/sludge storage tank, one residue/sludge holding tank, and ancilliary equipment such as valves and piping. Evaporation exhaust will pass throu a duct heater, HEPA bank, and an activated carbon filter prior to exiting throught he main stack for the MWTH building. Utility systems for the evaporation system will include service/instrument air and natural gas supply.

~~The proposed GASVIT™ system permit operating limits are listed in Table D-5637 in Attachment 3 of this RCRA/TSCA application. This list is preliminary and is subject to change pending final approval of the demonstration test plan. The feed control and AWFCO logic are the overall safeguards of the GASVIT™ system for ensuring that the emissions from the process are controlled and that the system is automatically shutdown in the event that a critical process parameter is outside of the operating range specified in the permit.~~

~~**1.5 Methods For Ensuring Compliance With Permit Feed Control Requirements**~~
~~The GASVIT™ waste feed control is maintained using a computer/PLC to independently control the three waste feed systems. The feed rate controls are depicted in P&ID drawing number 31001-P-080-1. Generally, waste will be introduced to the GASVIT™ process chamber using either the liquid feeder, the two batch solid waste feeders (GV-02-CG-0230) or the continuous solids feeder (GV-02-F-0226). Key permit feed control operating limits established for each of the feeder lines are: 1) toxic metals concentration feed rates; 2) chlorine/chloride concentration feed rate; and 3) maximum total feed rate. GASVIT™ system controls on these feeders are executed by a combination of administrative protocol, process instrumentation, and computer data monitoring, recording and storage system, as described below.~~

~~**Establishing Chlorine/Chloride and Metals Concentration of Feed:** This feed preparation subsystem receives waste containers from outside of the GVB and prepares them for feeding into the GASVIT™ process chamber. Operations conducted by this system are receipt, inspection, unloading, sorting, size reduction, interim storage, and bagging/canisterization. The inspection operations conducted in this subsystem are administratively controlled to ensure that the chlorine/chloride and toxic metals concentration of the repackaged material are tied to the original waste containers received in the GVB. The subsystem labels the repackaged material with bar-code charts allowing tracking of the waste characteristics during the feed preparation and processing steps.~~

~~**Liquid Feed Control:** The feed rate of liquids must be in compliance with the permit limits on maximum feed rate, the maximum allowable chlorine/chloride feed rate, and the maximum allowable metals concentration in the feed. The chorine/chloride and toxic metals concentrations of the feed are obtained by either sampling and analysis of the feed tank or by using the known characteristics of the containers that were transferred to the feed tank. Once the weight of chlorine and metals concentration in the tanks are known, the feed rate is determined by dividing the total weight of the chlorine/chloride and each toxic metal content in the tank by the permitted feed rates. The lowest feed rate obtained from these calculations is used as the basis for setting the maximum feed rate of the material in the feed tank. The liquid feed rate is controlled by a flow meter (FIT-0214) and a control valve (FCV-0215). Once the desired liquid feed rate is determined, the operator sets the feed rate from the main process control panel. A control loop measures the flow rate as indicated by the flow meter (FIT-0214) and adjusts the opening of the control valve (FCV-0215).~~

~~**Continuous Solids Feed Control:** As indicated above, a set of permit operating limits are imposed on the maximum total feed rate and the maximum feed rate of chlorine/chloride and toxic metals constituents introduced into the process chamber by the continuous feeder. The chlorine/chloride and toxic metals concentrations are obtained by an inventory control method as follows: As the waste containers arrive in the GASVIT™ building feed preparation area, their identification numbers are used to retrieve their profile data from the main data base system. Alternatively, an onsite sampling and analysis may be performed to characterize a container. In either case, data from the incoming containers along with a bar-code system are used to identify the characteristics of a series of repackaged bags that are prepared after the required sorting and size reduction operations are completed. The bags are weighed, bar-coded, and placed in a surge storage area. When a continuous solid waste feed campaign is desired, a series of bags are removed from the storage and are placed on the feed conveyor (CV-0103). The conveyor has an indexing drive and the actuation of each indexing event is controlled by a timer. Using a scanner (BSC-0222), the identification of the bags is transmitted to the MPC computer. The computer calculates the process time for each bag. The process time is determined based on the bag characteristics data (transmitted to the computer through the scanner) and by taking into account the permit limits. When the control room operator actuates the feed start command, the feed conveyor moves an index point to drop the first bag(s) into the lock- hopper leading to the screw feeder. A position switch (ZS-0224) informs the computer that the bag has been received in the lock hopper. The signal from the position switch initiates a timer for the next bag feed event. While a batch type method (i.e., a combination of bag weight and feed cycle time) is used for ensuring compliance with the permitted feed rates, the continuous feeder, which is located under the lock hopper, introduces the waste into the process chamber at a continuous feed rate.~~

~~**Batch Feeder:** The GASVIT™ system has two batch feeders. In a normal batch feed campaign, both of the batch feeders are used in an alternating mode. The permit limitations imposed on the batch feeders are controlled similar to that of the continuous feeder. First, the chorine/chloride and toxic metals concentrations of the feed are obtained by an inventory control practice as described for the continuous feeder. As the waste containers arrive in the feed preparation area, their identification number is used to obtain profile data from the main data base system. Alternatively, an onsite sampling and analysis may be performed to characterize a container. In either case, characterization data from the incoming containers, along with a bar-code system, are used to identify characteristics of the repackaged batch feed canisters. The bar-coded canisters are weighed and placed in a surge storage area. When a batch feeding campaign is desired, a series of canisters are placed on one or both of the batch feeder ramps. The feed ramps are indexed to automatically feed canisters to the batch feeder. A timer is used to control the indexing cycles. The time set point for each index cycle is initiated by a position indication switch (ZS-0234 and ZS-0244) located at the inlet of the batch feeder. The process time for each canister (time cycle between canister feed events) is calculated by the process control computer. The process time calculations take into account the feed rate limitations of the permit and by using the canister~~

~~characteristics data (transmitted to the computer by scanner BCS-0244). The computer calculates the process time for all of the canisters placed on the ramps. When the control room operator actuates the batch feed start command, the ramp automatically advances the canisters into the batch feeder at the calculated time cycles. If both batch feeders are used, the feeders are alternated to introduce canisters into the process chamber.~~

~~**Steam Feed Control:** Steam is metered into the process chamber (GV-03-Y-0301) to fully convert all carbonaceous waste material to syngas. The steam is controlled using a feed back control strategy based on the composition of the syngas exiting the main GASVIT™ process chamber.~~
~~The ratio of the carbon monoxide to carbon dioxide is used as an indicator for the addition of excess steam to the process. When the stoichiometric ratio of steam to that of carbon is exceeded, the normalized ratio of carbon monoxide to carbon dioxide begins to deviate from a value of 1.0.~~

~~The conversion of carbon has been precisely controlled using the normalized ratio of CO to CO_2 in an operating GASVIT™ system. The response to changes in feed rates is nearly immediate and feed back control of input steam corrects the deficiency in the relative quantities of CO_2 to CO which has been verified is a good indicator of carbon build up in the process chamber.~~

~~The initial minimum steam setting is by the waste feed rate. Once waste feeding has been established, the control of the steam input to the process chamber (GV-03-Y-0301) is governed solely by the ratio of carbon monoxide to that of carbon dioxide. If the level of carbon monoxide falls below a level of 1 percent absolute value in the process in the process off-gas, as measured by gas analyzer (GV-08-AE-0350), the control operator can override the automatic steam flow control (GV-03-FCV-0393) to deviate from the minimum rate at which steam is introduced to the process chamber (e.g., if pure soil is fed to the process GASVIT™ process chamber, no steam addition is required nor is it desired).~~

~~**Glass Former Feed Control:** Glass-former additions may be required during the processing of certain wastes. With some waste materials, the resultant glass product formed has properties (e.g., high viscosity at processing temperatures) that can be preferentially altered through the addition of glass formers. The glass-former addition will be a mixture of raw materials that in itself will result in a glass with acceptable properties. Based on the composition of the waste being processed during each campaign, the fraction of glass-forming additive required will be determined. The glass additives will be metered into the process chamber (GV-03-Y-0301) either through the batch feeder (GV-02-CG-0230) or the continuous solids feeder (GV-02-F-0226) in combination with the gravimetric additive feeder (GV-02-F-0220). To determine the quantity of glass-former addition required, a glass sample will be obtained and analyzed for every vitrified glass collection drum produced.~~

~~1.6 Methods For Ensuring Compliance With Permit AWFCO Requirements~~

~~An Automatic Waste Feed Cut Off (AWFCO) logic is provided as the overall safeguard of the GASVIT™ system. The AWFCO controls are depicted in P&ID drawing number 31001-P-080-2. The AWFCO is designed to automatically shut down the GASVIT™ feeders in the event a critical process parameter drifts outside the normal operating range specified as permit operating limits. The AWFCO subsystem integrates key instrumentation from the feed subsystem, process chamber subsystem, and syngas processing subsystems to initiate a single total feed shutdown to ensure GASVIT™ system permit compliance. AWFCO is implemented by a controller (YN-0100) which is housed inside the main PLC.~~

~~AWFCO intrelocks are summarized in Table D-5b36 in Attachment 3 of this RCRA/TSCA Permit application.~~

~~1.7 Compliance with Other Permit Requirements~~

~~**Ventilation (GV-09 and GV-22):** Fugitive emissions generated during waste feed preparation and secondary waste handling operations are controlled by the GASVIT™ process vent subsystem. The subsystem collects vent lines from various process hoods and enclosures where there is a potential for generating fugitive emissions. The vent lines are first filtered, if necessary, to remove dust and particulate. After initial filtration, the vent lines are sent to a carbon filter bank to remove any organic vapor constituents. The exhaust from the carbon filters are sent to the building ventilation ducts. The RCRA/TSCA permit requirements on the monitoring of this subsystem include periodic sampling of the carbon bed effluents to monitor the effectiveness of the beds and to plan their replacement before exhaustion. The GVB ventilation subsystem, referred to as "building confinement subsystem," maintains a negative pressure inside the GVB while providing approximately 7-10 air changes per hour. The GASVIT™ system exhaust is discharged into this system. Before release to the atmosphere, the building exhaust is passed through a set of pre-filters, HEPA filters, and charcoal filter banks. Since The GASVIT™ system exhaust is monitored before discharge into the building exhaust, there are no additional RCRA/TSCA permit conditions applied to the exhaust from this subsystem~~

~~**Building Exhaust Rad Monitors (GV-25):** The confinement system exhausts to outside the GVB are equipped with radiation samplers and flow meters, in accordance with the requirements established by the Mixed Waste Facility Radioactive Material License issued by the Washington Department of Health. There are no sampling and analytical requirements pursuant to the RCRA/TSCA permit.~~

~~**Building Containment Subsystem (GV-26):** Secondary containment is included in the GVB to collect any potential liquids spilled during the handling and processing of material in the GVB. The secondary containment, which is described in other sections of the permit application, is subject to the conditions specified in the RCRA and TSCA permit.~~

~~**Area Monitors (GV-28):** Radiation air sampling stations are provided at strategic locations in the GVB. This subsystem is subject to compliance with the Radioactive Material License issued by the Washington State Department of Ecology.~~

~~**Catch Pans:** Metal catch pans are installed beneath each of the following subsystems to Gv-01, -03, -04, -05, -06, -07, -08, -09, and -11. These pans collect any material that may be released during operations. The pans are designed to have a free volume greater than the internal volume of the equipment.~~

~~**Table 1.1.** List of key subsystems installed in the GASVIT™ building.~~

~~Subsystem~~	~~Reference PFD Drawing~~	~~Reference P&ID Drawing~~
~~GV-01, Feed Preparation~~	~~31001-P-050~~	~~31001-P--071-01 & 02~~
~~GV-02, Feed~~	~~31001-P-050~~	~~31001-P-072-01 through 04~~
~~GV-03, Process Chamber~~	~~31001-P-051~~	~~31001-P-073-01 through 09~~
~~GV-04, Product Handling~~	~~31001-P-051~~	~~31001-P-074-01, 02~~
~~GV-05, 06, and 07 Syngas Processing~~	~~31001-P-051~~ ~~31001-P-052-01 & 02~~	~~31001-P-075~~ ~~31001-P-076-01 through 04~~ ~~31001-P-077~~
~~GV-08, Syngas Sampling~~	~~31001-P-051~~	~~31001-P-078~~

~~Subsystem~~	~~Reference PFD Drawing~~	~~Reference P&ID Drawing~~
~~GV-09, GASVIT™ Process Vent~~	~~31001-P-053~~	~~31001-P-079~~
~~GV-10, GASVIT™ Process Feed Control/AWFCO~~	~~NR~~	~~31001-P-080-01 & 02~~
~~GV-11, Secondary Waste~~	~~31001-P-054~~	~~31001-P-081~~
~~GV-12, Caustic Addition~~	~~31001-P-052-01~~	~~31001-P-082~~
~~GV-13, Service and Instrument Air~~	~~31001-P-055~~	~~31001-P-083-01 & 02~~
~~GV-15, Nitrogen Supply~~	~~31001-P-056~~	~~31001-P-085~~
~~GV- 16, Process Water~~	~~31001-P-058-01~~	~~31001-P-086~~
~~GV-17, R.O. Water~~	~~31001-P-058-02~~	~~31001-P-087~~
~~GV-18, Steam Supply~~	~~31001-P-057~~	~~31001-P-088-01 & 88-02~~
~~GV-19, Process Cooling Water~~	~~31001-P-058-03~~	~~31001-P-089~~
~~GV-20, Chilled Water~~	~~31001-P-058-04~~	~~31001-P-090~~
~~GV-22, Building Confinement~~	~~31001-P-05-01 & 02~~	~~31001-P-092-01 & 02~~
~~GV-23, Electrical Power Distribution~~	~~NR~~	~~NR~~
~~GV-24, Main Process Control Panel~~	~~NR~~	~~NR~~
~~GV-25-Building Exhaust Monitors~~	~~NR~~	~~31001-P-095~~
~~GV-26, Building Containment~~	~~NR~~	~~NR~~
~~GV-27, Building and Structures~~	~~NR~~	~~NR~~
~~GV-28, Area Monitors~~	~~NR~~	~~NR~~

~~Table 1.2 Boiling or sublimation temperatures for metals, metal chlorides, and metal oxides.~~

	Metal	Boiling or Sublimation Temp. °C			Most Probable Deposition Loc				
		As Metal	As Chlorides	As Oxide	Vit 1300-1650°C	H.T. 650-760°C	Scrub 80°C	<100°C	<100°C
	Antimony	1,750	283	1,550	a, c		b		
H	Arsenic	613(s)	130	465	a, c		b		
a	Barium	1,640	1560	2,000	a, b, c				
z	Beryllium	>3,000	520	3,900	a, c		b		
a	Cadmium	762	960	1,559(s)	a, c	b			
r	Chromium	2,672	1300(s)	4,000	a, c				
d	Lead	1,740	950	NA	a	b			
o	Mercury	357	400(s)	100(d)			a, b, c		
u	Nickel	2,732	973 (s)	1,990	a, c	b			
s	Selenium	685	130(d)	180	a, b, c				
	Silver	2,212	1550	300(d)	a, b		c		
	Thallium	303	720	875	a, c		b		
R									
a	Ce	3,426	1727	NA	a, b				
d	Cs	678	1290	400(d)	c	b	a		

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~~Notes~~

~~1. From 1975-1976 Edition of CRC Handbook of Chemistry and Physics~~

~~2. (s) denotes sublimation point~~

~~3. (d) denotes decomposition point~~

~~4. NA denotes not available and presumed unstable~~

~~5. (a) denotes most likely partitioning location for metals; (b) denotes most likely partitioning location for metal chlorides; and, (c) denotes most likely partitioning location for metal oxides.~~

2. Process Throughput ~~and Mass Balance~~

Input waste strams will consist of tanker truck loads received from off-site and inorganic liquids in containers within the MWF. The wastesteam will be placed in the four storage tanks and then fed to the evaporators for significant volume reduction of waste.

2.1 ~~Feed Preparation Capacity~~Estimated Annual Throughput

Approximately 700,000 gallons per year of hazardous wastewater will be processed throught the evaporation system. Each evaporator is designed to evaporate 260 gallons per hour.

~~The GASVIT™ system feed preparation subsystem is designed to prepare 1500 lbs. per hour of solid waste. The design basis is to prepare sufficient material in one shift per day (five days per week) for processing by the GASVIT™ process in a 24 hours per day (seven days per week) operation.~~

~~2.2 Prepared Material Surge Storage Capacity~~

~~Surge storage capacity in the GVB is provided for liquid/sludge wastes and solid wastes packaged in canisters and bags. The design surge storage quantities for each unit are as follows:~~

~~**Liquid/sludge:** 375 gallons~~
~~**Solid waste packaged on canisters and bags:**~~
~~RCRA wastes: 1220 cubic feet~~
~~PCB waste: 480 cubic feet~~

~~2.3 GASVIT Unit 1 Processing Capacity~~

~~The GASVIT™ process is designed for a nominal capacity of 350 lbs. per hour. Maximum and minimum throughput varies with waste composition. The design range varies from 90 percent inorganic and 10 percent organic to 90 percent organic and 10 percent inorganic, with an average of 60 percent inorganic and 40 percent organic. Gas handling capacity limits the processing rate for high organic waste, whereas melting (thermal energy flux) capacity limits the processing rate for high inorganic waste. The assumed waste processing rate is 250 lbs. per hour for the 90 percent organic waste stream, 350 lbs. per hour for the 40 percent organic waste stream, and 500 lbs. per hour for the 10 percent organic waste stream.~~

~~2.4 Mass Balance Calculations for Design Conditions~~

~~Tables 2.1 – 2.6, located at the end of the Confidential Business Information (CBI) version of this section, provide results of a mass balance model developed for the GASVIT™ process. Numbers shown in the column headings of these tables refer to the nodes in the business confidential process and instrumentation drawings enclosed in Attachment 7. The model is presented in this section for high (90 percent), average (40 percent), and low (10 percent) organic content waste streams. The waste compositions used in the model are based on reported inventories[1] for mixed wastes at Hanford. The waste streams assumed are conservative in their interpretation of the expected wastes to be treated in the PEcoS Mixed Waste Facility. This is especially true for the radionuclides. Destruction and removal efficiencies for each unit operation in the model are based on process experience, vendor information, and thermodynamic modeling. These values will be verified or modified during demonstration testing. Two~~

~~[1] Place, B.G. *1996. Low-Level Mixed Waste Thermal Treatment Technical Basis Report* WC-SD-W242-ES-004. – Westinghouse Hanford Company.~~

~~sets of tables are provided for each of the three waste streams modeled. The first table of each group (Tables 2.1, 2.3, and 2.5) contains the mass flow rates of solids and gases for each major process stream. The stream number listed for each unit operation is consistent with the process flow diagram submitted with this document. All flow rates are in kg./hour, except for the radionuclides that are in Ci/hour. The second table of each group (Tables 2.2, 2.4, and 2.6) contain expected concentrations of solids and gases in all of the major gas streams. All concentrations are in mg/m^3, except for the radionuclides that are in Ci/m^3. The results of the mass balance model indicate that release of RCRA metals, radionuclides, particulate, and noxious gases from GASVIT™ should be well below regulatory limits.~~

~~**2.5 Mass Balance Calculations for Demonstration Test Runs**~~

~~Mass balance conditions for the demonstration test runs are provided and included in tables 2-3, 2-4, and 2-6, found in the CBI version of this section. The estimated annual quantities are presented in table 2.5 in Attachment 5, waste stream 500.~~

3. EQUIPMENT DESCRIPTION

3.1 ~~Subsystem GV-01, Feed Preparation~~EVAPORATION SYSTEM (TP-16)

1. General Function

The function of the ~~feed preparation subsystem is to receive, inspect, sort, size reduce, repackage and temporarily store the input wastes as needed for processing by the GASVIT™ system~~evaporation system (TP-16) is to reduce the volume of hazardous wastewater and concentrate waste constituents (e.g. metals, inorganic salts) into residues for additional treatment in the STB or to dispose of off-site.

2. Reference Documents

Process Flow Diagram: See drawings 31001-P-050 in Attachment RR of the Permit.
Piping and Instrumentation Diagram: See drawings 31001-P-071-01, ~~and~~ 02, and 03.
General Equipment Layout: See drawing 31001- M-100 (Sheet 4) in Att. RR of the Permit.
Key Components List: See Table ~~GV-01~~D-2-5 in Att. MM of the Permit ~~in the equipment and instrument list in Attachment 9~~.
Key Components Technical Specification: See the technical specification package ~~enclosed~~ in Attachment ~~9~~WW.
Key Control Devices: See Table ~~GV-01~~D-2-5 in ~~the equipment and instrument list in~~ Attachment ~~9~~MM of the Permit.
Instrument Data Sheets: See the technical specification package ~~that is enclosed~~ in Attachment ~~9~~WW.
Interfacing Subsystems: ~~GASVIT™ process vent subsystem (GV-09); feed subsystem (GV-02); GASVIT™ main control subsystem (GV-10)~~Low Capacity Mixer (TT-02); In-Container Mixer (TT-03) locatd in the STB building.

3. Equipment and Process Description

Evaporation system (TP-16) will consist of unloading pump (P-100), a second pump (P-200) to pump only if filter basket(s) is clogged, two filter baskets (BF-100 and BF-101), four storage tanks (each approximately 10,950 gallon capacity, two feed pumps to evaporators (P-300 and P-400), two evaporators (WWE-01 and WWE-02), two residue pumps (P-500 and P-700), one residue storage tank (T-105), one residue transfer to containers) pump (P-600), and associated piping, instrumentation, and controls.

TP-16 process will receive generally aqueous inorganic wastewater which may have trace amo0unts of organics. Ost of the input waste will be brought in tanker trucks from off-site generators. A small amount of containerized inorganic aqueous wastewater from WSB storage area will also be managed in the evaporation system. Wastewater will be unloaded into four storage tanks that will run through filter baskets from where it will be fed into one or more of the storage tanks. Depending on the amount of solids in the wastewater, the filter baskets may be bypassed. Residues from the evaporators will be pumped into the residue/sludge storage tank (T-105). This residue will then be pumped into containers for further treatment in either the Low Capacity Mixer (TT-02) or the In-Container Mixer (TT-03) systems located in the STB building or disposed of off-site.

~~Hazardous wastes, in both liquid/sludge and solid form, will be received at the Mixed Waste Facility for treatment. Upon arrival at the facility, the containers will be inspected and accepted/rejected as described in the waste analysis plan (WAP) presented in Section C. These incoming wastes will contain or will be suspected of containing, PCBs, RCRA Dangerous Wastes (as defined in Washington Administrative Code, WAC 173), and radioactive contamination. Upon completing the receiving inspection, the incoming waste containers will be transported to either storage, stabilization or the GVB. Wastes having a PCB contamination above the exempt concentration limits under TSCA and WAC will not be forwarded to the stabilization building (STB) and will be placed either in the storage area or sent to the GVB for treatment.~~

~~Generally, liquid/sludge waste will be transported, received, and stored in drums, flo-bins or overpacks. (e.g. a car-boy placed in an overpack filled with vermiculite). Solid waste will be received in drums or boxes.~~

~~The process flow for the feed preparation subsystem (GV-01) is based on campaign processing. Essentially, this means that processing will be done in a batch comprised of several containers that have similar requirements with respect to: 1) worker safety protection; 2) waste compatibility; 3) permit compliance; and 4) waste processing efficiency.~~

~~The first preparatory step for all containers entering the GVB is inspection. The container key physical data (e.g. weight, size, and configuration) will be checked against the container profile data in the main plant inventory control computer system. Any further decision on container sampling and analysis will be based on the criteria described in the GASVIT™ WAP. Wastes found acceptable will be released to the next step of the preparation while unacceptable waste will be immediately forwarded to a predetermined area clearly marked as "Rejected Containers." Procedures and protocol for handling rejected containers is defined in the WAP.~~

~~Liquid waste container inspection will be conducted inside a hazardous materials (HAZMAT) enclosure (GV-02-Z-0202). A hood, provided in the HAZMAT enclosure for liquid waste inspection, captures any organic vapors that might escape the container during the container opening and inspection process. Solid waste container inspection is conducted under a similar hood (Z-0110), but outside the HAZMAT enclosure. Fugitive emissions or dust that may be released during the container inspection are captured and forwarded to the GASVIT™ process vent system (GV-09).~~

~~Concluding inspection, liquid wastes will be forwarded to the liquid feeder (refer to subsystem GV-02-01). Liquid wastes arriving at the GVB in an overpack container will require opening the overpack cap, removing the liquid container from the overpack, and pouring the liquids/sludge into a funneled container (GV-02-C-0211) that is temporarily stored in the liquid feed HAZMAT enclosure (GV-02-0202). Before consolidating two or more liquids, all pre-cautionary and safety measures will be instituted to ensure waste compatibility of the liquid wastes. After removing the liquid container, the overpack, usually filled with absorbent material (e.g., vermiculite), will be sent to the feed preparation~~

~~area (GV-01) and staged for processing. In this area the absorbent material will be removed from the overpack, placed in bags (C-0102), placed on a weight scale (WE-0114), and labeled with weight and waste profile information. Container labeling will be discussed later in this section.~~

~~After solid waste containers are inspected and accepted for processing by the GASVIT™ system, they are sent to one of the two sorting devices: A) a sorting box (Z-0107) or B) a sorting table (Z-0105). PCB-contaminated wastes generally greater than exempt limits will be sent to the sorting box. All other wastes will be sent to the sorting table.~~

~~**Sorting Box:** The sorting box (Z-0107) is a totally enclosed housing equipped with a confinement system that maintains a slight negative air pressure inside the box with respect to the pressure in the immediate exterior airspace. Solid waste containers, generally 55 gallon drums, are rotated 90 degrees and horizontally connected to the sorting box. A standard industry air-lock is used to maintain airspace confinement. Once the container is positioned next to the sort box inlet port, the container lid is removed and dropped inside a bag. The sorting box inlet port is then opened and the solid waste is emptied into the sorting box. Large RCRA-contaminated metals are removed and placed in a metal collection drum (C-0108) located under the sorting box (Z-0107). When the metal collection drum is full, it is capped, weighed, labeled, and forwarded to the STB. PCB-contaminated metal pieces are placed into cardboard batch feed canisters (C-0106). If needed, PCB metals are size reduced so that no PCB metals are sent to the STB. The remaining waste objects are placed into separate batch feed canisters (C-0106). All filled canisters (C-0106) are capped and removed from the sort box, also using an industry standard air-lock change-out procedure. The filled containers are immediately weighed and labeled with a bar-code system containing waste profile criteria. Specifics regarding container bar-code labeling will be discussed later in this section. The containers are then forwarded and staged as feed through the batch feeder (refer to subsystem GV-02-03 in section 3.2.3).~~

~~**Sorting Table:** The sorting table is equipped with a vented hood (Z-0104). The hood collects fugitive emissions and dust generated during waste sorting operations (see subsystem system GV-09). The sorting table operation is similar to the box sorting operation. First, metal pieces not suitable for processing by the GASVIT™ chamber are removed and placed in a metal collection drum (C-0109). When the metal collection drum is full, it is capped, weighed, labeled, and sent to the STB for treatment. Solid waste objects that cannot be shredded, are packaged in batch feed canisters (C-0106) as in the section above. Solid waste objects capable of shredding and feeding as continuous solid feed are placed on an enclosed conveyor (CV-0103) and routed to the shredder (SHR-0101).~~

~~The shredder (SHR-0101) receives solid waste from the incoming conveyor and reduces the solids to a pre-selected size (usually 2 inches). The shredded material falls into a chute which leads to a bagging station. At this station, a continuous bag (C-0102) is placed under the chute and the chute discharge valve is opened allowing shredded material to fill the bag. When the bag is full to approximately 25 lbs., the chute discharge gate (FV-0101) is closed. The bag is then tied and sealed twice, twelve inches apart, cut between the seals, and horsetail wrapped at each stub end. The bag is then weighed, labeled with a bar-code, and staged for continuous solid feed (refer to GV-02-02 in section 3.2.2).~~

~~The weighing station (Z-0114) is an integrated unit equipped with a weight scale (WE-0114), and a computer terminal, and a label printer. At this station, the weight of the batch feed containers, bags and metal drums produced during the sorting operations will be measured. The computer terminal will record the weight of each packaged material, retrieve waste profile data from the main plant waste inventory control system, and generate a bar-code strip for affixing to the new package. Using the bar-code as an identification number, the computer generates and maintains a record file for the packaged material. The~~

~~file will relate the characteristics of the waste in the package to the characteristics of the container from which the packaged material was originated. In addition to the bar code, the computer will generate color-coded strips which will be affixed only to the packages destined for processing by the GASVIT™ system. The color coding scheme provides a visual indication to the operator to allow selection of the feed material composition for sequencing and blending so that the metals and chlorine/chloride concentrations imposed by the GASVIT™ process permit can be met.~~

~~From the weighing station (Z-0114), the bags (C-0102) and batch feed canisters (C-0106) will be stored in a surge feed storage area. The surge feed storage area maintains a capacity for bags and canisters sufficient for 48 hour of GASVIT™ operation based on a feed rate of 350 lbs./hr.~~

4. Operation and Control Description

Other operations for the TP-16 process include receiving incoming liquid waste and transferring the waste to storage tanks and then to evaporators.

Receiving Incoming Aqueous Wastewater: These wastewaters will be brought in from off-site in tanker trucks which will be positioned in the unloading area for inspections, shipping paperwork revfiew, and sampling as required by the WAP. A platform may be provided at theunloading area for the sampling of the tanker. A small protion of aqueous inorganic containerized wastewater will also be brought in from the WSB storage area into the unloading station on an as-needed basis. A flexible quick disconnect pipe will be used to connect the tanker outlet to the unloading unlet piping after the decision to accept the waste is granted.

Filtration: The wastewater may be filtered through the bag filters (BF-100 and BF-101) prior to being fed into one of the four storage tanks. Filter bag replacement will be prompted by the pressure indication gauges on the filter baskets. Spent filter bags will be removed from the filter housing and placed in containers for further on-site treatment in either the Low Capacity Mixer (TT-02) or the In-Container Mixer (TT-03) or off-site disposal.

Transfer to Evaporators: Evaporator feed pump P-300 will be utilized to transfer wastewater from tanks T-101 and T-102 while the feed pump P-400 will be used to transfer to evaporators from tanks T-103 and T-104. Piping and valving is arranged in a manner to allow the wastewater from the four storage tanks to be introduced in either of the evaporators.

Treatment in Evaporators: Each evaporator is equipped with PLC and operator interface panel indicating operational information as well as alarms. Residues generated in the evaporators are periodically pumped into the residue/sludge tank (T-105) from where they are pumped into containers for further on-site treatment or off-site disposal.

~~**Operating Campaign Planning:** Before a waste container is brought into the GVB feed preparation area, extensive planning and preparation are made to process the waste in a safe and efficient manner. Plans require incoming wastes to be processed in operating campaigns. General guidelines used for selecting containers for an operating campaign are that their contents must have generally similar characteristics with respect to: 1) personnel safety protection requirements (e.g. personnel protection equipment and airborne control measures); 2) permit compliance restrictions (e.g. controlling metals and chlorine concentrations in the feed); and 3) processing efficiency requirements of the GASVIT™ system (e.g., producing a glass product that can pass Subchapter C controls). Three major categories of the wastes that may be treated in a separate operating campaign are:~~

~~**PCB-contaminated Wastes:** PCB-contaminated wastes (with a concentration above TSCA and WAC exempt limits) will be processed in a separate operating campaign and will not be co-processed with a waste classified as RCRA "listed" waste. The objective of separate campaigns is to ensure that: 1) personnel safety requirements are adequately provided during the waste feed preparation steps; and 2) the final glass waste form will exit the TSCA and RCRA Subchapter C regulations. In order to meet the concentration limits imposed by the permit, the feeding of the waste from various containers will be sequenced and blended, as necessary. PCB solids and liquids may be processed in the same campaign. However, due to permitting restrictions, the liquid/sludge feeder will not be operated at the same time as the solids continuous feeder or the batch feeders.~~

~~**RCRA Listed Wastes:** To the extent practical, liquids/sludge and solids classified as RCRA listed wastes will be processed in a separate operating campaign. Unless specified by the generator, listed wastes will not be co-processed with PCBs or characteristic wastes. The final glass waste from processing listed wastes will be classified as RCRA listed waste and will be subject to Subchapter C disposal regulations. To pass the permit restriction on the feed concentrations, feeding of the waste from various containers will be sequenced and blended. Before changeover to another waste type, the process chamber internals will be flushed. Due to permitting restrictions, the liquids/sludge will not be fed to the process chamber at the same time that a solid material is being fed.~~

~~**Characteristic Wastes:** To the extent practical, characteristic wastes will be processed in a separate campaign. While characteristic wastes will not be co-processed with a listed waste, it may be co-processed with PCB wastes. The objective is to ensure that the final glass waste form will exit the RCRA Subchapter C regulations and that it can be disposed of in a non-Subchapter C disposal site. As with other waste types, the feeding of the waste from various containers will be sequenced to blend and control the metals and chlorine/chloride concentration of the feed to a level below the maximum feed rates allowed under the permit. Characteristic liquid/sludge and solids may be processed in the same operating campaign but cannot be fed to the process chamber at the same time.~~

~~**Concentration Based Wastes:** Wastes that do not have a BDAT treatment standard are subject to sampling and analysis of the final product in order to ensure compliance with the RCRA concentration standards. Hence, these wastes will be processed in a separate campaign in order to minimize the sampling costs.~~

~~**Waste Container Transfer:** When sufficient quantities of a given waste category are available to support one operating campaign, fork lifts or transfer carts will be used to transport the containers from the storage building, or STB, to the GVB feed preparation area (GV-01). The containers will be placed in their designated examination area. Solid waste containers (C-0111) will be placed in the container examination area, directly beneath the vented hood (Z-0110). Liquid waste containers will be placed inside the HAZMAT enclosure (Z-0202) directly under a hood in the liquid feeder area, for examination. (See subsystem GV-02-01.)~~

~~**Inspection:** Once in the inspection area, the container will be checked by entering its identification number into a local computer terminal connected to the main plant waste inventory control system. Upon entering the identification number, the computer terminal displays the container manifest and profile data. First, key physical characteristics (such as container size and weight) given in the profile sheets will be checked against the properties of the container in hand. For solid waste containers a scale (WIT-0111) is provided in the feed preparation area to allow for verification of the weight of the container. Next, the operator (wearing the appropriate personal protective equipment [PPE]) will ensure that the GASVIT™ process vent (GV-09) is on and that air flows through the inspection area hood (Z-0110) to provide the necessary confinement for personnel protection. Once this is verified, the operator opens the container and conducts a visual examination of the contents according to the examination criteria given in the~~

~~WAP. If the container properties, as observed by the operator, are inconsistent with the data in the computer information sheet, the operator will place the cap on the container and send the container to a location which is clearly marked "rejected containers." Rejected containers will be subject to further characterization and acceptance processing as described in the WAP. If a container meets the profile data, it will be forwarded for additional preparation steps as described below.~~

~~**Liquid Waste Preparation:** Both PCB and RCRA liquid wastes will be received at the GVB. Preparation for both types of wastes are similar and are described below.~~

~~**Bulk Liquid/Sludge Container Unloading:** No major preparation activity is needed for bulk liquid containers and, after the initial examinations, they will be ready to be hooked up to the container pump (GV-02-PMP-0203) and unloading operations, as described in the liquid feed operation section. (See Section 3.2.1.)~~

~~**Liquids/Sludge Overpack Unloading:** Some of the liquid/sludge wastes received by the facility may be shipped in small liquid containers (e.g. car-boy) placed in an overpack that is usually filled with an absorbent material (e.g., vermiculite). For this type of waste container, preparation will include: 1) placing the overpack in the liquid feed HAZMAT enclosure (GV-02-Z-0202); 2) removing the cap from the overpack container; 3) removing the liquid bottle from the overpack; and, 4) pouring the bottle into a funneled drum (GV-02-C-0211). Before mixing and consolidating liquids from different small containers, a chemical compatibility check will be performed to ensure safe operation. After consolidating compatible liquids from several small containers, the contents of the drum (GV-02-C-0211) will be fed to the GASVIT™ process chamber. (See liquid feed description in Section 3.2.1.) The empty overpack containing absorbent material will be sent to the solid waste preparation area where the absorbent material will be bagged (C-0102) or placed in batch feed containers (C-0106) and fed to the GASVIT™ process chamber. Solid waste bagging and batch feed container preparation operations are discussed below.~~

~~**Solid Waste Preparation:** Solid waste preparation equipment is designed for processing each incoming solid waste container (C-0211) according to the level of personnel protection requirements, the GASVIT™ permit limitations, and processing efficiency needs. Accordingly, solid waste containers with a PCB contamination greater than exempt limits will be sent to the sorting box (Z-0107). Other wastes will be sent to the sorting table (Z-0105).~~

~~**Sorting Box (Z-0107):** A totally enclosed glove sorting box is provided for unloading, sorting and "batch feed" canister packaging of wastes contained in the incoming waste drums (C-0111). A typical feed preparation campaign involves the following steps. First, the operator uses a drum-lift device to position a waste container (C-0111) horizontally and immediately adjacent to the sort box access port. Industry standard air lock change-out procedures are then used to extend sort box confinement to the container, remove the lid of the container, drop the container lid inside a bag, and bulkhead the container opening next to the sorting box access port. The ventilation connection to the GASVIT™ process vent subsystem maintains the entire confined area at a slight negative pressure with respect to the operator breathing area. The operator then opens the sort box access port and empties the waste contents into the glove box. Large RCRA metal pieces not suitable for feeding to the process chamber are removed and placed in a metal collection drum (C-0108) located immediately under the sort box. The filled metal collection drum is then sent to the weighing station. Large PCB-contaminated metals will be size reduced and placed inside the GASVIT™ feed canisters. The operator places all other waste material inside batch feed containers. The batch feed containers are capped, removed from the glove box using a standard glove bag change-out procedure, and forwarded to the weighing station (Z-0114) for weighing and labeling.~~

~~**Sorting Table (Z-0105):** A hood-covered sorting table is provided for unloading, sorting, and batch-feed canister packaging of wastes contained in the incoming drums (C-0111). A typical operation involves the following steps: 1) the operator brings a drum or a box of incoming waste and places it near the sorting table; 2) the operator ensures that the GASVIT™ process vent subsystem is on and air flows through the hood to carry any potential contamination away from the operator's breathing area; 3) the operator empties the drum or box contents onto the table; the operator sorts and removes large metal pieces not suitable for feeding to the process chamber and places these metal pieces in a metal collection drum (C-0109) located near the sort table; when full, the operator sends the metal collection drums to the weighing station (Z-0114); and 5) the operator sorts the remaining waste material on the sort table and either places it directly inside a batch feed canister (C-0106), a bag (C-0102) or dumps it to the inlet of an enclosed conveyor (CV-0103) leading to the solid waste shredder (SHR-0101).~~

~~**Solid Waste Shredding and Bagging:** Solid waste is carried to the shredder by an enclosed conveyor (CV-0103). The shredder (SHR-0101) is fully enclosed and equipped with a ventilation duct connected to the GASVIT™ process vent subsystem (GV-09). The shredder reduces the material to a given size (approximately 2 inches in diameter) which is controlled by a screen sieve mounted directly beneath the shredder blades. From the screen, the shredded solid waste falls into a chute which is connected to a bag. When the bag is full, the operator closes the discharge chute gate valve (FV-0101), removes and seals the filled the bag, and places the bag on the weighing station (Z-0114). The bag (C-0102) is a continuous plastic bag that seals and automatically extends a new bag, thereby maintaining airspace confinement.~~

~~**Data Recording and Container Mark-up:** A weighing station (Z-0114) is provided to weigh and bar-code label the canisters, bags and metal collection drums packaged during the solid waste sorting and shredding operations. The station is equipped with a scale connected to a computer terminal. This terminal is tied to the main inventory control computer system and has access to all plant waste container characterization records. At the weighing station, the operator enters the original identification number of the container into the computer terminal. Based on this identification number, the computer terminal will: 1) obtain from the scale and record the canister, bag, or metal drum weight; 2) retrieve characterization data relative to the original container from which the waste originated; 3) use the retrieved data to establish a new file and an identification number for the canister, bag, or metal drums generated during the sorting and shredding operations; 4) instruct a printer to issue a bar-code strip bearing a new identification number; and 5) assign a color-code strip for easy segregation of the bags and canisters during the feed operations. The color codes will inform the operator as to the feed sequencing needed for blending the GASVIT™ chamber waste feed. The operator affixes the bar-code to the canister, bags, and metal drums. The color code is affixed only to the canisters and bags. (No color code is needed for the sorted metal drums). Next, the operator stages the canisters and bags in the designated surge storage area while the metal drums are sent to the STB for treatment and packaging. The three color strips to be affixed to the canister and bags are described below.~~

~~**Red:** Chlorine content of the canister or bag is above the permitted concentration limits and, hence, feeding of the canister or bag to the process chamber is subject to blending in order to meet the chloride/chlorine concentration limits of the permit.~~

~~**Black:** Metals content of the canister or bag is above the permitted concentration limits and, hence, feeding of the canister or bag to the process chamber is subject to blending in order to meet the metals concentration limits of the permit.~~

~~**Green:** Both metals and chlorine/chloride concentrations are below the permitted concentrations and, hence, blending is not required.~~

~~**Empty container Handling:** Empty containers are sent to the empty container rinse tank system located in the stabilization building.~~

5. Safety Interlocks

Emergency Stop (E-Stop) (Tag ID: ILK-014): The emergency stop (E-Stop) is a manual push-button located on the local control panel to permit immediate shutdown of the ~~feed preparation sub~~Evaporation system in an emergency situation. The E-Stop actuates an interlock shutdown for both evaporators. ~~sort table (Z-0105), the enclosed conveyor (CV-0103), and the shredder (SHR-0101).~~

6. Surveillance & Maintenance

A surveillance, maintenance, and calibration event list will be provided for the key equipment and control/instrument device in this subsystem. The events will be based on the manufacturer's recommendations and will include maintenance frequency. When the facility operation is started, each surveillance, maintenance, and calibration event will be recorded and documented.

~~A preliminary guideline for surveillance, maintenance, and calibration events relative to this subsystem is presented below.~~

~~Weight Scale (WE-0111): Solid waste examination area, calibrated per manufacturer's recommendations on a quarterly basis.~~
~~Weight Scale (WE-0114): Canister/bag/drum weighing station, calibrated per manufacturer's recommendations on a quarterly basis.~~

3.2 AIR EMISSIONS

For both worker safety and contamination control, process ventillations is established in the MWTH Building prior to conduction any transfer or evaporation operations. The process ventilation system maintains the operations area under a negative air pressure. The exhaust gases from the evaporators (mainly steam with a trace amount of organics) passes through a duct heater, a HEPA bank, activated carbon filter prior to being discharged to the atmosphere throught MWTH Building exhaust stack.

3.3 COMPLIANCE WITH PROCESS & SAFETY PERFORMANCE REQUIREMENTS

Each evaporator is a vendor-supplied unit provided with a PLC and operator interface panel. An alarm condition will appear on the operator interface panel if any of the following pre-set setpoints are exceeded:

- High wastewater level in the evaporator
- Low wastewater level in the evaporator
- High wastewater termperature
- High combustion gas temperature
- Blower shut-off termperaure
- High differential pressure across the mist pad

3.4 PREVENTATIVE & PREPAREDNESS PROCEDURES & INSPECTION PLAN

Evaporation process equipment will be inspected, maintained, and calibrated, if necessary via the equipment manufacturer's recommendations.

~~3.2 SUBSYSTEM GV-02, FEED SUBSYSTEM~~

~~3.2.1 Subsystem GV-02-1 Liquid Feeder~~

~~1. General Function~~

~~The liquid feeder is one of three feed units used to introduce liquid and sludge waste at a controlled feed rate into the GASVIT™ process chamber (see subsystem GV-03) for treatment. The two remaining feed units are: continuous solids and batch solids, and are described in subsystems GV-02-2 and GV-02-3, respectively.~~

~~2. Reference Documents~~

~~**Process Flow Diagram:** See drawing 31001-P-050 in Appendix B and Attachment 7.~~
~~**Process and Instrumentation Diagram:** See drawing 31001-P-072-01 in Appendix B and Attachment 7.~~
~~**Key Components:** See Tables GV-02-1 in the equipment and instrument list in Attachment 9.~~
~~**Key Component Technical Specifications:** See the technical specification package enclosed in Attachment 9.~~
~~**Key Control Devices:** See Tables GV-02-01 in the equipment and instrument list in Attachment 9.~~
~~**Control Device Technical Specification:** See the technical specification package enclosed in Attachment 9.~~
~~**Interfacing Subsystems:** feed preparation subsystem (GV-01); process chamber subsystem (GV-03); GASVIT™ process vent subsystem (GV-09); GASVIT™ main process controls (GV-10)~~

~~3. Equipment and Process Description~~

~~The liquid feeder consists of a feed tank and a set of redundant feed pumps installed inside a HAZMAT enclosure. A portable, top-mounted pump is used for transferring liquid from incoming containers to a feed tank. The process flow is based on receiving the incoming liquid and sludge wastes in 55-gallon drums or flo-bin containers. The containers are placed in carts and are moved either manually or by a fork lift truck into a secondary containment ventilated HAZMAT enclosure (Z-202). Once in the HAZMAT enclosure, each container is fitted with a suction pipe and a container pump (PMP-0203). Next, the liquid is pumped into the feed tank (TK-0205) and the feed tank mixer is turned on to blend the liquid into a uniform consistency. A strainer (ST-0204) is mounted at the discharge of the container pump to remove solids from the liquid waste to avoid clogging the nozzles and small piping downstream of the liquid feed pumps. Spent sludge filters are removed from the filter housing, placed in a cubic foot canister, and staged as feed for the solids batch feeder. (This is further discussed in other parts of this section.) Nonpumpable sludges and liquids will be absorbed with dry media and packaged for feeding through the continuous feed (GV-02-02) or the batch feed (GV-02-03) systems.~~

~~Before feeding liquid to the process chamber, the feed pump discharge valves are lined up in a re-circulation mode and the feed pump (either PMP-0209 or PMP-0210) is turned on to re-circulate the liquid through the discharge piping and back into the feed tank. At this time, a grab sample may be taken from a sample port (V-02036) and analyzed to confirm that the waste falls within the given process guidelines. When all feed conditions meet the required specifications and when the process chamber conditions are within the specified limits, the waste feed cut-off valve (FV-0216) is opened to revert the flow from the recirculation to the feed mode. When the feeding operation is to be stopped, the feed cut-~~

~~off (FV-0216) is placed in the closed position and the liquid is allowed to re-circulate. At this time the feed pump (either PMP-0209 or PMP-0210) can be turned off, if necessary.~~

~~The HAZMAT modular enclosure (Z-0202) provides for both liquid containment and airspace confinement. All operations where waste feed may be exposed to the environment will be conducted inside the ventilated HAZMAT enclosure. Additionally, safety interlocks are designed into the system to both mitigate an environmental release and to ensure worker safety in the event of a leak, a spill, or ventilation failure. These safety features are discussed in further detail later in this section. Finally, all the liquid waste piping routed outside the containment area is coaxial (double contained). This includes the piping from the liquid tank to the process chamber.~~

~~**4. Operation and Control Description**~~

~~**Filling the Feed Mixing Tank:** Prior to conducting liquid waste feed operations, ventilation to the modular HAZMAT enclosure must be established. The ventilation system of the building maintains the enclosure at a negative pressure relative to the GVB environment. A flashing alarm light (PDAL-202) at the entrance to the enclosure is actuated by a differential pressure monitor (PDI-202) and warns the operator not to enter the enclosure when a negative pressure has not yet been established.~~

~~Liquid waste contained in drums or flow-bins is manually placed on the feed scale and weighed. The serial number and measured weight of the drum is recorded by the operator. The main PLC/computer also records the drum weight based on analog signal input from the transmitter (WIT-01-0111).~~

~~A container pump (PMP-0203) is inserted into the drum. Before starting the pump, the plant operator reads the feed tank (TK-0205) level gauge sight glass. A high-level condition in the tank prevents the container pump from being started. The operator starts the container pump using the hand switch (HS-0203) at the liquid feeder local control panel. An air solenoid valve (FV-0203) opens and supplies air to the pump. Air is supplied to the container pump until either the drum is empty or the desired level in the mixing tank is reached. In either case, the operator then secures the pump. The high-level alarm interlock (LAH-0205) will secure the container pump automatically if the level in the tank exceeds a pre-set maximum value.~~

~~**Mixing the Liquid Feed:** After the mixing tank is full, the liquid waste is blended to a uniform consistency before it is sent to the process chamber. The mixing tank is a vendor furnished packed unit with built-in mixer and waste feed pumps. The motor for the mixer (MX-0206) is air-operated and is actuated by a service air flow valve (FV-0206).~~

~~**Recirculating the Liquid Feed:** After the mixing process, the liquid waste is passed through a re-circulation loop beginning at the liquid feed mixing tank (TK-0205) and recycled back to the same tank, when the liquid feed cut-off valve (FV-216) is in the closed position. To initiate re-circulation, the liquid feed cut-off valve FV-216 is placed in position. At this point, one of the feed pumps (PMP-0209 or PMP-0210) is started from either the liquid feeder local control panel or the PLC/computer control panel. (The pumps are redundant units and only one pump will be used at any given time.)~~

~~**Feeding Liquids to the Process Chamber:** When liquid feed processing is desired, liquid feed to the process chamber is initiated by toggling the waste feed cut-off valve (FV-216) switch to the process chamber feed position. PLC programming and physical interlocks referred to as AWFCO (see subsystem GV-10) will open the AWFCO valve (FV-0216) and permit waste feed to the process chamber only when the conditions in the process chamber are within their specified limits.~~

~~**Setting Feed Rate:** The liquid feed rate is set by placing the flow control switch (PID controller [FC-0215]) at the desired flow rate. A signal from this switch will open the flow control valve (FCV-0215) and the flow meter (FIT-0214) will measure the flow through the feed pipe. The flow control loop will modulate the opening of the control valve (FCV-0215) according to the flow rate set point.~~

~~**Stopping Liquid Feed:** The flow may be stopped at any given time by placing the feed cut-off valve (FV-0216) switch in the closed position from the control panel. In addition, a low-level condition (LAL-0205) in the feed tank (TK-0205) automatically reverts the waste feed cut-off valve to the closed position, secures the operating feed pump (PMP-0209 and PMP-0210), and notifies the operator with a warning light and horn on the local process control panel.~~

~~**5. Safety Interlocks**~~

~~**Liquid Feed Tank LOW Level Cutout (Tag ID: ILK-001):** The liquid feed tank low-level interlock is designed to stop feed pumps (PMP-0209 and PMP-0210). The interlock also closes the waste feed cut-off valve (FC-0216) and stops the tank mixer (MX-0206).~~

~~**Liquid Feed Tank HI Level Cutout (Tag ID: ILK-002):** The liquid feed tank HI level interlock is designed to prevent overfilling of the feed tank (TK-0205). A tank level HI alarm stops the container pump (PMP-0203).~~

~~**Emergency Stop (E-Stop) (Tag ID: ILK-003):** The emergency stop (E-Stop) is a manual push-button located on the local control panel to permit immediate shut down of the liquid feed system in an emergency situation. The E-Stop actuates an interlock shut down from the PLC/Computer for the container pump (PMP-0203), the liquid feed tank mixer (MX-0206), and the liquid feed pumps (PMP-0209 and PMP-0210). The E-Stop also sets the waste feed flow control valve (FCV-0215) to the closed position.~~

~~**AWFCO (Tag ID: ILK-007):** See subsystem GV-10~~

~~**6. Preventative and Preparedness (P&P) Procedures and Inspection Plan**~~

~~A surveillance, maintenance, and calibration event list will be provided for the key equipment and control/instrument device in this subsystem. The events will be based on the manufacturer's recommendations and will include maintenance frequency. When the facility operation is started, each surveillance, maintenance, and calibration event will be recorded and documented.~~

~~A preliminary guideline for surveillance, maintenance, and calibration events relative to this subsystem is presented below.~~

~~Surveillance activities will encompass inspection of the tanks level measurement instruments and feed pump seals on a monthly basis.~~

~~All piping and valve connections will be inspected on a weekly basis to ensure leak tightness.~~

~~Liquid feed flow meters and tank level measurement instruments will be calibrated according to the manufacturer's recommendations.~~

~~The pressure relief valves will be inspected annually and will be replaced once every year with new or reconditioned relief valves.~~

~~**Tank Flushing:** The feed tank and piping will be rinsed periodically for maintenance or avoidance of customer waste co-mingling. Rinsing is accomplished by the following method: First, a drum or flo-bin filled with rinse water is brought to the HAZMAT building. The rinse water may need to contain an organic cleaner (Kerosene, TSP) to assist in the cleansing of the tank and piping. Next, the container pump (PMP-0203) is fitted on the container outlet and the pump is turned on to introduce rinse water into the feed tank. At the same time, the tank mixer (MX-0206) is turned on to agitate the feed tank contents. When sufficient rinse water has been introduced into the tank, the container pump (PMP-0203) is stopped. To empty the rinse water out of the tank the waste feed cut-off valve (FV-0216) is closed and the feed pump (either PMP-0209 or PMP-0210) is started in order to re-circulate the tank contents. The rinse water will flush the pipe line while being re-circulated. After a period of approximately five minutes, the flush water is ready for processing into the process chamber. Feeding of the rinse water to the process chamber is accomplished in the same manner as feeding liquid waste, which was previously described. If rinsing of the tanks is accomplished during periods when the process chamber is unavailable, the rinse water can be stored in a drum or flo-bin container by placing the re-circulation line valves so that the rinse water flows to a drum or flo-bin through the discharge valve (V-02036).~~

~~**Strainer Clean-out:** The strainer (ST-0204) will be checked at the beginning and end of each feed campaign. If necessary, the strainer will be cleaned and any sludge removed from the strainer will be placed inside a batch canister and will be processed in the process chamber.~~

~~**3.2.2 Subsystem GV-02-2, Continuous Solid Feeder**~~

~~**1. General Function**~~

~~The continuous solid feeder (GV-02-2) receives waste (generally organic) that has been presorted, packaged, and labeled in the feed preparation subsystem (GV-01) and introduces the packaged waste bags into the process chamber (GV-03) at a controlled feed rate~~

~~**2. Key Components**~~

~~**Process Flow Diagram:** See drawing 31001-P-050.~~
~~**Process and Instrumentation Diagram:** See drawing 31001-P-072-02.~~
~~**Key Components:** See Table GV-02-02 in the equipment and instrument list.~~
~~**Key Component Technical Specifications:** See the technical specification package enclosed in Attachment 9.~~
~~**Key Control Devices:** See Table GV-02-02 in the equipment and instrument list.~~
~~**Control Device Technical Specification:** See the technical specification package enclosed in Attachment 9.~~
~~**Interfacing Subsystems:** feed preparation subsystem (GV-01); process chamber subsystem (GV-03); GASVIT™ process vent subsystem (GV-09); GASVIT™ main process controls (GV-10).~~

~~**3. Equipment and Process Description**~~

~~The continuous solids feeder subsystem consists primarily of an enclosed conveyor (CV-0223), a hopper (H-0224), a nitrogen-purged airlock (AL-0225), a solids feeder extruder (F-0226), and a flux additive feeder (F-0220) that introduces raw glass forms to the process to ensure a leach-resistant product. When initiating a continuous solid waste feed campaign, a series of plastic bag waste containers (GV-01-C-0102) are taken from the surge storage area (see subsystem GV-01); bar-code scanned to define and log the container waste makeup and concentrations; and placed on the feed conveyor (CV-0223). The conveyor is equipped with an indexing drive that drops only one container per event. The actuation of~~

~~each indexing event is controlled by a timer (YK-0223). The waste containers fall into the hopper (H-0224), through the nitrogen-purged airlock (AL-0225), leading into the solids feeder extruder (F-0226). The scanned information is transmitted to the main process control computer, by way of the bar-code scanner (BCS-0222), and is used to calculate the process time for each bag. The process time is determined based on the bag characteristic data (scanned information: e.g. weight, makeup, concentrations, etc.) and by setting a feed rate that is compliant with permit maximum limits. As the conveyor indexes to drop a single bag into the hopper, the position switch (ZS-0224) confirms that a new bag has been dropped, and subsequently initiates a timer for the next bag feed event. Essentially, the rate of feed is controlled by measuring the concentrations of controlled material (i.e., chlorine/ chloride and metals) in each bag and varying the time index between waste bags, accordingly.~~

~~A cut-off isolation valve (FV-0228) is placed immediately downstream of the feeder extruder to comply with permit requirements for an automatic waste feed cut-off (AWFCO) in the event of an upset in normal operating ranges. Normal permit conditions must exist to engage permission for solid feeding. Immediately adjacent to the feed isolation valve, two water cooled jackets surround the process chamber (GV-03-Y-0301) solid feed port to reduce heat propagation to and upstream of the feed isolation valve.~~

~~Glass-former additives (flux), which may also be required during the processing of certain wastes, is introduced into the process chamber through the continuous solids feeder hopper. (The glass-former additive feeder [F-0220] is discussed in subsystem GV-02-04.)~~

~~**4. Operation and Control Description**~~

~~**Establish Confinement:** Prior to conducting solid feed operations, ventilation to the conveyor/hopper enclosure and the feeder airlock, will be established and confirmed. The building confinement exhaust subsystem (GV-22) maintains the hopper/conveyor enclosure at a negative air pressure relative to the worker environment. The GASVIT™ process vent subsystem (GV-09) maintains the feeder airlock at a negative pressure relative to the hopper. A local differential pressure alarm (PDAL-0224) annunciates to warn immediate workers that airspace confinement has been breached.~~

~~**Waste Bag Positioning and Scanning:** The operator places solid waste bags (GV-01-C-0102) onto the feed conveyor (CV-0223). As the bags are being loaded, the operator scans each bag, using a bar-code scanner (BCS-0222), in the order in which the bags are placed on the conveyor. The scanned data provides bag waste characteristic information (e.g. weight, makeup, concentrations, etc.) and transmits the information to the main process control system. (See subsystem GV-10.)~~

~~**Waste Bag Indexing:** The feed conveyor includes an automatic indexing drive that automates the introduction of waste bags into the hopper (H-0224). A single bag is dropped into the hopper per indexing event. The position switch (ZS-0224) is a light sensor that confirms the bag has been dropped into the hopper. The position switch, in turn, signals the airlock inlet gate (FV-0225) to open thereby allowing the bag to enter the airlock. A preceding permissive ensures that the feeder extruder inlet gate (FV-0226) is confirmed closed prior to opening the airlock inlet gate. The airlock inlet gate then automatically recycles back to its collapsed position.~~

~~**Airlock Purge:** After the bag enters the airlock (AL-0225) and the inlet gate is closed, the closed position indicator (ZIC-0225) confirms the gate is closed and signals the flow valve (FV-0221) to purge the airlock with nitrogen. The nitrogen purge is vented to the GASVIT™ process vent subsystem. (Refer to subsystem GV-09.) The airlock continues to purge with nitrogen until the oxygen sensor (AE-0225) confirms an oxygen level below a pre-set value. The oxygen sensor signals the nitrogen purge flow valve (FV-0221) to close and subsequently signals the feeder inlet gate (FV-0226) to open. The bag then falls into the feeder extruder (F-0226) and is then forced into the process chamber at a continuous feed rate.~~

~~**Feed Waste into Process Chamber:** The feeder extruder continues to auger feed the solid waste into the process chamber through a small run (generally less than 4 feet) of pipe connected directly to the process chamber solid feed port. The feed line includes two cooling water jackets, connected in series, that control the heat propagation to and upstream of the isolation gate valve. The water temperature of the cooling jacket is monitored. A HI alarm annunciates a pre-set value and the flow to the water jackets can be manually increased.~~

~~**Feed Rate:** The variable frequency drive (VFD) for the feeder extruder is used to maintain a continuous flow rate to the extent practical. The speed setting is generally common for most organic feed material with a density of 5 - 25 lbs.per cubic foot. For wastes with a higher density, a slight adjustment to the nominal set point will be necessary. In this way, the only variable for adjusting the solid feed rate is governed by event timer (YK-0223). The timer receives a time index from the main process computer, which is based on the waste characteristics of the bag being fed at that time. Essentially, the main process computer receives waste characteristic data from the scanned information. The computer then calculates the waste concentrations and total makeup and compares the characteristic values to maximum permit values. Based on this information, the computer automatically adjusts the time index between waste bags.~~

~~**5. Safety Interlocks**~~

~~**Emergency Stop (E-Stop) (Tag ID: ILK-008):** The emergency stop (E-Stop) is a manual push-button located on the local control panel to permit immediate shut down of the continuous solid feed system in an emergency situation. The E-Stop actuates an interlock shut down for the feeder extruder (F-0226), the flux additive feeder (F-0220), the nitrogen purge flow valve (FV-0221), and the AWFCO feed isolation valve (FV-0228).~~

~~**Automatic Waste Feed Cut-Off (AWFCO) (Tag ID: ILK-007):** This interlock (ILK-007) will shut down the feeding process for each of the three waste feed systems. (Refer to subsystem GV-10.) The continuous solid. portion of the AWFCO logic is listed below.~~

~~The control signal to the solids feed solenoid valve FV-0228 will also be interrupted, closing the valve and preventing solid feeding. The valve closed position switch (ZSC-0228) will signal once the valve is closed confirming that solids feeding has been stopped.~~

~~**6. Preventative and Preparedness (P&P) Procedures and Inspection Plan**~~

~~A surveillance, maintenance, and calibration event list will be provided for the key equipment and control/instrument device in this subsystem. The events will be based on the manufacturer's recommendations and will include maintenance frequency. When the facility operation is started, each surveillance, maintenance, and calibration event will be recorded and documented.~~

~~A preliminary guideline for surveillance, maintenance, and calibration events relative to this subsystem is presented below.~~

~~Surveillance activities will encompass inspection of the airlock mechanism, feed conveyor, scanners and continuous feeder.~~

~~The following instruments must be calibrated as recommended by manufacturers.~~

~~Oxygen sensors~~

~~CO sensor~~

~~3.2.3 Subsystem GV-02-3, Solid Batch Feeder~~

~~1. General Function~~

~~The solid waste batch feeder (GV-02-3) receives wastes packaged in canisters by the feed preparationsystem (GV-01) and introduces the canisters into the process chamber (GV-03) at a controlled feed rate. Two identical batch feed charge chambers are included in the GASVIT™ system.~~

~~Note: Since two identical batch feeders are provided, only one batch feeder (No. 1) is referenced. The second batch feeder (No 2) is presented on a separate P&ID (No. 31001-P-072-04) and the reader should refer to this drawing for equipment and instrument tag numbers for the second batch feeder.~~

~~2. Reference Documents~~

~~**Process Flow Diagram:** See drawing 31001-P-050.~~
~~**Process and Instrumentation Diagram:** See drawing 31001-P-072-03 and 31001-P-072-04.~~
~~**Key Components:** See Tables GV-02-03 and GV-02-04 in equipment and instrument list.~~
~~**Key Component Technical Specifications:** See the technical specification package enclosed in Attachment 9.~~
~~**Key Control Devices:** See Tables GV-02-03 and GV-02-04 in the equipment and instrument list.~~
~~**Control Device Technical Specification:** See the technical specification package enclosed in Attachment 9.~~
~~**Interfacing Subsystems:** feed preparation subsystem (GV-01); process chamber subsystem (GV-03); GASVIT™ process vent subsystem (GV-09); GASVIT™ main process controls (GV-10)~~

~~3. Equipment and Process Description~~

~~The charge chamber unit consists primarily of a ramp feeder (Z-0234), an airlock gate (AL-0232), and a process chamber gate (CG-0230), which is essentially a plug mounted at the inlet to the process chamber. The process chamber gate is designed, in both material and geometry, to reflect sufficient heat away from the charge chamber in order to eliminate the need for a cooling water jacket. Two automatically actuated clamps (ZX-0231-01 and ZX-0231-02) are provided to lock the charge chamber gate (CG-0230) in its closed position. During the feed cycle, nitrogen is introduced into the charge chamber to purge the gases out of the chamber.~~

~~An assortment of remote actuators, position indicating switches, and preprogrammed controls and interlocks are provided for an automatic operation of the batch feed cycle. A typical batch feed cycle operates as follows. First, a series of pre-packaged cardboard canisters (C-0230), each containing approximately one cubic foot of pre-sorted waste material (refer to the feed preparation system [GV-01]), are loaded onto a ramp (Z-0234). The ramp is approximately ten feet long with a slight incline to allow the canisters to gravity roll forward to the charge chamber airlock gate (AL-0232). Once the maximum number of containers have been manually loaded onto the feed ramp, a remotely operated actuator opens the airlock gate (AL-0232) allowing one canister to roll into the charge chamber. A position indicator (ZI-0234) is provided to detect and provide a signal to the control panel when a canister is introduced to the charge chamber. Next, the airlock gate (AL-0232) closes and the nitrogen-purge valve (FV-0238) is automatically opened to introduce nitrogen and purge the charge chamber. The purged gases flow to the GASVIT™ process vent subsystem (GV-09) through a vent line. When the purge cycle is over, the purge vent line valve closes, the charge chamber gate clamps (ZX-0231-01 and ZX-0231-02) are unlocked, the chamber gate is raised (CG-0230), and the canister is allowed to drop into the process chamber. The feed~~

~~cycle is completed by positioning the chamber gate clamps (ZX-0231-01 and ZX-0231-02) back to their locked positions.~~

~~The start of the subsequent feed cycles is controlled by the GASVIT™ main control subsystem. (See GV-10.) This subsystem takes into consideration the composition of the waste in the canister and calculates the time for each feed cycle based on the maximum feed rates allowed by the permit. The canister position indicators (ZI-0234) start a feed cycle timer which is used to control the feed rates of the canisters for ensuring compliance with the permit requirements.~~

~~4. Operation and Control Description~~

~~Canister Positioning and Scanning:~~ ~~The operator places filled canisters on the ramp. The operator scans each canister with a bar-code reader (BCS-0234) according to the sequence that the canisters are placed on the ramp. The scanned data encompassing canister waste characteristics information (e.g. waste type, total weight, etc.) is transmitted to the main control system. (See GV-10.)~~

~~Feed Rate:~~ ~~At the completion of a batch feed cycle, the batch feeder is placed in standby mode. The time between each feed cycle for controlling the feed rate is set by an event timer (KY-0231) which is set by the PLC for automatic feed control, as described in subsystem GV-10. The automatic batch feed rate control is essentially a computer calculated time index between feed cycles that takes into account the metals and chlorine/chloride constituents of the feed as compared to the maximum feed rates allowed by the permit.~~

~~5. Safety Interlocks~~

~~Automatic Waste Feed Cut-Off (AWFCO) (Tag ID: ILK-007):~~ ~~Interlock (ILK-007) will shut down the feeding process for each of the three waste feed systems. (Refer to subsystem GV-10.) The solid batch feed portion of the AWFCO logic is listed below.~~

~~The close signal to the batch feeder charge chamber feed gate motors (HS-0232 and HS-0232) will be initiated, thereby closing the gates and interrupting current batch feed cycles.~~

~~Emergency Stop – Batch Feed #1 (Tag ID: ILK-046):~~ ~~The emergency stop (E-Stop) is a manual push-button located on the local control panel to permit immediate shutdown of the Batch Feed # 1 system in an emergency situation. The E-Stop actuates an interlock shut down from the PLC/Computer for the charge chamber airlock gate (AL-0232) and charge chamber gate (CG-0230).~~

~~Emergency Stop – Batch Feed #2 (Tag ID: ILK-046):~~ ~~The emergency stop (E-Stop) is a manual push-button located on the local control panel to permit immediate shutdown of the Batch Feed # 2 system in an emergency situation. The E-Stop actuates an interlock shut down from the PLC/Computer for the charge chamber airlock gate (AL-0232) and charge chamber gate (CG-0230).~~

~~6. Preventative and Preparedness (P&P) Procedures and Inspection Plan~~

~~A surveillance, maintenance, and calibration event list will be provided for the key equipment and control/instrument device in this subsystem. The events will be based on the manufacturer's recommendations and will include maintenance frequency. When the facility operation is started, each surveillance, maintenance, and calibration event will be recorded and documented.~~

~~A preliminary guideline for surveillance, maintenance, and calibration events relative to this subsystem is presented below.~~

~~Surveillance activities will encompass inspection of the airlock mechanism, feed conveyor, scanners, and batch feeder gate valves.~~

~~The following instruments must be calibrated as recommended by manufacturers.~~

~~Oxygen sensors~~
~~CO sensor~~

~~**3.2.4 Subsystem GV-02-4, Flux Feeder**~~

~~**General Function**~~

~~The flux feeder system is used to introduce glass-forming additives into the process chamber (GV-03) to assure that a durable glass product results from the treatment of the feed. This system utilizes a screw auger feeder to feed fluxing agents, such as soda ash (Na_2CO_3), as well as an additional glass former, such as silica (SiO_2), into the airlock that feeds the process chamber. The pre-mixed flux and glass former are added to a hopper that feeds the screw auger.~~

~~**2. Reference Documents**~~

~~**Process Flow Diagram:** See drawings 31001-P-050.~~
~~**Piping and Instrumentation Diagram:** See drawings 31001-P-072-02.~~
~~**Key Components:** See Table GV-02-02 in the equipment and instrument list in Attachment 9.~~
~~**Key Component Technical Specification:** See the technical specification package enclosed in Attachment 9.~~
~~**Key Control Devices:** See Table GV-02-02 in the equipment and instrument list in Attachment 9.~~
~~**Key Control Device Technical Specifications:** See the technical specification package enclosed in Attachment 9.~~
~~**Interfacing Subsystems:** waste feed preparation subsystem (GV-01); waste feed subsystem (GV-02)~~

~~**3. Equipment and Process Description**~~

~~The composition of the feed materials is utilized to determine the type and amount of fluxing agents and additional glass former that are required to assure that the resulting glass product is chemically durable and that it will meet the required specifications (e.g. pass the Toxicity Characteristic Leaching Procedure [TCLP]). Additionally, fluxes and glass former are required to assure that the feed materials will be able to be processed in the GASVIT™ system. For example, the viscosity (10 to 100 poise) and electrical conductivity (1 to 10 ohm-cm) will be within operating limits for the process chamber. The ratio of feed material to flux/glass former addition will be decided by engineering staff for each feed material processed in the GASVIT™ system. Then the feed rate will determine the required addition rate of fluxes and additional glass former.~~

~~The flux/glass former feed hopper will be purged with nitrogen to assure that oxygen does not enter the process chamber through the auger feed unit.~~

~~**4. Operation and Control Description**~~

~~**Establish Confinement:** Prior to conducting flux/glass former feed operations, the sealing of the flux/glass former feed hopper must be established and confirmed. This sealing will be confirmed by operating staff after each addition of fluxes and glass former to the hopper.~~

~~**Feed Rate:** The predetermined ratio of feed material to the flux and glass former will be set manually as a set point in the PLC controller. This set point will control the mass feed rate of fluxes and glass former to the process chamber. A low flux/glass former feed rate annunciator will alert operators to this condition.~~

~~**5. Safety Interlocks**~~

~~The E-Stop interlock for the flux feeder is specified in subsystem GV-02-2. Failure of the flux feeder motor is annunciated in the main process control panel for operation action. The feeder is also interlocked so that it can not be operated unless the continuous solid feeder is in operation.~~

~~**6. Preventative and Preparedness (P&P) Procedures and Inspection Plan**~~

~~A surveillance, maintenance, and calibration event list will be provided for the key equipment and control/instrument device in this subsystem. The events will be based on the manufacturer's recommendations and will include maintenance frequency. When the facility operation is started, each surveillance, maintenance, and calibration event will be recorded and documented.~~

~~A preliminary guideline for surveillance, maintenance, and calibration events relative to this subsystem is presented below.~~

~~The mass of fluxing agents and glass former in the feed hopper shall be surveyed to assure adequate supply of these materials are available for supply to the process chamber.~~

~~Preventative maintenance of the feed auger bearing shall be periodically performed according to the manufacturer's specifications.~~

~~**3.3 SUBSYSTEM GV-03, PROCESS CHAMBER**~~

~~**1. General Function**~~

~~The function of the GASVIT™ process chamber is to receive liquid/sludge and solid organic feeds from three different feed devices described in the feed subsystem (GV-02). The chamber heats the feed in a reducing environment such that the organic constituents in the feed are gasified while the metals and mineral contents are melted to form a molten bath. The gasified organic compounds are reacted with steam to produce a synthesis gas (syngas) which is discharged as the chamber by-product. The chamber is designed to operate safely and reliably and have sufficient residence time and temperature so that organics contained in the feed are destroyed, while maintaining low levels of particulate and metals carryover. The chamber has the capability to receive additives/fluxes that mix with the molten metals and minerals in the feed, to produce a leach-resistant product. Molten bath discharge reliability is provided by two alternative means for the discharge of the molten material in the chamber.~~

~~**2. Reference Documents**~~

~~**Process Flow Diagram:** See drawing 31001-P-051 Appendix B in this document.~~
~~**Process and Instrumentation Diagram:** See drawing 31001-P-073-01, -02, -03, -04, -05, -06, -07, -08, and -09 Appendix B in this document.~~
~~**Key Components:** See Tables GV-03 in the equipment and instrument list in Attachment 9.~~
~~**Key Component Technical Specifications:** See the technical specification package enclosed in Attachment 9.~~
~~**Key Control Devices:** See Tables GV-03 in the equipment and instrument list in Attachment 9.~~

~~**Control Device Technical Specification:** See the technical specification package enclosed as in Attachment 9.~~
~~**Interfacing Subsystems:** feed (GV-02); product handling subsystem (GV-04); GASVIT™ process vent subsystem (GV-09); GASVIT™ main process controls subsystem (GV-10).~~

~~**3. Equipment and Process Description**~~

~~The process chamber system is the heart of the GASVIT™ system and is the location where feed materials are processed to produce synthesis gas, a vitreous (glass-like) product, and metal. Two sources of energy are utilized to process the feed: the DC arc plasma zone, and the AC joule-heated zone. The DC arc plasma is created by applying a DC potential across the three 6 inch diameter graphite arcing electrodes with a single electrode at one polarity and the other electrodes at the opposite polarity. A stable plasma arc is then formed between the molten bath and arcing electrodes. The second source of energy to the process chamber is supplied directly to the molten glass through three 6 inch diameter graphite joule-heating electrodes submerged in the melt. A three-phase AC potential is placed across the joule-heating electrodes which results in current flow through the glass. The molten glass acts as a resistor so that power is supplied directly to the molten glass. Organic constituents which are subjected to the DC plasma arc and joule heating are pyrolized and steam reformed producing CO, H_2, HCl, and H_2S. Inorganic constituents decompose to oxides and dissolve into the glass phase. Any metals present in the feed settle to the bottom of the melt tank beneath the glass phase.~~

~~The process chamber is a water-jacketed 304L stainless steel vessel lined with refractory. The process chamber encompasses two subsystems for product removal: a vacuum assisted, weir overflow for slag removal and an inductively-heated bottom drain for metal removal. (See subsystem GV-04.) The process chamber proper consists of two zones, the melt tank which contains the molten slag, or glass, the metal phase which lies on the bottom of the melt tank, and the plenum, or vapor space above the melt. The chamber lining is composed of several different types of refractory and insulating materials. These materials serve to reduce energy losses to the water jacket as well as to contain the molten glass and metal phases. The plenum area of the process vessel is lined with both insulating materials as well as material to protect the steel shell from corrosive feed decomposition gases and vapors.~~

~~The process flow for the process chamber is based on the receipt of feed from the solid waste batch feed system and/or the liquid feed system, and the glass former feed system. Feed enters the process chamber and falls to the molten glass surface, forming a feed pile where the feed material is exposed to energy from the DC plasma and the joule-heated glass. Steam is injected into the process chamber plenum, in the region of the feed pile, to steam reform organic constituents. (See Section 1.2.1.) Organic constituents in the feed are destroyed, in the absence of oxygen, to produce CO, H_2, HCl, and H_2S. Inorganic oxides dissolve into the slag phase. Metals present in the feed melt and settle to bottom of the tank.~~
~~Power is input into the process from two sources, the DC plasma and AC joule heating of the molten glass. The relative fraction of power from these two sources is controlled by the operating staff and varies based on the type of feed being processed. Feeds that contain a high percentage of organic material require a higher percentage of power from the DC plasma, while feeds that contain a high fraction of inorganic material will be processed with a higher fraction of processing power from the joule-heated glass tank. The refractory temperature and the plenum temperature will also determine the amounts of power from each source. Section 1.2.1 describes the power and feed controls for the system.~~

~~All of the electrodes enter the process chamber through penetrations in the lid. The three AC electrodes enter the chamber at the perimeter of the melt tank and are equally spaced 120° apart. They protrude through the plenum, protected by Inconel alloy sheaths, into the molten glass. The joule-heating electrodes are protected from gases in the process chamber plenum by inerting the annular space between the electrodes and the sheath with an overpressure of nitrogen. The three DC electrodes also enter the~~

~~process chamber through the lid, but near the center of the chamber. Like the AC electrodes, the DC electrodes are equally spaced 120° apart. Additional nitrogen is injected into the furnace through the DC electrode penetrations in the lid of the process chamber.~~

~~The DC plasma power is controlled by way of the current and the voltage. The plasma voltage is proportional to the length of the arc, which is controlled by adjusting the physical distance between the tips of the electrodes and the molten glass surface. System operators will set the desired plasma voltage set point and manually adjust the current to achieve the desired power. The control system will correspondingly adjust the vertical position of the electrodes to maintain the plasma voltage set point.~~

~~Adjusting the AC current flowing through the molten glass bath controls the joule-heating power. The resistance of the molten glass determines the corresponding potential and power added. The resistance of the glass is controlled by its composition. Therefore, the operating staff will set the desired power as a set point and the AC power supply will achieve this power input by adjusting AC current to achieve that set point. In addition to passing AC current between the joule-heating electrodes, the electrical configuration will enable operators to pass AC current to the floor of the melt tank. The bottom of the melt tank is equipped with three electrical connections to allow this operational mode. The current can be transferred to the bottom of the furnace if the temperature of the lower melt needs to be increased; possibly to assist in pouring material through the bottom drain.~~

~~Process syngas is removed from the process chamber by way of the process syngas removal vent and subsequently treated by the process vent system. (See subsystem GV-09.) Indicators (TI-0351, PI-0352, and FI-0351) monitor the temperature, the pressure, and the volumetric flow rate of the process off gas, respectively. The process chamber is maintained under a slight vacuum by the process vent system to assure that no process gases or vapors escape untreated from the chamber. The process chamber is also equipped with an emergency off-gas vent to prevent an over pressurization of the process chamber in the event of a plug in the process off-gas jumper that connects the process chamber to the process ventilation system.~~

~~The thermal residence chamber (TRC) is a cylindrical, refractory-lined 304L stainless steel vessel. Temperature in the TRC is measured via a Type K thermocouple inserted mid-level of the vessel. The refractory lining is a material resistant to the composition of the syngas. An insulating layer of refractory is located behind the gas contact refractory to minimize heat losses from the TRC.~~

~~The TRC is an insulated, refractory-lined stainless steel vessel located between the process chamber and the high-temperature filter. The TRC has a conical bottom to collect any particulate that may settle in the vessel. Syngas, steam and any unreacted or partially reacted organic compounds flow from the process chamber into the TRC. The open volume of the TRC provides additional time at elevated temperatures allowing any uncollected reformation reactions to go to completion. The TRC assures complete destruction of organic materials processed in the system. No additional energy is added to the syngas in the TRC.~~

~~The injection of nitrogen into the plenum at the joule-heating electrode penetrations, the plasma electrode penetrations, and the steam injection penetrations maintain inert conditions in the process chamber ports. At each of these nitrogen-injection points, the overall nitrogen flow rate and pressure of the nitrogen supply header is monitored.~~

~~The external surfaces of the process chamber are water cooled via the vessel jackets. The cooling water also provides a safety backup for containment of the melt in the event of a catastrophic failure of the melt tank refractory. The water cooling jacket is made up of 13 distinct circuits, three in the process vessel lid, four in the process vessel walls, four in the process vessel floor, and two in the over flow section. The~~

~~inlet temperature of the process water as well as the outlet temperatures for each cooling water circuit are continuously monitored. In addition to the water cooling of the process chamber vessel, a high-purity process water stream cools the electrical connections to both the plasma and joule-heating electrodes.~~

~~A nitrogen-cooled thermal dam is located at the interface between the main process chamber and the overflow section of the system. This dam prevents glass from flowing around the weir. The nitrogen supply pressure to this dam is monitored along with its outlet temperature. The nitrogen exhausted from the dam is cooled by a gas/water heat exchanger and either recycled into the electrode purges or vented to the building exhaust.~~

~~**4. Operation and Control Description**~~

~~**Process Chamber Confinement:** Molten glass is established in the process chamber as described in Section 4.1. Prior to adding feed to the process chamber, the ventilation of the process chamber must be established and confirmed to assure proper function of the off-gas treatment system. Next, the desired vessel vacuum is input to the control system (PC-0644). The pressure indicator (PI-0380) monitors the plenum pressure. An enunciator alerts operators to high and low pressure conditions in the plenum (PAH-0380 and PAL-0380, respectively). These conditions indicate a potential problem with the process vent system or that the process chamber confinement has been compromised. In the event of a high-high pressure alarm (PAHH-0380) an AWFCO is activated. The process chamber is also equipped with an Emergency Off-Gas (EOG) Vent that allows gas to flow when the plenum pressure reaches a level that overcomes the WC in the seal pot, located in the line. Operators are alerted to an emergency off-gas vent by the plenum pressure alarm (PAHH-0380).~~

~~**Thermal Residence Chamber:** The TRC is essentially a wide place in the off-gas line between the process chamber and first-stage syngas processing system. Increasing or decreasing the power levels in the process chamber controls the temperature in the TRC. The temperature in the TRC is monitored via the TI-0355 thermocouple placed in the syngas flow stream. System operators are alerted to a low temperature condition in the TRC via the low temperature alarm, TAL-0355. If the temperature falls below the low-low temperature alarm level, an AWFCO is activated. Maintaining the temperature above the target temperature level assures that conditions are adequate for reformation reactions to proceed.~~

~~**Nitrogen Inerting:** The process chamber plenum and electrode entrance locations are inerted with nitrogen to assure that little air is present in the process chamber during the feed processing.~~

~~**DC Plasma Power:** DC plasma power is provided to the process chamber by way of the three central electrodes. Controlling both plasma current and potential controls the total power to these electrodes. The starting level of plasma power is determined by the feed rate and the type of feed being processed (i.e., the relative amounts of inorganic and organic constituents in the feed).~~
~~If the combined current to all three electrodes falls below a certain level, a problem with the electrodes is indicated. This condition activates an AWFCO, shuts down the power to all of the DC power supplies, raises all DC electrodes to their rest position, and alerts the operators. Once any of these automated actions are performed by the control system, the system must be restarted, as discussed in Section 4.~~

~~Note that operators may turn off the DC power supply at any time via the emergency shut down switch HS-0324.~~

~~**AC Joule-Heating Power:** Joule heating power to the glass melt is provided via three graphite electrodes that are submerged into the molten glass. A three-phase AC power supply (PS-0375) controls the power supplied to the joule-heating electrodes.~~

~~The AC power supply is equipped with an emergency cut off switch (HS-0375).~~

~~**Process Chamber Molten Tank Flushing:** Flushing of the melt tank will be performed if co-mingling of molten product from two different waste processing campaigns must be avoided. This process chamber flushing and composition adjustment will be accomplished as follows.~~

~~Utilizing the bottom drain, the glass in the melt tank will be drained until a volume of approximately 12 cubic feet remains in the tank.~~

~~The process chamber will be fed with a mixture of glass forming chemicals with a composition that is equivalent to the glass product from the next waste processing campaign.~~

~~While maintaining the glass volume at 12 cubic feet, new glass formers will be added and glass will be drained from the bottom discharge point until a volume of approximately 12 cubic feet is removed. This amount of glass, which is equal to one residence volume, is considered sufficient for flushing.~~

~~After the tank flush is completed, a sufficient quantity of glass-forming feed will be fed to the process chamber to bring the glass volume back to the normal operating level.~~

~~The next waste processing campaign will then be initiated utilizing operating conditions for waste processing.~~

~~**5. Safety Interlocks**~~

~~**High Pressure in the Process Chamber (PAHH-0380):** A high-high pressure alarm in the processing chamber indicates a problem with the off gas system. If this condition occurs an AWFCO will be activated.~~
~~**Low Temperature in the Process Chamber (TALL-0315):** A low-low temperature alarm in the off-gas indicates that the process is running on too little power or too high a feed rate. If this condition occurs an AWFCO will be activated.~~

~~**High Temperature in the Process Chamber (TAHH-0315):** A high-high temperature alarm in the off-gas indicates that the process is running on too much power or too low a feed rate. If this condition occurs an AWFCO will be activated.~~

~~**Low Current to the Arcing Electrodes (IALL-0325):** A low-low current alarm to the arcing electrodes indicates a problem with the arcing electrodes. If this condition occurs, an AWFCO will be activated.~~

~~**Low Temperature in the Thermal Residence Chamber (TALL-0355):** A low-low temperature alarm in the TRC indicates inadequate power input into the process chamber for the current feed rate. If this condition occurs, an AWEFCO will be activated.~~

~~**6. Preventative and Preparedness (P&P) Procedures and Inspection Plan**~~

~~A surveillance, maintenance, and calibration event list will be provided for the key equipment and control/instrument devices in this subsystem. The events will be based on the manufacturer's recommendations and will include maintenance frequency. When the facility operation is started, each surveillance, maintenance, and calibration event will be recorded and documented.~~

~~A preliminary guideline for surveillance, maintenance, and calibration events relative to this subsystem is presented below.~~

~~The condition of the process chamber refractory requires periodic surveillance. Monitoring the refractory temperature and observing any changes in the temperature over time comprises this surveillance.~~

~~The condition of the refractory in the TRC requires periodic surveillance. The surveillance is performed by routinely measuring the external vessel temperature. This assures the insulating refractory is in good condition. Visual examination should be performed via access ports in the vessel lid.~~

~~Required maintenance of the TRC is comprised of regular checks for accumulation of particulate in the bottom of the vessel. Any accumulation can be removed via the valved port in the bottom of the TRC. Additionally, the thermocouple will require replacement when it fails or does not meet calibration specifications.~~

~~Required maintenance of the process chamber encompasses maintenance of the plasma and joule-heating electrodes. Arcing electrodes are consumed as feed is processed. New arcing electrode material is supplied by adding new sections of electrode, as required. DC power and feeding are ceased prior to the addition of new electrode material. Furthermore, the joule-heating electrodes are consumed as feed is processed, although to a lesser degree than the arcing electrodes. Periodically, the joule-heating electrodes require replacement. When a new joule-heating electrode is required, the old electrode will be removed and a new electrode assembly installed in its place. Each joule-heating electrode assembly utilizes an Inconel alloy protection sheath.~~

~~3.4 SUBSYSTEM GV-04, PRODUCT HANDLING~~

~~1. General Function~~

~~The function of the product handling system is to discharge the molten product from the process chamber and to provide confinement during discharge. Molten glass is discharged via the side drain of the overflow section or the bottom drain of the process chamber. Molten metals are discharged through the bottom drain of the process chamber. The ventilation system maintains a slight vacuum in the enclosure to ensure containment and processes all ventilation air through a HEPA filter.~~

~~2. Reference Documents~~

~~**Process Flow Diagram:** See drawing 31001-P-052 in Appendix B in this document.~~
~~**Process and Instrumentation Diagram:** See drawings 31001-P-074-01 and 02 in Appendix B in this document.~~
~~**Key Components:** See Tables GV-04 in the equipment and instrument list in Attachment 9.~~
~~**Key Component Technical Specifications:** See the technical specification package enclosed in Attachment 9.~~
~~**Key Control Devices:** See Table GV-04 in the equipment and instrument list in Attachment 9.~~
~~**Control Device Technical Specification:** See the technical specification package enclosed in Attachment 9.~~
~~**Interfacing Subsystems:** feed (GV-03); process chamber (GV-04); GASVIT™ process vent subsystem (GV-09); GASVIT™ main process controls subsystem (GV-10)~~

~~3. Equipment and Process Description~~

~~Vitrified product, is poured from the process chamber (GV-03), via the side or bottom drains, into steel receiving canisters. The product handling system for the side and bottom drains operate similarly. Poured product from either drain is sealed from the surrounding atmosphere via a stainless steel jumper that mates the drain line with a stainless steel overpack that contains the receiving canister. A flexible metal bellows is incorporated in the connecting jumper to allow for thermal expansion. The bellows enables the mating assembly to be raised and lowered when full canisters are removed and new canisters loaded. Additionally, the bellows enables load cell measurements of each canister during pouring.~~

~~The overpack serves several purposes. Its primary purpose is to prevent air from getting into the process chamber during pouring operations. The overpack also provides for containment of the small quantity of vapors and aerosols that may emanate from the pour stream. Additionally, the overpack provides a shield for radiant energy transfer from the hot glass canisters to the surrounding equipment. Air-actuated clamps on the canister mating assembly enable operators to detach and attach canisters remotely to avoid contamination by volatile radioactive constituents. Similarly, a cable-driven cart enables operators to remotely remove and position new canisters under the drain assembly.~~

~~Molten product is poured from the bottom of the process chamber via an inductively-heated, freeze-valve drain. When molten product is not being removed via the bottom drain, a frozen plug of glass is maintained in the bottom drain by water flow through the induction coil. Pouring is initiated by applying a high-frequency (3.3 to 9.6 kHz) AC potential across the induction coil via PS-0360. This high-frequency current induces a current in the bottom drain that heats it to a point where the frozen glass plug melts allowing molten product to flow from the drain. Turning off the high-frequency power to the coil, and allowing the drain to be cooled by the water flow in the coil stops the flow by reformation of the frozen glass plug. Molten product flow can also be stopped by increasing the pressure in the bottom drain~~

~~via FCV-0423 in the nitrogen supply line. The bottom drain can be isolated from the overpack canister via isolation gate valve V-04316.~~

~~A HEPA-filtered hood ventilates the entire canister removal/addition enclosure in order to minimize radioactive contamination spread to operators and surroundings. Canisters enter and exit the product handling enclosure through the enclosure door D-0415 (for the side drain enclosure) and D-0425 (for the bottom drain enclosure). The negative ventilation pressure in the enclosure mitigates the spread of any airborne contamination.~~

~~The key control devices for each product handling system (the side and bottom drains) are the canister load cells (WI-0410 for the side and WI-0420 for the bottom), the clamping canister mating assemblies (controlled by FV-0410 and FV-0411 on the side and FV-0420 and FV-0421 at the bottom), and the isolation gate valves (controlled by FV-0412 on the side and FV-0422 at the bottom). The load cells enable continuous weight measurements of the canisters alerting operators when a canister is full and needs to be changed out. The clamps on the overpack-mating assemblies enable operators to remotely attach and detach the overpacks from the sealed drain assembly during canister changes. The isolation slide gate valve (V-04307 on the side and V-04316 on the bottom) closes to maintain a seal on the discharge pipe during can changes. Finally, the cable-driven canister conveyor enables operators to remotely position canisters under the process chamber drain.~~

~~The product handling assembles for both the side and bottom drains are shown in P&ID drawings 31001-P-074-01 and 31001-P-074-02, respectively.~~

~~4. Operation and Control Description~~

~~**Canister Replacement:** Canisters are removed and replaced under both the side and bottom drain assemblies in the same manner. Canister replacement is typically performed when a given canister is full of molten material, as indicated by the load cell measurements (WI-0410 for the side drain, and WI-0420 for the bottom drain).~~

~~Canisters enter and exit the product handling enclosure through the enclosure door (D-0415, for the side drain enclosure and D-0425, for the bottom drain enclosure). The negative ventilation pressure in the enclosure prevents the spread of any airborne contamination. Once the canister has been replaced, operators need to stage the full canister in a cool down area and add a new canister to conveyor.~~

~~5. Safety Interlocks~~

~~When the canister mating assemblies for each drain are detached from the canister, the corresponding isolation gate valve is closed. This assures a seal on the drain area and keeps molten material from pouring on the conveyor and surrounding systems.~~

~~6. Preventative and Preparedness (P&P) Procedures and Inspection Plan~~

~~A surveillance, maintenance, and calibration event list will be provided for the key equipment and control/instrument device in this subsystem. The events will be based on the manufacturer's recommendations and will include maintenance frequency. When the facility operation is started, each surveillance, maintenance, and calibration event will be recorded and documented.~~

~~A preliminary guideline for surveillance, maintenance, and calibration events relative to this subsystem is presented below.~~

~~Identify plugging or abnormal behavior and monitor the pour stream from each drain assembly.~~

~~The load cell measurements for each drain canister should be monitored regularly to assess the fill level of each canister.~~

~~3.5 SUBSYSTEM GV-05, FIRST STAGE SYNGAS PROCESSING~~

~~1. General Function~~

~~The first stage syngas processing subsystem (GV-05) reduces and maintains the process chamber exhaust gases to a temperature range of 800° - 1832° Fahrenheit during waste processing operations and filters solid particulate from the gas stream exiting the process chamber (GV-03) before it is scrubbed by the caustic scrub system (GV-06). The filter is back blown periodically by a nitrogen jet pulsing system to clean the accumulated solids from the filter surface. These solids fall to the bottom of the filter housing, through an isolation gate valve, and into a receiving container. The receiving container provides a confinement feature to minimize any potential airborne contaminant generated during the operation.~~

~~2. Reference Documents~~

~~**Process Flow Diagram:** See drawing 31001-P-051 in Appendix B in this document.~~
~~**Process and Instrumentation Diagram:** See drawing 31001-P-075 in Appendix B in this document.~~
~~**Key Components:** See Tables GV-05 in the equipment/instrument list in Attachment 9.~~
~~**Key Component Technical Specifications:** See the technical specification package enclosed in Attachment 9.~~
~~**Key Control Devices:** See Tables GV-03 in the equipment/instrument list in Attachment 9.~~
~~**Control Device Technical Specification:** See the technical specification package enclosed as in Attachment 9.~~
~~**Interfacing Subsystems:** process chamber subsystem (GV-03); second stage syngas processing subsystem (GV-06); GASVIT™ main process controls subsystem (GV-10); cooling water subsystem (GV-16); nitrogen supply subsystem (GV-15)~~

~~3. Equipment and Process Description~~

~~**Syngas Temperature Control:** The gas temperatures leaving the process chamber (GV-03) could range above 700° Celsius during waste processing operations. Before entering the first stage syngas process filter, the temperature must be reduced to an average of 700° Celsius during regular operation.~~
~~The temperature range must be controlled to below the maximum design temperature of the filter (1,000° Celsius for short durations) and above 800° Celsius in order to keep the gases above their dew points. The off-gas temperature is increased by the power input into the process chamber (using the plasma power) and decreased by an atomized water/steam spray. Temperature element TE-0351 is the sensor used to call for heating or cooling of the stream entering the filter.~~

~~**Filtration:** The first stage syngas process filter uses ceramic filter media to withstand the high temperature requirements of the service. The expected off-gas particulate from the furnace has a mass mean diameter of less than 2 microns. The particulate is collected on the filter elements until a certain pressure drop is reached, then pressurized nitrogen is blown back through the unit to clean the filter~~

~~elements. This back flow is not great enough to upset the normal flow through the off-gas system. A bypass line is provided around the filter so that it can be serviced during maintenance.~~

~~**Nitrogen Jet Pulsing:** The key control device for cleaning the filter is the nitrogen jet pulsing system. This system activates a short-duration of jet pulses of nitrogen through the filter media when the pressure drop across the filter reaches a predetermined level. The primary sensor for controlling this operation is PDI-0501.~~

~~**Residue discharge:** The off-gas particulate is collected on the filter elements until a certain pressure drop is reached, then nitrogen is blown back through the unit to clean the filter elements.~~

~~**4. Operation and Control Description**~~

~~**Filter Start-up:** The first stage syngas process filter is bypassed during the start-up of the syngas processing train. Once the process chamber gas flow is established, the filter can then be "valved in" to the process using valves V-05301 and V-05303. Note that the initial gas temperatures should be below 400° Fahrenheit so that the ceramic filter media is not thermally shocked. The filter will produce a pressure drop greater than the minimum, as specified by the manufacturer, at the given flow rate. If the pressure drop is below this minimum the filter should be valved out and examined for integrity. The off-gas temperature should be increased gradually to the target operating temperature via the process chamber plasma so that the ceramic filter media is not thermally shocked.~~

~~**Filter Operation:** The gas temperatures entering the filter should be maintained in a broad temperature range above 800 Fahrenheit° during waste processing operations to assure that the off-gas is above its dew point, but below the maximum operating temperature of the filter. Increases in power to the furnace plasma shall be made to achieve off-gas temperature increases. Conversely, decreases in power to those units and injection of an atomized steam/water spray will be used to decrease the off-gas temperature.~~

~~**Nitrogen Jet Pulse Operation:** Particulate is collected on the filter elements until a certain pressure drop is reached across the filter (read by PDI-0501). Once this pressure is reached, nitrogen is blown back through the unit to clean the filter elements. The solids blown off of the filter settle to the bottom of the filter housing through an isolation gate valve assembly (V-05304) and into a receiving canister. When the canister is full the gate valve is closed, the canister removed, a new canister added and the gate valve reopened. The canister-removal area is covered by a ventilation hood to protect workers from airborne contaminants.~~

~~**Residue Packaging:** The solids blown off of the filter settle to the bottom of the filter housing through an isolation gate valve assembly (V-05304) and into a receiving canister. The isolation gate valve is only opened when a canister is mated to the bottom of the assembly. Routine inspections of the receiving canister reveal when the canister is full enough to remove and be replaced with a new canister. Radiological dose rates in excess of predefined levels may also notify operators when a canister must be replaced. In order to replace a canister operators must access the canister through the enclosure. The isolation valve between the filter and receiving canister must first be opened. Next, the canister must be detached from the mating flange and bagged out of the enclosure. A new canister may then be added into the containment enclosure and mated to the filter. Finally, the isolation gate valve must be reopened to allow particulate accumulation to continue in the canister.~~

~~**AWFCO Controls:** The pressure drop across the filter is monitored in case it drops below a certain level (PDALL-0501). This alarm indicates a breach in the filtering media and triggers the AWFCO controller. Any problems with the filter that may result in too high of a pressure drop, despite back flow cleaning attempts, can be addressed by bypassing the filter assembly with valve V-05302.~~

~~**5. Safety Interlocks**~~

~~**Automatic Waste Feed Cutoff (AWFCO)** is triggered by PDALL-0501 and indicates a breach in the filter media.~~

~~**6. Preventative and Preparedness (P&P) Procedures and Inspection Plan**~~

~~A surveillance, maintenance, and calibration event list will be provided for the key equipment and control/instrument device in this subsystem. The events will be based on the manufacturer's recommendations and will include maintenance frequency. When the facility operation is started, each surveillance, maintenance, and calibration event will be recorded and documented.~~

~~A preliminary guideline for surveillance, maintenance, and calibration events relative to this subsystem is presented below.~~

~~The filter pressure drop data should be inspected daily to identify any obvious high or low trends which could indicate problems with the filter.~~

~~The filter back flow system should be maintained per vendor specifications.~~

~~The level of solids in the collection canister must be monitored regularly to assure that it does not over fill. This monitoring will be performed on the routine operating rounds. Radiological dose rates from the receiving canister will also be monitored. If those dose rates reach a predefined level, operators will be alerted and the canister removed before the dose rates exceed operational limits.~~

~~The residue packaging enclosure must be checked for the particulate accumulation. The radiation monitor should be surveyed daily to assure that it is on and operating.~~

~~Radiation monitor (GM-0520) should be maintained on a monthly basis with quarterly recalibration. The residue packaging enclosure HEPA filter, for that enclosure, should be flow checked monthly.~~

~~**3.6 SUBSYSTEM GV-06, SECOND STAGE SYNGAS PROCESSING**~~

~~**1. General Function**~~

~~The second stage syngas processing system provides acid gas scrubbing, mercury vapor abatement, and particulate removal capability to clean the gas stream exiting the first stage syngas processing system (GV-05). The second stage syngas processing system also conditions all syngas effluent to the acceptable entrance limits for the third stage syngas processing (GV-07). The design of the second stage syngas processing system includes provisions for complete bypass of the first stage syngas processing unit. Note that the two scrubbers, together, have a design removal efficiency for HCl of 99.96 percent at a flow rate of 50 lbs. per hour of HCl.~~

~~2. Reference Documents~~

~~**Process Flow Diagram:** See drawing 31001-P-052-01 in Appendix, Attachment #7 (RR). in this document.~~
~~**Process and Instrumentation Diagram:** See drawing 31001-P-076-01, -02, -03, -04, and -05 in Attachment 7.~~
~~**Key Components:** See Tables GV-06 in the equipment and instrument list in Attachment #9.~~
~~**Key Component Technical Specifications:** See the technical specification package enclosed as in Attachment 12.~~
~~**Key Control Devices:** See Tables GV-06 in the equipment and instrument list in Attachment #9.~~
~~**Control Device Technical Specification:** See the technical specification package enclosed in Attachment 9.~~
~~**Interfacing Subsystems:** first stage syngas processing subsystem (GV-05); third stage syngas processing (GV-07); secondary waste subsystem (GV-11); GASVIT™ main process controls subsystem (GV-10); cooling water subsystem (GV-16)~~

~~3. Equipment and Process Description~~

~~The process flow for the second stage syngas processing system involves wet gas scrubbing with tandem ejector scrubbers. The scrubbers are packed tower absorption units, followed by a high efficiency mist elimination unit, pre-heater, HEPA filters, and post HEPA carbon filters for mercury abatement. A description of each unit is as follows:~~

~~**High-Temperature Ejector Scrubber and Packed-Tower Acid Gas Scrubber:** The first ejector reduces the incoming gas temperature from approximately 1,000° Celsius to below 60° Celsius using a sub-cooling system with a heat exchanger. This cooler is designed to remove approximately 937,000 Btu/hour of thermal energy from the gas stream during normal operation. This energy is transferred to the process cooling water subsystem (GV-16). The ejector scrubber is fabricated using Alloy C-276 with high-alumina refractory in the inlet portion of the ejector. The packed tower and re-circulation tank are constructed of 11 gauge Alloy C-276. The packed tower includes an Alloy C-276 packing support, ceramic super intalox saddle packing, and non-metallic liquid distribution. The first ejector and packed tower system is equipped with a re-circulation pump capable of delivering 50 gallons per minute at 85 Pounds per Square Inch Gauge (psig).~~

~~**Second Stage Ejector Scrubbing System:** The second stage scrubbing system provides acid gas scrubbing to remove all remaining acid gas constituents to regulatory release limits and to remove a portion of the Hg vapors. The second ejector reduces the incoming gas temperature from approximately 60° Celsius to below 10° Celsius using a sub-cooling system with a heat exchanger. This cooler is designed to remove approximately 296,000 Btu/hour of thermal energy from the gas stream during normal operation. This energy is transferred to the chilled process cooling water subsystem. The ejector scrubber is fabricated using Alloy C-276 with high alumina refractory in the inlet portion of the ejector. The packed tower and re-circulation tank are constructed of 11 gauge Alloy C-276. The packed tower includes an Alloy C-276 packing support, polypropylene super intalox saddle packing, and non-metallic liquid distribution. The final stage of the packed column absorber includes an Inconel 625 mesh-type mist eliminator. The second ejector and packed tower system is equipped with a re-circulation pump capable of delivering 50 gallons per minute at 85 psig.~~

~~**High-Efficiency Mist Eliminator (HEME):** The high-efficiency mist eliminator (HEME) provides final removal of fine mists from the syngas prior to final filtration and conditioning. The HEME is equipped with a TeflonÆ filter element and an Inconel 625 mesh-type mist eliminator as well as a heat exchanger~~

~~for cooling the 1 gallon per minute of makeup water to the system from 20°C to 2°C. This energy is transferred to the chilled process cooling water subsystem.~~

~~**High Performance Centrifugal Fan:** Two high-efficiency radial blade fans (BLO-0644 and BLO-0645), piped in parallel, provide the required draft on the GASVIT™ process chamber and the wet scrubber system syngas processing train to ensure adequate vacuum is maintained in the overall system and that the required flow of syngas is maintained. If one fan fails the other fan starts to maintain a draft through the system. Each fan is variable speed and controls the plenum pressure via PC-0644. Note that a minimum flowrate is maintained from the process chamber by keeping the supplemental nitrogen flowrate above 10 SCFM at all times (controlled by FCV-380).~~

~~**Gas Reheater:** The syngas is reheated after exiting the second stage syngas processing unit to raise the temperature well above the gas dew point. This prevents water impingement of the subsequent HEPA filters and mercury adsorption carbon filters. The gas reheater (HT-0646) uses Incoloy sheathed electric heating elements controlled by an SCR in an Alloy C-276 housing. The heating elements provide up to 50,000 Btu/hour to heat the gas stream to a minimum of 25° F above the saturation point, before filtration through the HEPA and Carbon filters.~~

~~**HEPA Filters:** The HEPA filter housing is constructed of 316 SS (in accordance with ASMG W509/5) with ground and polished internal surfaces. Each filter of the parallel HEPA filter systems (FLT-0641 and FLT-0642) houses a pre-filter, followed by a HEPA filter (99.97 percent efficiency for particulates greater than or equal to 0.3 micron), with a knife-edge seal. Each filter housing incorporates a bag-in/bag-out ring to enable containment of radioactive materials collected in the HEPA during filter replacement activities. Each filter is sized to handle 100 percent of the total syngas flow and is equipped with a pre-filter and HEPA filter element.~~

~~**High Performance Centrifugal Booster Fan:** An additional high-efficiency radial blade fan (BLO-0646), boosts the syngas flow through the HEPA and the carbon filter trains. This additional fan provides the required motive force to ensure that a negative pressure is maintained in the filters as well as overall system. A maintenance bypass line is provided for this fan. During maintenance, or in the event of a fan failure, the fan bypass valve is opened and the main syngas fans (BLO-0644 and BLO-0645) will be used to flow the syngas through the bypass line.~~

~~**Post HEPA Carbon Filters**. The carbon filter housing is also constructed of 316 SS with ground and polished internal surfaces. Each filter assembly of the parallel carbon filter (FLT-0660 and FLT-0661) consists of four sections. The first section, the primary carbon bed, is located in front of the filter assembly and houses a carbon media that is impregnated for mercury removal. The second section, the plenum, is an empty gas space down stream of the primary carbon bed. A mercury vapor sampling and detection system is installed in this section. The third section, the backup carbon bed, contains a carbon media that is similar to the media in the primary carbon bed. This section is provided to increase the filtration system mercury abatement reliability. The last section, polishing filter, contains a roughing filter element that removes carbon fines in the event that such fines are released from the carbon media in the beds. Each filter train is sized to handle 100 percent of the total syngas. The filter assembly is sized for a flow rate of 300 scfm and to adsorb approximately 0.006825 lb/hr of elemental mercury, which is based on 85% removal efficiency in the two scrubbers preceding the carbon filter.~~

~~The carbon media has an operating temperature range of 50 °F to 248 °F, however the actual operating range for the syngas inlet is 75 °F to 140 °F. The filter is designed for a minimum gas residence time of approximately two (2) seconds to ensure an overall removal efficiency of 99.7%. This removal efficiency exceeds the estimated removal efficiency used in the MWF Preliminary Risk Assessment calculation~~

~~(97.5%). The higher removal efficiency of the carbon media ensures that the GASVIT™ system will meet the MACT standards applicable to mercury emissions.~~

~~The maximum mercury loading to the carbon media is 15% by weight. The weight of the carbon media in the primary filter section is approximately 972 lb (assuming a density of 34.4 lb/ft^3). The calculated maximum media life in the primary bed is then 2.14 yr, assuming 85% of the mercury is removed by the scrubbers. The calculated minimum bed life is 0.32 yr, assuming no mercury is removed by the scrubbers. The back-up carbon in the third section of the filter has approximately 14% of the media mass in the primary bed. Hence, the anticipated life of the back-up carbon bed is 0.3 yr. (maximum) and 0.05 yr. (18 days minimum). These carbon bed life calculations are highly conservative because they are based on the assumption that the GAVSIT™ will operate continuously at the maximum permitted solids feed rate (350 lb/hr) with the maximum allowable mercury concentration (0.0455 lb/hr).~~

~~**4. Operation and Control Description**~~

~~**High Temperature Ejector Scrubber and Packed Tower Acid Gas Scrubber:** The operation of the high-temperature scrubber and packed tower system involves the use of water as a scrub solution. *The water is fed to the ejector at a rate of 50 gallons per minute, at a pressure of 85 psig. If the flow rate to the ejector falls below 30 gallons per minute an AWFCO response is triggered.* The scrubbing solution is neutralized with sodium hydroxide solution. Fresh caustic solution is automatically added to the scrubber tank based on a pH feed back control loop (AIC-602) which adjusts valve ACV-601. A portion of the re-circulated scrub solution is directed to the packed tower liquid distributor *at a rate of approximately 6 gallons per minute*. A separate stream of scrub solution re-circulates through disposable filter cartridges to remove particulate from the scrub solution tank.~~

~~**Second Ejector Scrubber:** The operation of the second scrubber and packed tower system also involves the use of water as a scrub solution. *The water is fed to the ejector at a rate of 50 gallons per minute and a pressure of 85 psig. If the flow rate to the ejector falls below 30 gallons per minute an AWFCO response is triggered.* This scrub solution is also neutralized with sodium hydroxide solution. Fresh caustic solution is automatically added to the scrubber tank based on a pH feed back control loop (AIC-621) which adjusts valve ACV-621. And, like the primary scrubber, a portion of the re-circulated scrub solution is directed to the packed tower liquid distributor *at a rate of approximately 6 gallons per minute*. A separate stream of scrub solution is recirculated through disposable filter cartridges to remove particulates from the scrub solution tank.~~

~~**High Efficiency Mist Eliminator (HEME):** The high efficiency mist eliminator (HEME) is used to remove liquid aerosols and sub-micron particulate that exit the second stage packed tower scrubber. HEME fiber filters can also remove acid or caustic fumes. *Since the HEME can be operated wet, a water spray can be periodically employed to wash down and clean the filter element of accumulated solids. This spray consists of a 1 gallon per minute re-circulated scrubbing solution stream fed from a 2 horse power (HP) pump, at 20 psig. The normal operating differential pressure of the HEME is 12 inches of water column at maximum operating syngas flow rate.*~~

~~**High Performance Centrifugal Fan:** Two high efficiency radial blade fans (BLO-0644 and BLO-0645) piped in parallel, provide the required draft on the GASVIT™ process chamber and the entire syngas processing train to ensure adequate vacuum is maintained in the overall system and that the required flow of syngas is maintained. If one fan fails the other fan starts to maintain a draft through the system. Each fan is variable speed and controls the plenum pressure via PC-0644. Note that a minimum flowrate is maintained from the process chamber by keeping the supplemental nitrogen flowrate above 10 SCFM at all times (controlled by FCV-380).~~

~~**Gas Reheater:** The syngas reheater (HT-0646) maintains the temperature of the syngas *at the setpoint of 140° Fahrenheit* using temperature feed back control (TIC-0646) and uses a temperature-sensing element (TE-0646). *The gas exiting the second stage syngas processing unit enters the syngas reheater at approximately 35°-50° Fahrenheit.* The electric heater, as described in section 3 above, can *provide up to 50,000 Btu/hour to* heat the syngas *to the required 140° Fahrenheit* to ensure an adequate margin of temperature is maintained above the dew point prior to exhausting the syngas through the HEPA and mercury carbon filters.~~

~~**HEPA Filters:** The parallel HEPA filter system (FLT-0641 and FLT-0642) housings are constructed of 316 SS with ground and polished internal surfaces. The filter housings are equipped with a bagout ring to enable containment of radioactive materials collected in the HEPA filter during replacement activities. Each filter is sized to handle 100 percent of the total syngas flow. The differential pressure across each HEPA filter (PDI-0641) is monitored. A high differential pressure alarm signal from the switch is sent to the AWFCO controls (see subsystem GV-10) via PDAHH-0641.~~

~~**High Performance Centrifugal Booster Fan:** The high efficiency radial blade fan (BLO-0646) provides additional draft for the GASVIT™ process chamber and the entire syngas processing train to ensure the HEPA filters are under vacuum and that the required flow of syngas is maintained at a pressure required to flow the syngas through the flame arrestor (Z-0718).~~

~~**Post HEPA Carbon Filters.** The post HEPA carbon filters are designed for efficient and reliable mercury vapor abatement. There are two parallel filter trains and each filter train is designed for 100% syngas flow. As explained previously in this section, each filter train has four sections: the primary filter bed, the plenum, the second carbon bed and the polishing filter. During normal operation one filter train is in service while the second unit is in standby. The primary carbon bed in the filter train removes Mercury vapor in the syngas. When the bed reaches its saturation capacity, the mercury detector in the plenum space will initiate a high mercury alarm in the GASVIT™ system main control room. It should be noted that this alarm means that a breakthrough in the first carbon bed has occurred while the second carbon bed still has capacity to remove mercury vapor from the syngas stream. The high mercury alarm is set at 350ug/m3. The alarm set point is calculated by 1) setting the mercury concentration in the gas exiting the converter to a value of 40 ug/dscm, 10% below the MACT standard of 45 ug/dscm, 2) assuming a flow rate of 5,000 scfm at the converter outlet, 3) assuming a syngas flow rate of 250 scfm through the carbon filter where the mercury monitor is located, 4) assuming that the dry flow at the monitoring location is 50% of the total flow, and fionally 5) adjusting the high mercury alarm concentration for a non-standard temperature of 120°F. The alarm setting is than 100 times higher than the mercury detection limit. Upon receipt of the high mercury alarm, the operator manually aligns the manifold valves to route the syngas through the standby filter unit. A vacuum device that has both HEPA and carbon filter at its exhaust line is used to remove the spent carbon media from the bed. Before removing the spent carbon, the filter train is purged with nitrogen. Similarly, after filling the filter with new carbon media, the filter train is purged with nitrogen before placing the unit in stand-by service. A carbon monoxide monitor in the filter discharge line provides indication to the operator that the unit has been safely purged and is ready for maintenance. Likewise, an oxygen monitor provides indication that the carbon filter is sufficiently inerted before placing the filter into operation. The spent carbon media will be packaged and sent to offsite facilities for processing and disposal. To ensure that the filters are not plugged, the differential pressure across the filter trains (PDI-0660) is monitored. A high differential pressure alarm signal from the switch is sent to the AWFCO controls (see subsystem GV-10) via PDAHH-0660. The differential pressure across the filter during maximum flow conditions is calculated to be 15.07-inch w.c. The high-pressure alarm is set at twice the pressure drop, that is 30-inch w.c. The syngas reheater (HT-0646) maintains the syngas temperature above the dew point prior to entering the post HEPA carbon filters. The temperature margin is sufficient to prevent condensation in the post HEPA carbon beds. To avoid possible buildup of condensate in the carbon filters, a low-low temperature signal~~

~~from a temperature-sensing element (TE-0646) at the inlet of the HEPA filter is interlocked to initiate an AWFCO alarm. This temperature is set at 75°F which is 25°F above the highest syngas dewpoint at 50°F. The manufacturers recommended operating temperature range for which the carbon media can provide a minimum of 99% removal efficiency is 50 °F – 248 °F. In order to ensure that the inlet gas does not exceed the upper bound temperature limit, a high-high temperature alarm from temperature-sensing element (TE-0646), which is set at 200 °F, will initiate an AWFCO event. To further enhance mercury abatement, the heat exchange in the second scrubber recirculation loop is used to lower the temperature of the second scrubber liquid to approximately 50° F. This lower temperature minimizes the amount of mercury vapor that may get entrained in the syngas exhaust.~~

~~**Final Flow Rate Element:** The total flow rate of the syngas is continuously monitored *using a pitot tube flow rate measuring device (FI-0644)*. This flow rate is tied into the AWFCO system to prevent operation of the feed system under high syngas flow rates, which is a condition in which the process chamber retention time is reduced.~~

~~**5. Safety Interlocks**~~

~~**No. 1 Scrubber Injector Low-Low Flow Rate (FALL-0601):** A low-low flow rate in the scrub solution spray line for the first scrubber indicates a plug in that line or that the pump is no longer functioning. If this condition occurs an AWFCO will be activated.~~

~~**No.2 Scrubber Injector Low-Low Flow Rate (FALL-0621):** A low-low flow rate in the scrub solution spray line for the second scrubber indicates a plug in that line or that the pump is no longer functioning. If this condition occurs an AWFCO will be activated.~~

~~**No.1 Scrubber Injector Low-Low Pressure (PALL-0601):** A low-low injector pressure may be the result of either a scrubber pump failure or a scrubber injector failure. This event is interlocked to the initiate an AWFCO event.~~

~~**No.2 Scrubber Injector Low-Low Pressure (PALL-0621):** A low-low injector pressure may be the result of either a scrubber pump failure or a scrubber injector failure. This event is interlocked to the initiate an AWFCO event.~~

~~**No.1 Scrubber Injector Low-Low Recirculation Flow (FALL-0602):** A low-low recirculation flow may be the result of scrubber recirculation pump failure. This event is interlocked to initiate an AWFCO event.~~

~~**No.2 Scrubber Injector Low-Low Recirculation Flow (FALL-0622):** A low-low recirculation flow may be the result of scrubber recirculation pump failure. This event is interlocked to initiate an AWFCO event.~~

~~**No. 2 Scrubber Low-Low pH : Empty (AALLL-6022):** A low-low pH measured in the scrub solution for the second scrubber indicates inadequate caustic neutralization. If this condition occurs an AWFCO will be activated. This AWFCO interlock has an instantaneous and a rolling average low-low pH value.~~

~~**No. 2 Scrubber High-High Conductivity (AHH-0623):** A high-high conductivity signal from the second scrubber may indicate a failure of the scrubber blow down system. This event is interlocked to initiate an AWFCO event.~~

~~**High-High Differential Pressure Across HEPA Filters (PDAHH-0641):** A high-high differential pressure across the HEPA filters indicates a problem with the filter. If this condition occurs an AWFCO will be activated.~~

~~**High-High Differential Pressure Across Carbon Filters (PDAHH-0660):** A high-high differential pressure across the carbon filters indicates a problem with the filter. If this condition occurs, an AWFCO will be activated.~~

~~**High-High Off-Gas Flow Alarm (FAHH-0644):** A high-high off-gas flow rate may indicate a breach in the HEPA filter or other problem with the off-gas system. If this condition occurs an AWFCO will be activated.~~

~~**High-High HEPA/Carbon Filter Inlet Gas Temperature (TAHH-0646):** A high-high inlet temperature could reduce the mercury removal efficiency of the carbon media. An AWFCO event will be activated if this condition occurs.~~

~~**Low-Low HEPA/Carbon Filter Inlet Gas Temperature (TAHH-0646):** A low-low inlet temperature could result in gas condensation in the carbon media and reduce the mercury removal efficiency of the carbon media. An AWFCO event will be activated if this condition occurs.~~

~~**6. Preventative and Preparedness (P&P) Procedures and Inspection Plan**~~

~~The normal surveillance procedures for the GASVIT™ system syngas processing unit will include monitoring of all critical elements as detailed in subsystem GV-10.~~

~~**3.7 SUBSYSTEM GV-07, THIRD STAGE SYNGAS PROCESSING**~~

~~**1. General Function**~~

~~The third stage syngas processing (i.e., syngas conversion) system provides final conditioning, via conversion of syngas to the stable products of water and carbon dioxide, prior to discharge.~~

~~**2. Reference Documents**~~

~~**Process Flow Diagram:** See drawing 31001-P-052-02 in Attachment 7.~~
~~**Process and Instrumentation Diagram:** See drawing 31001-P-077-01 and 02 in Attachment 7.~~
~~**Key Components:** See Table GV-07 in the equipment and instrument list in Attachment 12.~~
~~**Key Component Technical Specifications:** See the technical specification package enclosed in Attachment 9.~~
~~**Key Control Devices:** See Table GV-07 in the equipment and instrument list in Attachment 9.~~
~~**Control Device Technical Specification:** See the technical specification package enclosed in Attachment 9.~~
~~**Interfacing Subsystems:** second stage syngas processing subsystem (GV-06); GASVIT main process controls subsystem (GV-10); and GASVIT Building confinement System (GV-22).~~

~~**3. Equipment and Process Description**~~

~~Subsystem GV-07 is the final stage for syngas conditioning, prior to discharge. The syngas will convert the stable products of water and carbon dioxide in a flameless conversion reaction process accomplished by keeping the syngas concentration below its lower flammability limit (LFL). If the conversion air supply to the converter drops below a low flow set point, the control system will automatically bypass the~~

~~syngas flow around the converter, to avoid a potential buildup of LFL syngas concentrations in the converter. The syngas entering the converter has already been scrubbed and filtered (refer to subsystems GV-05 & 06) to remove trace acid gases and particulates. A maximum 250 SCFM postulated syngas flow rate is expected during maximum organic waste feed rates through the process chamber (GV-03-Y-0301). The syngas composition for maximum and minimum organics, respectively, are presented in the following table.~~

~~Syngas Component~~	~~MW~~	~~Syngas Composition Ranges~~				
		~~Mole Fraction~~	~~Mole Fraction~~	~~Mole Fraction~~	~~Minimum~~	~~Maximum~~
~~H2~~	~~2.02~~	~~3.32%~~	~~37.71%~~	~~46.44%~~	~~0.00%~~	~~55.00%~~
~~CO~~	~~28.01~~	~~8.07%~~	~~30.17%~~	~~29.33%~~	~~5.00%~~	~~55.00%~~
~~CO2~~	~~44.01~~	~~22.20%~~	~~0.71%~~	~~0.48%~~	~~0.00%~~	~~55.00%~~
~~O2~~	~~32.00~~	~~0.00%~~	~~0.00%~~	~~0.00%~~	~~0.00%~~	~~0.00%~~
~~N2~~	~~28.01~~	~~51.70%~~	~~16.71%~~	~~9.07%~~	~~5.00%~~	~~85.00%~~
~~H2O~~	~~18.02~~	~~14.69%~~	~~14.69%~~	~~14.69%~~	~~5.00%~~	~~20.00%~~
~~NO~~	~~30.01~~	~~0.00%~~	~~0.00%~~	~~0.00%~~	~~0.00%~~	~~1.00%~~
~~NH3~~	~~17.04~~	~~0.00%~~	~~0.00%~~	~~0.00%~~	~~0.00%~~	~~1.00%~~
~~SO2~~	~~64.06~~	~~0.00%~~	~~0.00%~~	~~0.00%~~	~~0.00%~~	~~1.00%~~
~~H2S~~	~~34.08~~	~~0.01%~~	~~0.00%~~	~~0.00%~~	~~0.00%~~	~~1.00%~~
~~S~~	~~32.06~~	~~0.01%~~	~~0.00%~~	~~0.00%~~	~~0.00%~~	~~1.00%~~
		~~100.00%~~	~~100.00%~~	~~100.00%~~		
	~~SCFM~~	~~52.40~~	~~143.93~~	~~239.44~~	~~24.00~~	~~250.00~~
~~G41~~	~~Btu/lb~~	~~5,984~~	~~9,040~~	~~36.8~~		
	~~Btu/sft²~~	~~10,163~~	~~219.4~~	~~245.1~~		

~~The third stage syngas processing system is a vendor supplied package unit, comprising of a flameless syngas converter (Z-0703) (Text deleted.) and support equipment (e.g., seal pot, flame arrestor, water quench tower, pumps, blowers, instrumentation).~~

~~**Syngas Converter:** The conversion unit (Z-0703) consists of a reinforced, insulated bed chamber filled with ceramic heat exchanger media. The syngas flow is automatically controlled by a zero leakage poppet valve mechanism (FCV-0706-01 and 02) which reverses the direction of the syngas flow, through the beds, at regular intervals. The syngas flow direction is controlled via a locally mounted integral programmable logic controller (PLC). An external burner is used only for initial cold startup, typically twelve hours. An additional natural gas supplement unit provides supplement fuel to the oxidizer in the event that the syngas total BTU content falls below a preset value.~~

~~The syngas is combined with the conversion air at the suction of the conversion air blower (BLO-0702). The static mixer helps to properly mix the syngas with the conversion air to avoid stratification. This in turn helps to mitigate pressure spikes or hot flashes in the chamber. Back flame propagation is mitigated by the inclusion of two design features: First, the conversion chamber is isolated from the incoming conversion air and syngas mixture by a water seal mechanism at the inlet of the chamber. Second, a water seal drum (Z-0718) is provided at the incoming syngas line just up stream of the syngas blower.~~

~~Conversion air is supplied by the conversion blower BLO-0702 and regulated by flow control valve FCV-0706. The system has been sized so there is always sufficient conversion air to keep the converter below the lower explosive limit (LEL). When the converter is operating in standby mode, maintaining temperature with natural gas alone, the inlet air-natural gas mixture is 34% of the LEL. When the converter is maintaining temperature processing the design syngas mixture (which includes some supplemental natural gas) the inlet air-CO-H_2-natural gas mixture is 77% of the LEL. The converter is equipped with several safety systems to ensure that the inlet mixture does not reach the LEL. These systems include both LEL monitoring and temperature monitoring, each with shutdown interlocks. When the inlet air-CO-H_2-natural gas mixture reaches 85% of the LEL, the monitor will send an alarm signal to activate the GASVIT™ system automatic waste feed cutoff (AWFCO) controls. The LEL monitoring instrumentation accuracy, which is plus or minus 3% of the instrument full range (full range is 0-150%), when added to the AWFCO LEL alarm setting of 85% keeps the gas mixture 90% of the LEL. In the presence of abundant oxygen content of the process gas, complete conversion readily occurs when the oxidation reaction point is reached in the converter (typically 1500°-2,000° Fahrenheit). Process hydrocarbons are converted to carbon dioxide and water vapor. With a sufficient concentration of flammable constituents in the incoming process gas (syngas), the syngas will be sufficiently exothermic so that the conversion of syngas to CO_2 and H_2O will be virtually self-sustaining. A small quantity of auxiliary heat energy will be added to maintain precise temperature control. Conversely, if the process chamber is running idle or if organic feed is deficient in the process, the resultant syngas will fall short of the minimum BTU content for a self-sustaining reaction. When this happens, an auxiliary natural gas supplement unit introduces additional fuel into the converter system to maintain the reaction.~~

~~A high degree of heat recovery is achieved as a result of regenerative (or recuperative) heat transfer. The organic vapor-laden syngas enters a porous bed filled with high temperature ceramic heat transfer media. The syngas-air mixture is preheated by the ceramic bed to a maximum temperature. At this point the hydrocarbons are converted to carbon dioxide and water vapor. The converted syngas then exits to a quench tower (Z-0730) to reduce the exhaust temperature before being routed to the building confinement exhaust subsystem (GV-22).~~

~~4. Operation and Control Description~~

~~**Cold Start-up:** For initial or cold start-up, the oxidizer unit is ramped up to the design operating temperature of 1,700° Fahrenheit, via an external start-up pre-heater management unit, typically up to twelve hours. A natural gas injection system is used to allow the oxidizer unit to be operated without the use of the start-up burner. This eliminates the need for combustion excess air and reduces natural gas consumption by up to 40 percent.~~

~~**Syngas Conversion:** At full operation, the maximum syngas flow rate entering the oxidation chamber is 240 SCFM with a weighted average heat of combustion calculated to approximately 277 BTU/cubic foot (10,163 BTU/lbm). The total heating value is 3,521 kBTU/hour (e.g., approximately equivalent to an 80 hp steam generator).~~

~~Syngas is introduced into the converter via variable speed blower GV-06-BLO-0644 or 0645, start-up pre-heater management unit (refer to subsystem GV-06, second stage syngas processing), and measured by flow indicator FIT-0702. At the same time, make-up air is metered into the syngas flow steam, via flow control valve FCV-0706. The automated flow ensures that sufficient excess air is introduced into the syngas flow-stream, prior to the converter ceramic bed, to guarantee the syngas mixture remains below the maximum LFL set point.~~

~~As the syngas enters the bed, it is preheated to a pre-determined maximum temperature. The heated syngas is the oxidized (via flameless thermal oxidation) to form carbon dioxide and water vapor. The gas then exits the combustion chamber to the water quench tower (Z-0730).~~

~~The quench tower (Z-0730) is able to lower the boiler exhaust temperature below 350° F. After the converter exhaust is cooled even further, by combining it with the building ventilation, the combined air temperature safely meets the maximum allowable temperature requiement (i.e., T<200°F) for the HEPA filters on the GASVIT building exhaust units (EFU-2263 and 64).~~

~~**Syngas Converter Bypass:** A syngas bypass (FCV-0705) feature is provided to automatically bypass the converter/boiler unit in the event of a system upset. The system abnormal conditions that what initiate a bypass are: 1) a syngas low flow condition; 2) a dilution air low flow condition; 3) a building exhaust fan failure condition; 4) a syngas converter low temperature, and a quencher exhaust total carbon (high) condition. These abnormal conditions and respective safety features are discussed later in this subsystem description.~~

~~**5. Safety Features**~~

~~Risk of accidental over-pressurization in the GASVIT™ syngas processing line is mitigated by several design features listed below: 1) the syngas will be converted to water and carbon-dioxide in a flameless oxidation reaction process accomplished by maintaining the syngas concentration below its lower flammability limit (LFL); 2) if the air supply to the converter drops below a low flow set point, the local control system will automatically cut off the syngas flow to the converter and simultaneously route the syngas to a bypass line, thus, preventing a potential build-up of syngas in the converter at concentrations that could initiate a burning of the syngas; 3) accidental flow of flame from the converter to the scrubbers section (refer to subsystem GV-05 and O6) is eliminated by designing the syngas pipe sizes such that the normal velocity of the flow in the ID fan discharge line is above the fuel flame velocity; 4) to further prevent the travel of a flame front from the converter to the scrubbers section, a seal pot and a flame arrestor will be installed on the syngas inlet to the converter; 5) to prevent the further travel of accidental flame from the conversion zone in the converter to the upstream piping, a water seal will be nstalled at the bottom of the converter; 6) a flammability meter, monitoring the syngas LFL, will be placed between the dilution air/syngas eductor and the inlet to the syngas converter; and ; 7) the conversion air blower and the associated electrical equipment n the converter system will be explosion proof construction.~~

~~**Syngas Converter Bypass (ILK-028):** The following abnormal conditions initiate a syngas bypass around the third stage converter 1) a syngas low flow condition; 2) a dilution air low flow condition; 3) a building exhaust fan failure condition, and 4) a syngas converter low temperature; and 5) a quench exhaust total carbon (high) condition. The local bypass alarm in turn initiates an AWFCO, via logic tag number YN-0700. Each of these conditions are discussed below:~~

~~**Syngas Low-Low Flow (FALL-0702):** If the syngas blower fails, it is possible that air could be forced, by the dilution air blower, back through the syngas line into the high temperature region. This could result in a combustion of syngas, accompanied by a potential over-pressurization of piping and equipment. Therefore, if the syngas flow rate falls below a predefined set point, low flow alarm FAL-0702 initiates the nitrogen line to supplement the flow so that the total flow in the syngas line is maintained above a pre-set limit. If the syngas flow falls below the low-low set point, the syngas converter failure signal is initiated.~~

~~**Conversion Air Low-Low Flow (FALL-0700):** The converter is designed to operate in a flameless mode by virtue of a packed ceramic bed with the added safety feature of receiving an air-fuel mixture~~

~~with a fuel (syngas) concentration that is below the syngas lower flammability limit (LFL). Failure of the dilution air blower can lead to a fuel concentration momentarily exceeding the LFL. If this occurs, a flame-front could propagate through the syngas/air mixture. This could result in a pressure surge in the converter, and it could also result in over-pressurization of piping and equipment in the low-temperature region. Therefore, instrumentation will be provided to ensure that the ratio of dilution air to syngas flow is controlled to provide a mixture that is below the LFL of the mixture. Dilution air low-low flow alarm FALL-0700 is therefore set to bypass the syngas if the dilution air flow is not sufficient to ensure the mixture stays below the LFL.~~

~~**Building Exhaust Fan Failure:** Again, to prevent the potential of accumulating syngas concentrations that are above the LFL logic from the GASVIT™ building exhaust fans initiate a syngas converter bypass when a building exhaust fan failure condition occurs.~~

~~**Missing text**~~

~~**Syngas Converter Low Temperature (TAL-0703-03):** A minimum syngas converter temperature of >750° F. is required to correctly treat the syngas. For this reason, TAL-0703-03 is linked to the syngas bypass and initiates at the preset temperature level.~~

~~**Quencher exhaust total carbon high (AAHH-0715):** If the exhaust from the quencher exceeds 50 ppm, this would indicate a failure with the oxidizer. At this limit, the oxidizer shuts down and initiates an AWFCO.~~

~~**Missing text**~~

~~**Missing text**~~

~~**6. Preventative and Preparedness (P&P) Procedures and Inspection Plan**~~

~~A surveillance, maintenance, and calibration event list will be provided for the key equipment and control/instrument device in this subsystem. The events will be based on the manufacturer's recommendations and will include maintenance frequency. When the facility operation is started, each surveillance, maintenance and calibration event will be recorded. Also, as indicated above, during normal plant operation, programs will be instituted to perform routine syngas inspection.~~

~~**3.8 SUBSYSTEM GV-08, SYNGAS SAMPLING FOR PROCESS CONTROL**~~

~~**1. General Function**~~

~~The syngas composition is continuously monitored and used in feed back control loop, for controlling the addition of steam to the process chamber. This section details the function and the operation of the gas monitoring system. The control strategy for the addition of steam to the process chamber is discussed in subsystem GV-10 (section 3.10) of this document.~~

~~**2. Reference Documents**~~

~~**Process Flow Diagram:** See drawings 31001-P-052-01.~~
~~**Piping and Instrumentation Diagram:** See drawings 31001-P-078.~~
~~**Key Components:** See Table GV-8 in the equipment and instrument list in Attachment 9.~~

~~**Key Component Technical Specification:** See the technical specification package enclosed in Attachment 9.~~
~~**Key Control Devices:** See Table GV-8 in the equipment and instrument list in Attachment 9.~~
~~**Key Control Device Technical Specifications:** See the technical specification package enclosed in Attachment 9.~~
~~**Interfacing Subsystems:** process chamber subsystem (GV-03)~~

~~**3. Equipment and Process Description**~~

~~The syngas analysis system provides signals to the main process PLC to as a feed back control element for the steam supply control system. The syngas analyzer system is comprised of four separate analyzer devices. Individual analyzers monitor a given gas component in the GASVIT™ process syngas exhaust stream. These analyzers provide process signals for both the steam injection control and for general process monitoring and safety. The four gas components analyzed are carbon monoxide (CO); carbon dioxide (CO_2); oxygen (O_2); and hydrogen (H_2). These systems will have redundant analyzers, which will be compared and averaged to ensure accurate signals are being used for the control of the GASVIT™ process. The oxygen and hydrogen analyzers will only be single units.~~

~~**4. Operation and Control Description**~~

~~The operation and control of the syngas gas sampling system involves the use of a gas conditioning process to ensure a clean gas stream is continuously fed to each of the four analyzers. The gas is drawn from an isokinetic sampling probe situated in the syngas process exhaust directly after the thermal residence chamber (TRC, Z-0350). The gas is drawn into a 1/4 inch stainless steel sample tube leading first to a high temperature filtering system (FLT-0801). This filter removes the bulk solid content of the syngas. The syngas sample stream then passes through a condenser (CN-0801) to remove water vapor from the stream. The syngas finally passes through a second filter (FLT-0802) which removes fine particles prior to the syngas entering the individual analyzers. The gas is drawn through each of the analyzers sequentially in this order: 1) carbon dioxide; 2) carbon monoxide; 3) hydrogen; and 4) oxygen. The gas then passes through the sampling vacuum pump (PMP-0801) and is directed back into the syngas process stream at a point just prior.~~

~~**5. Safety Interlocks**~~

~~**Automatic Waste Feed Cutoff (AWFCO) (Tag ID: ILK-007):** This subsystem (GV-09) provides inputs to the AWFCO logic. Refer to the GASVIT™ Main Process Control subsystem (GV-10).~~

~~**6. Preventative and Preparedness (P&P) Procedures and Inspection Plan**~~

~~A surveillance, maintenance, and calibration event list will be provided for the key equipment and control/instrument device in this subsystem. The events will be based on the manufacturer's recommendations and will include maintenance frequency. When the facility operation is started, each surveillance, maintenance, and calibration event will be recorded and documented.~~

3.~~9~~5 System GV-09, ~~GASVIT™~~MWTH Process Vent System

1. General Function

The function of the ~~GVB~~ MWTH process vent system (GV-09) is the abatement of fugitive emissions to the environment. The system collects and treats fugitive emissions generated by the various waste

handling and pretreatment operations. The MWTH process vent system is currently isolated and is not hooked up to any processing equipment in the MWTH building.

2. Reference Documents

Process Flow Diagram: See drawings 31001-P-053.
Piping and Instrumentation Diagram: See drawings 31001-P-079-02.
Key Components: See Table GV-09 in the equipment and instrument list in Attachment ~~9~~UU.
Key Component Technical Specification: See the technical specification package enclosed in Attachment ~~9~~WW.
Key Control Devices: See Table GV-09 in the equipment and instrument list in Attachment ~~9~~UU.
Key Control Device Technical Specifications: See the technical specification package enclosed in Attachment 9.
Interfacing Subsystems: ~~waste feed preparation subsystem (GV-01); waste feed subsystem (GV-02); product handling subsystem (GV-04);~~ building confinement subsystem (GV-22)

3. Equipment and Process Description

Vent collection: ~~Capture hoods are provided for operations that are likely to produce organic vapors, particulate, and dust such as waste feed sorting and shredding.~~ As stated above, GV-09 is not currently operating. Exhaust from these operations is maintained at high transport velocities (above 3500 fpm) to prevent settling of particles in the ductwork.

~~Other fugitive emissions likely to consist of only vapors and fine particulate, such as from the batch feeders and metals and glass drain ports, are captured and filtered in the carbon filter beds (FLT-0924).~~ The process vent system exhaust flow rate is maintained by a dedicated blower (BLO-0925) which discharges into the building exhaust system ahead of the main carbon filter beds.

~~An accordion fume hood connected to the process vent system is provided in the liquid feed HAZMAT enclosure for use while inserting and removing the transfer pump in the liquid/sludge container (C-0201). This hood is positioned by the operator as needed. The liquid feed tank (TK-0205) is also exhausted to the process vent system. Since this is a mixing tank which is likely to produce particulate, a small in-line HEPA filter is provided in this duct ahead of the point where the exhaust stream leaves the HAZMAT enclosure.~~

~~Due to the potential existence of mercury at the sources to this subsystem, the carbon filter beds will be mixed (or layered) with impregnated carbon media. The exhaust pick up sources and flow rates for this system are listed below.~~

Carbon Filter Bed Tag	Line Number	Source Tag	Source Description	Flow Rate (CFM)
	~~GV-01~~	~~Z-0105~~	~~SORTING TABLE~~	~~1,200~~
	~~GV-01~~	~~Z-0107~~	~~SORTING BOX~~	~~50~~
	~~GV-01~~	~~SHR-0101~~	~~SHREDDER~~	~~800~~
	~~GV-02~~	~~Z-0110~~	~~WASTE INSPECTION STATION HOOD~~	~~250~~
	~~GV-02~~	~~C-0201~~	~~LIQUID/SLUDGE CONTAINER~~	~~250~~
	~~GV-02~~	~~TK-0205~~	~~LIQUID FEED TANK~~	~~10~~
	~~GV-02~~	~~AL-0225~~	~~AIRLOCK~~	~~20~~
	~~GV-02~~	~~CG-0230~~	~~CHARGE CHAMBER GATE~~	~~150~~
	~~GV-02~~	~~CG-0240~~	~~CHARGE CHAMBER GATE~~	~~150~~

	~~GV-04~~	~~N/A~~	~~METALS COLLECTION~~	~~10~~
	~~GV-04~~	~~N/A~~	~~GLASS COLLECTION~~	~~10~~
GV-09-FLT-0924			**TOTAL FLOWRATE**	~~**2,900**~~

Organic Vapor Removal: The carbon filter beds are designed for the given flow rate as recommended by the carbon filter bed manufacturers. The design basis used for sizing the carbon filter beds is: 100 lbs. of carbon for every lb. of organic vapor to be removed or as recommended by the manufacturer.

~~**Mercury Removal:** To remove any potential airborne mercury from the process vent effluent, the carbon filter beds for this system will be mixed (or layered) with impregnated carbon media. A summary of the assumptions used for sizing the carbon filter beds of this subsystem for mercury abatement is presented below.~~

~~Basis for sizing the carbon filter bed for Mercury (Hg) removal is developed based on the assumption that 1 percent of the incoming waste contains mercury (260 ppm).~~

~~The total weight of mercury calculated on this basis is approximately 0.5 kg/yr.~~

~~It is assumed that 10 percent of this mercury may become airborne during handling operations and be collected by the stabilization process vent and is subsequently collected by the carbon filters beds.~~

4. Operation and Controls Description

Blowers: The blower for the subsystems is sized specifically for the flow rate and pressures required by the system. The process vent blower~~s~~ (BLO-0925) is started manually at the associated motor control center in the HVAC equipment room.

Dust Filtration: Differential pressure across the dust collectors is monitored by vendor provided instrumentation. Blowdown of the cartridges occurs automatically at preset values of filter differential pressure. Collected particles and dust are sent to the in-container mixing system (TT-03) for stabilization ~~or to GASVIT™ system~~ for treatment.

Carbon Filter Bed Exhaust Monitoring: The organic vapor removal effectiveness of the carbon filters is monitored continuously by an organic vapor meter (OVM) installed at the outlet of the first carbon filter bed. ~~The mercury vapor removal effectiveness is also monitored continuously.~~ The OVM uses a 10.2 ev lamp in a photo-ionization detector such as an OVM 580 PID, manufactured by Thermo Environmental, or equal. ~~The mercury monitor uses an electrode sensor such as a Jerome Mercury Analyzer manufactured by Arizona Instrument, or equal.~~

Bed breakthrough occurs when the rolling 24 hour average concentration of organic vapors is 20 ppm above the background level and mercury vapors are more than 0.04 mg/m^3 above background readings. This background level is established by measuring a four hour average of the OVM reading at the outlet of a freshly charged carbon filter bed. ~~Background mercury is also measured in the same manner.~~

During the background measurement period, the process vent system will be operating but all activities that generate organic ~~and mercury~~ vapors fed to the filter system are shut-down. Between carbon changeouts, the organic vapor ~~and mercury~~ monitoring instruments are reset by drawing building air through the monitors.

Carbon Filter Replacement: When bed breakthrough occurs, the carbon is replaced as follows: 1) the spent carbon is unloaded from the bed and placed in a TIC; 2) fresh carbon is loaded into the bed, and 3) the order of flow through the beds is reversed. After reversing the order of flow through the vessels, the vent gases flow first through the carbon that had previously been in the downstream bed and then through the new carbon.

5. Compliance with Performance Requirements

Performance requirement for this system is:

Dust collection: 99 percent for particles greater than 1.5 microns
Particle filtration: 99.97 percent
Organic vapor abatement: Background concentrations
~~Mercury abatement: Background concentrations~~

The following design features are included to provide compliance to the performance requirements for the system as a continuous and reliable abatement of fugitive emissions.

Filter changeouts: Differential pressure indicators, OVM ~~and mercury~~ monitors are provided to monitor the performance of the filters. Carbon filter beds are replaced periodically when they are spent. Dust collection filters have automatic cleaning systems and their replacement is rarely required. However, HEPA filters and pre-filters will be replaced when they reach a differential pressure that is recommended by the manufacturer.

Equipment Operation Monitoring: Normal equipment safe operation and shut down features are provided by the manufacturer for the process vent blowers fan and the dust collectors.

Reverse Flow Prevention: Except for the normal equipment safety features provided by the induced draft fan and the baghouse manufacturer, there is only one automatic safety interlock in this subsystem. ILK-075 shuts down the process vent blower (BLO-0925) when there is a loss of building confinement exhaust. The signal to activate this interlock is provided by a pressure differential transmitter in the main confinement exhaust duct. (Refer to the P&ID for subsystem GV-22, drawing 31001-P-092-02). This interlock is used to prevent back pressure and reverse flow in the building confinement exhaust system when the main exhaust fans are not running or if a main exhaust damper is inadvertently shut.

Operation Verification: Negative air pressure indicators (manometers) are provided inside the hoods and enclosures for visual observation by the operators to verify safe operation environment.

6. Inspection Plan

Equipment inspection, maintenance, and calibrations are performed on this subsystem based on the manufacturer's recommendations. The ~~mercury sensor and~~ OVM sensors are subject to periodic inspections as per the inspection plan included in Attachment 19 of RCRA/TSCA permit application.

~~**Subsystem GV-10, GASVIT™ Process Feed Control**~~

~~**General Function**~~

~~The function of the main process control subsystem is to control, monitor, and record the waste feed rate and provide the automatic waste feed cut-off (AWFCO) activities of the GASVIT™ system in compliance with the permit conditions. The anticipated permit conditions are listed in Modules VI and~~

~~VII of the MWF permit. The feed control and AWFCO logic are the overall safeguards of the GASVIT™ system for ensuring that the emissions from the process are controlled and that the system is automatically shutdown in the event that a critical process parameter falls outside of the operating range specified in the permit.~~

~~The planned GASVIT™ system operating staffing is based on having one supervising operator in the main control room and one in floor areas at all times (24 hour basis). These operators will have primary responsibility for the overall system operations and daily events relative to compliance with the feed control and AWFCO operating limits imposed by the permit. The supervisor in the main process control room will control the liquid, continuous solids, and batch solids feeders controls and their associated cut-off valves from the main control panel. These items are not locally controlled items and can not be overridden during waste processing campaigns. They can be overridden only during idle mode, scheduled maintenance, or any emergency shutdown event.~~

~~**Reference Documents**~~

- ~~**Process Flow Diagram**: See drawings 31001-P-050, 51, and 52 in Attachment 7.~~
- ~~**Piping and Instrumentation Diagram**: See drawings 31001-P-080-01, 02 and 03 in Attachment 7.~~
- ~~**Key Components**: See Table GV-10 in the equipment and instrument list in Attachment 9.~~
- ~~**Key Component** Technical Specification: See the technical specification package enclosed in Attachment 12.~~
- ~~**Key Control Devices**: See Table GV-10 in the equipment and instrument list in Attachment 9.~~
- ~~**Key Control Device Technical Specifications**: See the technical specification package enclosed in Attachment 9.~~
- ~~**Interfacing Subsystems**: Waste feed preparation subsystem (GV-01); waste feed subsystem (GV-02); process chamber subsystem (GV-03); first stage syngas processing subsystem (GV-05); second stage syngas processing subsystem (GV-06); third stage syngas processing subsystem (GV-07); syngas sampling subsystem (GV-08), GASVIT™ Building Confinement System (GV-22).~~

~~**Equipment and Process Description**~~

~~A number of subsystems are utilized to accomplish the feed control and AWFCO functions. A description of the waste feed control process is presented in Section 1.5. The AWFCO process is described in section 1.6~~

~~**Operation and Control Description**~~

~~**Waste Feed Control Operations**~~

~~The GASVIT™ waste feed control is maintained using a computer/PLC to independently control the selected waste feeder mechanism. Generally, waste will be introduced to the GASVIT™ process chamber using either the two batch solid waste feeders (GV-02-CG-0230 and GV-02-CG-0240), the continuous solids feeder (GV-02-F-0226), or the liquid feeder (GV-02-FCV-0215). Only one of the three feeding mechanisms will be used at any given time. Waste feed control methodology for each feed mechanism is described below.~~

~~**A) Liquid/Sludge Feeder**~~

~~**Campaign planning**: Before starting a liquid/sludge feed campaign, the operator develops plans for a liquid feed waste campaign, as described in feed preparation subsystem (GV-01). Once a set of waste containers is selected, the operator determines the liquid feed rate for the campaign by dividing the total weight of each toxic metal and chloride/chlorine contained in all of the containers by the maximum hourly feed rates allowed under the permit for the given metal and chloride/chlorine. Next, the operator compares the calculated feed rates for each of the metals and chlorine/chloride present in the feed and selects the lowest feed rates as the basis for the feed rates of the campaign. If the feed rate calculated in this manner is not acceptable (for economies or other reasons), the operator may then Make adjustments to the list of containers selected for the given campaign.~~

~~**Selecting feed rate**: When the planning step is complete, the feed preparation operator brings the selected containers one-by-one to the liquid feed inspection area in the HAZMAT enclosure. The operator weighs each container with a scale (GV-01-WE-0111), enters the identification of the container into a computer terminal (GV-02-BCS-0201), and performs a final container inspection. The total weight of the container as well as the container characteristic data (metals and chloride/chlorine concentration), is transmitted electronically to the main process control computer. The control room operator acknowledges the receipt of the data and issues a permissive signal to allow the feed preparation operator to transfer the liquids/sludge from the container into the feed tank. A similar set of steps is followed for other containers until the feed tank is full. Having access to the total weight and composition data on the tank contents, the control room operator calculates the feed rates so that each metal and chloride feed rate is below that specified by the permit. The operator then compares the calculated metals and chloride feed rates and selects the lowest number as the basis for the process feed rate set point. In order to allow compliance inspection and verification, the metals and chloride/chlorine concentration in the liquid/sludge feed tank and the calculated campaign feed rate are recorded and stored in the computer archives. This data is available for inspection by regulatory bodies.~~

~~**Setting and controlling feed rate**: Before selecting the desired flow rate, the control room operator instructs the feed operator to switch the feed pump to re-circulation mode. Once this action has been confirmed and flow is established in re-circulation mode, the control room operator enters the desired liquid/sludge feed rate into the main control panel computer/PLC. Next, the operator opens the liquid feed rate cut-off valve (GV-02-FV-0216) from the control panel. The cut-off valve (GV-02-FV0216) opens only if all of the AWFCO conditions are within the specified limit. When the cut-off valve is opened, the flow meter (FV-02-FT-0214) and the flow control valve (FV-02-FCV-0215) will automatically take over the feed rate adjustment controls and maintain the flow at the pre-set rate. The liquid/sludge feed rate is recorded versus time and is stored in the computer. This data is available for inspection by the regulatory bodies.~~

~~**B) Continuous Solids Feeder**~~

~~**Campaign planning**: As with the liquid/sludge feed campaign, the operator develops plans for a continuous solid feed campaign by obtaining characterization data for all of the containers that may be subject to blending/processing in a single campaign. Details of campaign planning are described in feed preparation subsystem (GV-01).~~

~~**Selecting feed rates**: As described in subsystem GV-01, during the feed preparation step, the containers selected for the campaign are brought into the GVB and inspected. Their contents are then dumped on a sorting table, shredded, and packaged into bags or batch feed canisters. Each bag or canister is weighed and affixed with a bar-code and color-code label. The bar-code label provides the identification of the bag which relates the bag to its characteristics data already stored in the MWF inventory control computer. The color-coding provides a visual indication to assist the operator in feeding the desired type of waste into the feed conveyor, as needed for sequencing and blending to achieve permit conditions. A black color-code indicates metals concentrations of the bag is above the permit limits if the maximum allowable feed rate is practiced. For these bags, the operator determines feed rate by summing the total weight of each metal in the bags and dividing this sum by the maximum hourly feed rate for that metal. Next, the operator compares the calculated feed rate for the various toxic metals and selects the lowest toxic metal feed rate as an approximate feed rate for the campaign. The red color code indicates that the chloride/chlorine content of the bag is above the permit feed rate if the maximum allowable feed rate is practiced. For these bags, the operator calculates the appropriate feed rate by dividing the total weight of the chloride/chlorine by the maximum hourly chloride/chlorine allowed by the permit. The green color indicates that both the metals and chlorine/chloride concentration are below the permit limits and they can be fed to the process chamber at the maximum solid waste feed rate allowed by the permit.~~

~~**Setting and controlling feed rate:** The actual process feed rate for the bags is automatically determined by the process control computer in accordance with the permit restrictions on the maximum feed rates. When the process chamber is ready to receive waste for processing, the feed preparation operator places several bags on the feed conveyor (GV-02-CV-0223) which has an indexing drive mechanism. Using a bar-code scanner (GV-02-BSC-0222), the feed preparation operator scans each bag after it is placed on the feed conveyor. The scanned data is sent to the main process control panel. When a permissive signal for feeding the process chamber is received, the control room operator starts the feed conveyor. The conveyor advances one index point and the first bag is dropped into the feed lock hopper. The position switch (GV-02-ZS-0224) acknowledges the receipt of the bag in the air lock hopper (GV-02-H-0224). Once this signal is received by the process control computer, the processing time is determined by the computer. The selected process time will be based on either one of the metals or the chlorine/chloride process time, whichever has the highest processing time requirement. The conveyor (GV-02-CV-0223) is interlocked so that the next index point is automatically advanced to drop a second bag into the air lock hopper when the time for processing the first bag is expired. As with the first bag, the time for processing the second bag is determined by the computer. This feed control process continues until all of the bags in the campaign are processed. The computer records and stores data related to each bag feed event. This data is archived and is available for inspection by the regulators.~~

~~**C) Batch Feeder**~~

~~**Campaign Planning:** As with the continuous feed campaign, the operator develops plans for a batch feed campaign by obtaining characterization data for all of the containers that may be subject to blending/processing in a single campaign. Details of campaign planning are described in the feed preparation subsystem (GV-01).~~

~~**Selecting feed rates**: The feed selection process for feeding pre-packaged canisters to the batch feeder is similar to the continuous feed operations discussed above.~~

~~**Setting and controlling feed rate:** The actual process feed rate for the batch feed canisters is automatically determined by the process control computer, in accordance with the permit restrictions on maximum feed rates. When the process chamber is ready to receive waste for processing, the feed preparation operator places several canisters on either one or both of the batch feeders. (The operator has the option of using one or two batch feeders in a campaign.) When both feeders are employed, they are operated in an alternative feed mode. The batch feeder ramps have an indexing mechanism that automatically feeds canisters to their respective air lock chamber (GV-02-AL-0232 and GV-02-AL-0242). Using a bar-code scanner (GV-02-BSC-0234 and GV-02-BSC-0244), each canister is scanned before it moves into the charge chamber air lock. The scanned data is sent to the main process control panel. When a permissive signal for feeding material into the process chamber is received, the control room operator starts the feed ramp indexing mechanism. The mechanism advances one index point and the first canister rolls into the batch feeder air lock chamber. A position switch (GV-02-ZS-0234 or ZS-0244) acknowledges the delivery of the canister to the air lock chamber. Once this signals is received by the process control computer, the computer uses the scanned data from the canister and automatically calculates the process time for the canister. This calculation is done by dividing the total weight of each toxic metal and the chlorine/chloride concentration of the canister into the maximum concentrations allowed by the permit. The selected process time will be based on either one of the metals or the chlorine/chloride process time, whichever has the highest processing time requirement. The feed ramp indexing device is interlocked such that the next index point is automatically advanced to roll a second canister into the air lock chamber when the time for processing the previous canister is expired. As with the first canister, the time for processing the second canister is determined by the computer. The feed control process for batch feeding operation continues until all of the bags in the campaign are processed the computer records and stores data related to each canister feed event. This data is archived and is available for inspection by the regulators.~~

~~**Steam Feed Control**: Steam is also metered into the process chamber (GV-03-Y-0301) to fully convert all carbonaceous waste material to syngas. The steam will be controlled using a feed back control strategy based on the composition of the syngas exiting the main GASVIT™ process chamber. The initial minimum steam setting is dictated by the waste feed rate. The control operator can override the automatic steam flow control (GV-03-FCV-0393) to deviate from the minimum rate at which the steam is introduced to the process chamber (e.g., if pure soil is fed to the process GASVIT™ process chamber, no steam addition is required, nor is it desired).~~

~~**Flux Feed Control:** Flux additions may also be required during the processing of certain wastes. With some waste materials, the resultant glass product formed has rheological properties (i.e., high viscosity at processing temperatures) that can be preferentially altered through the addition of fluxing agents. Typical fluxes to be used will include lime, soda ash, or pre-manufactured glass frit with high concentrations of soda ash or other fluxing elements incorporated in the frit. The flux will be metered into the process chamber (GV-03-Y-0301) either through the batch feeder (GV-02-CG-0230 or GV-02CG-0240) or the continuous solid feeder (GV-02-F-0226) in combination with the gravimetric flux additive feeder (GV-02-F-0220). To determine the quantity if flux addition required, a glass sample will be obtained and analyzed for every vitrified glass collection drum produced, (refer to section 3.4 product handling.)~~

~~**AWFCO Operation**~~

~~When the feed rates for the batch feeder, continuous feeder, or liquid feeder are set, the process chamber automatically processes the material only if all AWFCO permissives are met. (See AWFCO discussions below and the process chamber operations descriptions in subsystem GV-03). Once material processing begins in the chamber, the plasma arc power level is adjusted automatically according to the requirements of the waste being processed and the chosen feed rate. The process steam is then metered into the process chamber (GV-03-Y-0301), via a flow control valve (GV-03-FCV-0393) at increasing rates until a predetermined carbon monoxide to carbon monoxide plus carbon dioxide ratio is met for the syngas exiting the thermal residence chamber. (See section 1.6 for steam control operations.) Waste and steam feeding continue until either: a) a planned change of waste feed is introduced, or b) other system requirements dictate waste feed termination.~~

~~If during waste processing the GASVIT™ system exceeds a set of operating parameter set points established by the permit, then the system controls automatically place the process in a safe shut down mode, referred to as AWFCO. The AWFCO controller (YN-0100) is housed inside the main PLC. Under equilibrium operating conditions, the process parameters are within the specified range and the AWFCO controller is not activated allowing the waste feed operations to commence. In the event that one of these critical parameters is out of the specified normal operating range, the AWFCO controller will activate interlock ILK-007 that will stop the feeding process until the parameter returns to the normal operating range. Operator action is required to reinitiate feed flow to the system. The AWFCO controls operation and the philosophy for the various AWFCO interlocks are discussed below.~~

~~**Waste Feed AWFCO Events:** Upon receipt of an AWFCO signal, each feeder being used will be stopped according to the following sequence of events (AWFCO event numbers are given on Dwg. 31001-P-080):~~

~~1. **Liquid Feeder:** AWFCO No. 7 is activated if total hourly feed rate, measured by flow transmitter FIT-0214, exceeds the permit limit. Upon receipt of an AWFCO command, the control signal to the liquid feed solenoid (FV-0216) will be interrupted, closing the valve, and preventing liquid feeding. The valve closed position switch (GV-02-ZSC-0216) will signal once the valve is closed confirming that liquid feeding has stopped.~~

~~**Continuous Feeder**: AWFCO No. 9 is activated if the hourly rolling average weight of the feed, as measured by scale WIT-0114 and transmitted to control system by scanner BCS-0222, exceeds the permit limit. Upon receipt of an AWFCO command, the control signal to the solids feed solenoid FV-0228 will also be interrupted, closing the valve and preventing solid feeding. The valve closed position switch (GV-02_ZSC-0228) will signal once the valve is closed confirming that solids feeding have stopped~~

~~**Batch Feeder:** The batch feeder has two AWFCO activation events. The first, AWFCO No. 8, event can occur if the hourly rolling average weight of the feed as measured by scale WIT0114 and transmitted by control system by BCS-0244 and BCS-0234, exceeds the permit limit. The second, AWFCO No. 10, is activated when the time between each batch event as measured by timer YK-0231, is shorter than the permit limit. Upon receipt of an AWFCO command, the close signal to the charge chamber gates motor (GV-020HS-0232, HS-0242) will be initiated, closing the gates, and preventing batch feeding. The gate closed position switches (GV-02-ZSC-0242 and GV-02-ZSC-0232) will signal once the gate is closed confirming that batch feeding has stopped.~~

~~**Process Chamber and Thermal Residence Chamber AWFCO Events:** There are eight process chamber AWFCO interlocks. AWFCO Nos. 1 to 4 are activated in the event of a high or a low temperature in the exhaust gas outside of the set points established for this parameter. A high temperature event must be avoided because it could result in an undue volatilization of toxic metals and increase the emissions beyond those measured during the demonstration test. Operating the chamber below the low temperature set point could result in an incomplete destruction of organic material and, therefore must be avoided. The process chamber pressure is controlled at levels that minimize the possibility of releasing gases to the building environment. To enforce this safety consideration, a process chamber high pressure set point is provided as AWFCO No. 21. AWFCO controls are also interlocked to the loss of current to the plasma heater. This interlock, AWFCO No. 26, is provided because the gasification process is an endothermic process and the loss of a heating source could result in an incomplete processing of the organic material.~~

~~In addition to generating inputs to the AWFCO controller, the following parameter measurement devices on the process chamber (GV-03-Y-0301) initiate alarms at the PLC/computer when out of spec condition occurs:~~

~~Process chamber gas temperature (GV-03-TE-0315).~~
~~Related alarms: high-high temperature. – Hourly rolling average (AWFCO No. 3)~~

~~Process chamber gas temperature (GV-03-TE-0315).~~
~~Related alarms: high-high temperature. – Instantaneous (AWFCO No. 4)~~

~~Thermal residence chamber exit gas temperature (GV-03-TE-0355)~~
~~Related alarms: low-low temperature. – Hourly rolling average (AWFCO No. 1)~~

~~Thermal residence chamber exit gas temperature (GV-03-TE-0355).~~
~~Related alarms: low-low temperature. – Instantaneous (AWFCO No. 2)~~

~~Process chamber pressure (GV-03-PT-0380).~~
~~Related alarms: high-high pressure (AWFCO No. 21)~~

~~Process chamber pressure (GV-03-PT-0380).~~
~~Related alarms -high-high-high pressure indicating the activation of the thermal residence chamber and the first scrubber ejector by-pass (AWFCO No. 31)~~

~~Process Chamber Plasma Failure (IT-0325).~~
~~Related alarm: low-low current. (AWFCO No.26)~~

~~Process chamber CO/(C02+CO) ratio (AET-350)~~
~~Related alarm: high percentage of CO. (AWFCO No. 22)~~

~~**First Stage Syngas Process Filter:** A low differential pressure AWFCO is provided for this filter. The purpose of this alarm is to ensure that the filter is effectively removing the particulate leaving the process chamber. A low pressure differential is an indication of filter failure. In addition to generating inputs to the AWFCO controller, the following parameter measuring devices on the first stage syngas filter (GV-05-FLT-0501) initiates an alarm at the PLC/computer when an out of spec condition occurs:~~

~~Filter differential pressure (GV-05-PDT-0501).~~
~~Related alarm: high-high differential pressure. (AWFCO No. 23)~~

~~Filter inlet temperature (GV-05-TE-0505)~~
~~Related alarm: low-low temperature (AWFCO No. 33)~~

~~**Scrubbers:** The removal efficiency of the scrubbers is dependent on their re-circulation water flow rates. Flow and pressure to the ejector are also key parameters affecting removal efficiency. A low flow rate or low pressure in these lines decrease the removal efficiency. Therefore, the re-circulation and the ejector flow rate and ejector pressure of both scrubbers are monitored and a low flow event or low pressure condition from each of the monitors is connected to AWFCO interlock. The re-circulation line water pH and conductivity are monitored in scrubber #2 to ensure proper removal efficiency. The scrubber #2 re-circulation water pH level initiates a low-low alarm which is followed by a corrective action by the operator. If a low-low alarm is encountered, an AWFCO interlock is triggered. The conductivity is a measure of salt concentration in the scrub solution. When conductivity is reached at an alarm level an AWFCO signal is triggered.~~

~~In addition to generating inputs to the AWFCO controller, the following parameter measurement devices on the scrubber system (GV-06-SC-0601 and GV-06-SC-0621) initiate alarms at the PLC/computer when an out-of-spec condition occurs.~~

~~Scrubber #1 ejector water flow rate (GV-06-FT-0601)~~
~~Related alarm: low-low flow rate (AWFCO No. 11)~~

~~Scrubber #1 recycle water discharge rate (GV-06-FLT-602~~
~~Related alarm: low-low flow rate. (AWFCO No. 13)~~

~~Scrubber #2 ejector water flow rate (GV-06-FT-0621).~~
~~Related alarm: low-low flow. (AWFCO No. 12)~~

~~Scrubber #2 recycle water discharge rate (GV-06-FLT-622)~~
~~Related alarm: low-low flow rate (AWFCO No. 14)~~

~~5. Scrubber #2 recycle water pH (GV-06-AET-0622)~~
~~Related alarm: low-low pH. 10 minute rolling average. (AWFCO No. 17)~~

~~6. Scrubber #2 recycle water pH (GV-06-AET-0622).~~
~~Related alarm: low-low pH. Hourly rolling average (AWFCO No. 18)~~

~~7. Second packed bed conductivity (GV-06-AET-0623)~~
~~Related alarm: high-high conductivity. hourly rolling average. (AWFCO No. 19)~~

~~8. Scrubber #1 ejector liquid discharge pressure (GV-06-PT-0601)~~
~~Related alarm: low-low pressure. (AWFCO No. 15)~~

~~Scrubber #2 ejector liquid discharge pressure (GV-06-PT-0621)~~
~~Related alarm: low-low pressure. (AWFCO No.16)~~

~~**HEPA Filters**: A high pressure event in the HEPA filters could result in a possible loss of integrity and therefore must be controlled. In addition to generating inputs to the AWFCO controller, the HEPA filters differential pressure indicator (GV-06-FLT-0641 and GV-06-FLT-0642) will initiate alarms at the PLC.computer when an out-of-spec condition occurs. There are two redundant HEPA filters; one is in service while the other is in standby. The following alarms are used according to this application to the process.~~

~~HEPA filter #1 or HEPA filter #2 differential pressure (GV-07-PDT-0641).~~
~~Related alarm: high-high differential pressure. (AWFCO No. 24)~~

~~**Post HEPA Carbon Filters**: To ensure that the filters are not plugged, the differential pressure across each post HEPA carbon filter train (PDI-0660 and PDI-0661) is monitored. A high differential pressure alarm signal from the switch is sent to the AWFCO controls (see subsystem GV-10) via PDAHH-0660 and PDAHH-0661. The syngas re-heater (HT-0646) maintains the syngas temperature above the dew point prior to entering the post HEPA carbon filters. The temperature margin is sufficient to prevent condensation in the post HEPA carbon beds. To avoid possible buildup of condensate in the carbon filters, a low-low temperature signal from a temperature sensing element((TE-064) at the inlet of the HEPA filter is interlocked to initiate an AWFCO alarm. To avoid a reduction in mercury abatement efficiency, a high-high temperature signal from the incoming syngas temperature sensor is interlocked to initiate an AWFCO event. To further enhance mercury abatement, the heat exchange in the second scrubber re-circulation loop is used to lower the temperature of the second scrubber liquid to approximately 35 – 65 degrees F. This lower temperature minimizes the amount of mercury vapor that may get entrained in the syngas exhaust.~~

~~Post HEPA carbon filter #1 or #2 differential pressure (PDT-0660~~
~~Related alarm: high-high differential pressure. (AWFCO No. 34)~~

~~Post HEPA carbon filter inlet temperature (TE-0646)~~
~~Related alarm: low-low temperature. (AWFCO No. 35)~~

~~Post HEPA carbon filter inlet temperature (TE-0646)~~
~~Related alarm: high-high temperature (AWFCO No. 25)~~

~~Syngas Discharge: The maximum syngas flow is measured based on a minimum residence time of the gases in the process chamber. If the syngas flow exceeds these limits, the syngas residence time could be reduced resulting in a less efficient destruction and removal efficiency. A high syngas flow rate measured after the discharge of the carbon filter provides an input to the AWFCO controller. In addition, the high pressure alarm initiates an alarm at the PLC/computer when an out-of-spec condition occurs:~~

~~Syngas discharge flow rate (GV-06-FIT-0644).~~
~~Related alarm: high-high flow. (AWFCO No. 20)~~

~~**Syngas Converter**: The system has been sized so there is always sufficient conversion air to keep the converter below the lower explosion limit (LEL). When the converter is operating in stand-by mode, the maintaining temperature with natural gas alone, the inlet air-natural gas mixture is 34% of the LEL. When the converter is maintaining temperature processing the design syngas mixture (which includes some supplemental natural gas) the inlet air-CO-H2-natural gas mixture is 77% of the LEL. When the inlet air-CO-H2-Natural gas mixture reaches 85% of the LEL, the monitor will send an alarm signall to activate the GASVIT™ system automatic waste feed cut-off(AWFCO) controls. The LEL monitoring instrumentation accuracy, which is plus or minus 3% of the instrument full range (full range is 0-150%), when added to the AWFCO LEL alarm setting of 85% keeps the gas mixture always kept below 90% of LEL. The converter is equipped with several safety systems to ensure efficient conversion of syngas and prevent a high LEL condition in the converter inlet gas. These systems include LEL monitoring, flow monitoring and temperature monitoring each connected to an AWFCO shutdown signal.~~
~~In addition to generating input to the AWFCO controller, the following parameter measurement devices on the syngas converter initiate alarms at the PLC/computer when an out-of-spec condition occurs:~~

1. Syngas incoming flow rate (FIT-0702)
   Related alarms: low-low flow (AWFCO No. 27)

2. Conversion air flow rate (FIT-0770)
   Related alarm: low-low flow (AWFCO No.28)

3. Converter chamber temperature (TE-0703-03)
   Related alarm: low-low temperature – hourly rolling average (AWFCO No. 5)

4. Converter chamber temperature (TE-0703-03)
   Related alarm: low-low-low temperature. Instantaneous (AWFCO No. 6)

5. Syngas bypass line valve position switch (YN-0700)
   Related alarm: syngas is bypassed (AWFCO No. 32)

6. Converter Inlet Gas Flammability Monitor (AET-0702)
   Related alarm: high-high LEL (AWFCO No. 36)

7. Quench outlet carbon monoxide (AET-0715)
   Related alarm: high-high carbon monoxide (AWFCO No. 29)

Building Exhaust fan failure: A low flow in the building HVAC flow could indicate a failure in the ability to maintain negative pressure in the GASVIT building. The following alarms are connected to an AWFCO event to prevent a potential fugitive emission release to outside environment.

1. Building confinement system flow rate (FIT-2520)
   Related alarm: low-low flow rate (AWFCO No. 30)

5. Safety Interlocks

AWFCO (Automatic Waste Feed Cut-Off) (tag ID: ILK-007): Interlock ILK-007 will shut down the feeding process for each of the three feed systems.

The control signal to the liquid feed solenoid (GV-02-FV-0216) will be interrupted closing the valve and preventing liquid feeding. The valve closed position switch (GV-02-ZSC-0216) will signal once the valve is closed, confirming that liquid feeding has stopped.

The control signal to the solids feed solenoid (GV-02-FV-0228) will also be interrupted, closing the valve and preventing solid feeding. The valve closed position switch (GV-02-ZSC-0228) will signal once the valve is closed, confirming that solids feeding has stopped.

A close signal to the batch feeder charge chamber feed gates motor (GV-02-HS-0232, HS-0242) will be initiated, closing the gates and preventing batch feeding. The gate closed position switches (GV-02-ZSC-0242 and GV-02-ZSC-0232) will signal once the gate is closed, confirming that batch feeding has stopped.

6. Preventive and Preparedness (P&P) Procedures and Inspection Plan

A surveillance, maintenance and calibration event list will be provided for the key equipment and control/instrument device in this subsystem. The events will be based on the manufacturer's

~~recommendations and will include maintenance frequency. When the facility operation is started, each surveillance, maintenance and calibration event will be recorded and documented.~~

~~3.11 SUBSYSTEM GV-11, SECONDARY WASTE~~

~~1. General Function~~

~~The secondary waste treatment system (GV-11) treats liquid waste from the syngas scrubbers and building 5 containment floor drains. Water rejected from the filters (system GV-03, FLT-301 and 302) and the liquid/solid separators (TK-0304 and 0305) in the syngas scrubber spray loops is transferred to the scrubber bottom waste tank (TK-1105). Waste water from this tank is transferred to the waste concentrator unit (EVP-1103) for treatment. Steam heat is used to evaporate the waste water. The distillate is collected and reused by the syngas scrubbers while the concentrate is sent to waste drums for off-site recycle or disposal.~~

~~2. Reference Documents~~

~~**Process Flow Diagram:** See drawings 31001-P-054.~~
~~**Piping and Instrumentation Diagram:** See drawings 31001-P-081.~~
~~**Key Components:** See Table GV-11 in the equipment and instrument list in Attachment 9.~~
~~**Key Component Technical Specification:** See the technical specification package enclosed in Attachment 9.~~
~~**Key Control Devices:** See Table GV-11 in the equipment and instrument list in Attachment 9.~~
~~**Key Control Device Technical Specifications:** See the technical specification package enclosed in Attachment 9.~~
~~**Interfacing Subsystems:** second stage syngas processing subsystem (GV-06); third stage syngas processing subsystem (GV-07); syngas sampling subsystem (GV-08)~~

~~3. Equipment and Process Description~~

~~The secondary waste treatment system is designed to treat approximately 125 gallons per hour of waste water contaminated with oil, solids, and sludge.~~

~~Water rejected from the filters in the scrubber spray loops is sent to the 1,000 gallon feed tank (TK-PCW) for interim storage. When the water level in the feed tank is sufficient, waste water is automatically transferred to the evaporator (EVP-1103) by the air-operated transfer pump. The evaporator, transfer pump, concentrate pump, and all operating and safety controls are provided with the vendor furnished packaged unit.~~

~~Steam heat is used to evaporate the waste. Water vapor is removed from the evaporator by a 500 scfm blower and then condensed. The condenser unit (CD-1108) is cooled by process cooling water (system GV-19). The condensed distillate drains to the distillate tank (TK-1115) where it is stored for reuse in the scrubbers.~~

~~Sludge and oil scum in the evaporator are periodically drained to a concentrate drum. Level controls linked to the air-operated transfer pump prevent the drum from overfilling. Concentrated wastes are packaged and shipped off-site for recycling or disposal.~~

~~4. Operation and Control Description~~

~~The waste concentrator is a vendor provided packaged unit. With the exception of the feed tank and concentrate drum level controls, all the controls and monitoring for system operation are self-contained and do not interface with the GASVIT™ system.~~

~~In summary, the waste concentrator has the following safety features:~~

~~Temperature controls to modulate the steam input.~~
~~Redundant evaporator tank level controls and high and low-level shut downs.~~
~~An overspray/foaming control system.~~
~~System trouble alarms and a warning light~~

~~5. Safety Interlocks~~

~~The only significant active component in the secondary waste treatment system is the concentrator unit. Except for equipment safety features provided as part of the vendor supplied unit, no safety interlocks are included in this subsystem. Abnormal conditions that affect operation of this unit are addressed in instructions provided by the vendor.~~

~~6. Preventative and Preparedness (P&P) Procedures and Inspection Plan~~

~~Equipment inspection, maintenance, and calibrations will be performed on this subsystem based on the manufacturer's recommendations. Surveillance procedures for the GASVIT™ secondary waste subsystem will include monitoring of all critical elements as detailed in Table GV-11.~~

~~3.12 NOT USED~~

3.~~13~~6 SUBSYSTEM GV-13, SERVICE/INSTRUMENT AIR

1. General Function

The service and instrument air systems provide plant equipment and instruments with a source of dry compressed air. Many of the valves used in the ~~GASVIT™ feed system~~Evaporation System (TP-16) are air actuated as are other selected plant components and instrumentation. Service air is also used to atomize water used in the off-gas quenchers. Service and instrument air both originate from the same 75 HP rotary screw air compressors, the only principle difference between the two flow streams is that the instrument air is further purified with an additional drying and filtration stage.

The air compressors and associated controls are packaged, vendor furnished units.

2. Reference Documents

Process Flow Diagram: See drawings 31001-P-055.
Piping and Instrumentation Diagram: See drawings 31001-P-083-01.
Key Components: See Table GV-13 in the equipment and instrument list in Attachment ~~9~~UU.
Key Component Technical Specification: See the technical specification package enclosed in Attachment ~~9~~WW.
Key Control Devices: See Table GV-13 in equipment and instrument list in Attachment ~~9~~UU.
Key Control Device Technical Specifications: See the technical specification package enclosed in Attachment ~~9~~WW.

Interfacing Subsystems: ~~waste feed subsystem (GV-02); process chamber subsystem (GV-03); first stage syngas processing subsystem (GV-05); second stage syngas processing subsystem (GV-06); third stage syngas processing subsystem (GV-07)~~Evaporation system (TP-16)

3. Equipment and Process Description

The compressed air system is designed to provide the ~~GASVIT™ facility~~MWTH Building with 300 scfm (maximum) of air at 100 pounds per square inch (psi). All active system components are supported with a redundant back-up unit. Air is compressed from the atmosphere in one of two 75 HP rotary screw air compressors (CMP-1301 and CMP-1302), the other compressor serving as a back-up unit. The air is dried in a regenerative twin tower desiccant dryer (DR-1303) and then passed through an oil coalescing and particulate filter (FLT-1304/1305).

The compressed air is stored in a 2,000 gallon air receiver tank (TK-1306). Air exits the receiver and is directed to either the service or instrument air header as determined by plant demand. Service air is regulated to a nominal pressure of 100 psig and sent out to plant loads through the distribution piping.

Instrument air is passed through a refrigerated air dryer (DR-1307) to achieve a dew point of minus 40° Fahrenheit. Instrument air also receives a final filtration stage to remove particulates larger than one (1) micron. Instrument air is then regulated to a nominal pressure of 30 psi and sent out to plant loads through the distribution piping.

Service and instrument air supply header pressure is monitored locally ~~and~~ in the ~~GASVIT™~~MWTH ~~plant control room on the PLC/computer display panel~~. Operator response is required to correct any out-of-spec conditions.

4. Operation and Control Description

The air compressors, dryer units, and associated controls are vendor furnished. Control features of these components are self-contained and do not interface with the ~~GASVIT™~~Evaporation system. ~~Receiver tank and supply header pressures are monitored and fed back to the GASVIT™ control room.~~ Pressure instrument (PIT-1306) monitors receive tank pressure and send an alarm signal to the local process control panel and to the main PLC/computer. Pressure instrument PIT-1310 monitors service air supply header pressure and actuates a low pressure alarm at the main PLC/computer. PIT-1311 performs a similar function for the instrument air system.

5. Safety Interlocks

Except for normal equipment safety features provided as part of the vendor supplied unit, no safety interlocks are included in this subsystem.

For the service/instrument air system, a "system low pressure condition" could result from a major service air leak that causes receiver tank pressure to drop below a given setpoint which would be sensed by the tank pressure instrument (PIT-1306). This signal activates alarms at the local process control panel ~~and in the main control room~~. The alarm signal from PAL-1306 triggers flow controller (FC-1312) to close flow valve (FV-1312) and isolate the service air header. The instrument air system would remain in operation. Plant operator response is required to investigate and correct the cause of the low pressure condition.

6. Preventative and Preparedness (P&P) Procedures and Inspection Plan

Equipment inspection, maintenance, and calibrations will be performed on this subsystem based on the manufacturer's recommendations. Surveillance procedures for the ~~GASVIT™~~MWTH

Service/Instrument Air subsystem will include monitoring of all critical elements as detailed in Table GV-13.

~~**3.14 NOT USED**~~

3.~~15~~7 SUBSYSTEM GV-15, NITROGEN SUPPLY

1. General Function

The nitrogen supply system (GV-15) provides N_2 gas for various plant equipment and processes that require a purged or inert environment. This includes the GASVIT™ process chamber feeder air locks, charging chambers, and discharge drains. Blowdown of the high temperature bag filter is also performed with pressurized N_2 from this system.

The N_2 source is a 1,400 gallon liquid N_2 storage tank (TK-1501). The tank, vaporizer, and associated controls is a vendor furnished package and will be located outdoors, on the south side of the GVB.

2. Reference Documents

Process Flow Diagram: See drawings 31001-P-056.
Piping and Instrumentation Diagram: See drawings 31001-P-085.
Key Components: See Table GV-15 in the equipment and instrument list in Attachment ~~9~~UU.
Key Component Technical Specification: See the technical specification package enclosed in Attachment 9.
Key Control Devices: See Table GV-15 in the equipment and instrument list in Attachment ~~9~~UU.
Key Control Device Technical Specifications: See the technical specification package enclosed in Attachment ~~9~~WW.
Interfacing Subsystems: ~~feed subsystem (GV-02); process chamber subsystem (GV-03); product handling (GV-04); first stage syngas processing subsystem (GV-05); second stage syngas processing subsystem (GV-06); third stage syngas processing subsystem (GV-07)~~None

Equipment and Process Description

The N_2 system is designed to provide ~~the GASVIT™ process with~~ 200 scfm of 99.99 percent pure N_2 gas on a continual basis. Weekly filling of the insulated storage dewar (TK-1501) by the supplier is required to meet the expected plant usage. The tank level is monitored and it is refilled by the liquid N_2 supplier when required. The storage tank (TK-1501) is an insulated dewar outfitted by the vendor with piping and controls in order to maintain a constant pressure of approximately 100 psi (pressure setpoint is adjustable). Tank pressurization is maintained by the natural flashing of the cryogenic N_2 caused by heat transfer from the environment. The tank is automatically vented to keep the pressure within allowable limits.

Liquid N_2 is withdrawn from the tank and vaporized in one of the evaporators (EVP-1502 or EVP-1503). The gas is then regulated (V-15005 or V-15013) to provide 100 psi N_2 to the supply header. System pressure is also regulated at use points as required to match equipment or process criteria.

N_2 supply header pressure is monitored locally ~~and in the GASVIT™ plant control room~~ on the PLC/computer display panel. Operator response is required to correct any out-of-spec conditions.

4. Operation and Control Description

The N_2 supply unit and associated controls are vendor furnished. Control features of the supply unit are self-contained and do not interface with the ~~GASVIT™~~Evaporation system. ~~Only supply header pressure is fed back to the GASVIT™ control room.~~ Pressure instrument PIT-1505 monitors supply header pressure and actuates high and low pressure alarms at the main PLC/computer.

5. Safety Interlocks

System Pressure High or Low: The ~~GASVIT™ control room~~MWF supervisor would be notified of a N_2 system high or low pressure condition by PIT-1505 and its associated high and low pressure alarm (PAL-1505 and PAH-1505). Plant operator response is required to investigate and correct the cause of the low pressure condition. System pressure can be changed by manual adjustment of the in-service pressure regulating valve (V-15005 or 15013).

6. Preventative and Preparedness (P&P) Procedures and Inspection Plan

Equipment inspection, maintenance, and calibrations will be performed on this subsystem based on the manufacturer's recommendations. Surveillance procedures for the ~~GASVIT™~~MWTH nitrogen subsystem will include monitoring of all critical elements as detailed in Table GV-15.

3.~~1~~68 SUBSYSTEM GV-16, PROCESS WATER

1. General Function

The process water subsystem provides domestic water primarily as a feed source for the Reverse~~.~~ Osmosis~~.~~ (RO) water subsystem. Process water is also used as an emergency source of cooling water by the process cooling water (PCW) system (GV-19). The process water system is isolated from the domestic water supply by a backflow preventer. Domestic water is provided for the rest room and other potable water use points within the facility.

R.O. brine, emergency PCW return, and sanitary waste from the building rest room all drain to the domestic sanitary sewer system.

2. Reference Documents

Process Flow Diagram: See drawings 31001-P-058-01.
Piping and Instrumentation Diagram: See drawings 31001-P-086.
Key Components: See Table GV-16 in the equipment and instrument list in Attachment ~~9~~UU.
Key Component Technical Specification: See the technical specification package enclosed in Attachment ~~9~~WW.
Key Control Devices: See Table GV-16 in the equipment and instrument list in Attachment ~~9~~UU.
Key Control Device Technical Specifications: See the technical specification package enclosed in Attachment ~~9~~WW.
Interfacing Subsystems: R.O. water subsystem (GV-17); process cooling water subsystem (GV-19)

3.~~1~~79 SUBSYSTEM GV-17, REVERSE OSMOSIS (R.O.) WATER

1. General Function

The reverse osmosis (R.O.) water system (GV-17) supplies filtered and clean water by removing 98 percent of the dissolved inorganic, organic, bacteria and pyrogen contaminants. The pure water or R.O. water is collected in a storage tank (TK-1707) to be used as make-up water to multiple water systems

~~within the GASVIT™ process~~. The R.O. loop pump (PMP-1705) provides a constant re-circulation flow of R.O. water within the tank and supplies water to the process cooling water (PCW), steam, and chilled water systems.

Feed to the R.O. water system is provided by the process water supply system (domestic water with back flow prevention) via an electric water pre-heater (HT-1701).

The R.O. system is a vendor furnished package containing a water pre-heater, water softener tanks, carbon filter, multimedia filter, 1,500 gallon storage tank, and associated controls and instrumentation.

2. Reference Documents

Process Flow Diagram: See drawings 31001-P-058-02.
Piping and Instrumentation Diagram: See drawings 31001-P-087.
Key Components: See Table GV-17 in the equipment and instrument list in Attachment ~~9~~UU.
Key Component Technical Specification: See the technical specification package enclosed in Attachment ~~9~~WW.
Key Control Devices: See Table GV-17 in the equipment and instrument list in Attachment ~~9~~UU.
Key Control Device Technical Specifications: See the technical specification package enclosed in Attachment ~~9~~WW.
Interfacing Subsystems: ~~process chamber subsystem (GV-03); first stage syngas processing subsystem (GV-05); second stage syngas processing subsystem (GV-06); third stage syngas processing subsystem (GV-07)~~None

3. Equipment and Process Description

The R.O. supply water system is designed to operate at an initial production capacity of 17 gpm or 24,000 gallons per day. Process water (city water) is passed through the 125 gallon pre-heater (HT-1701) to boost the water temperature to 77° Fahrenheit to optimize the operating efficiency of the system. The preheated water is then passed through the water softener to remove the calcium from the water to prevent calcium scaling within the other water systems. Water from the softener flows through a carbon filter which removes the chlorine from the water, then flows through the sediment filter before entering the reverse osmosis system.

R.O. water is produced and flows into a 1,500 gallon storage tank (TK-1707) for use within the ~~GASVIT™ process~~MWF treatment processes. The R.O. loop pump (PMP-1705) will constantly provide the R.O. water by drawing from the bottom of the storage tank and pumping the water to the required source destination. (Refer to the P&ID, drawing GV-17.) The loop pump also re-circulates a percentage of the R.O. water via manual control flow valve to prevent stagnation of the R.O. water in the storage tank. The R.O. system has a time clock sequential back-flush feature that flushes the system and drains the brine to the sanitary sewer system.

4. Operation and Control Description

The R.O. water supply unit and associated controls are vendor furnished. Instrumentation and control features on the R.O. unit are self-contained and do not interface with the ~~GASVIT™~~Evaporation system. A low-level alarm LAL-1707 sends a signal to the level controller (LC-1707) which automatically responds by opening the normally closed solenoid valve (LCV-1707). The valve opens allowing R.O. make-up water to fill the storage tank (TK-1707) until the level controller (LC-1707) is reset by the high-level switch (LSH-1707) to close the level control valve. Pressure transmitter PIT-1705 sends a signal

proportional to the operating pressure of the R.O. delivery system to the central PLC/computer. This signal is converted to a value and displayed as PI-1705.

5. Safety Interlocks

Except for equipment safety features provided as part of the vendor supplied unit, no additional safety interlocks are provided as part of this subsystem.

For the R.O. water supply system, a system low pressure condition could result from a significant leak or failure of the R.O. loop pump (PMP-1705). System pressure is monitored on PIT-1705 which is displayed locally and in the control room. The associated low pressure alarm (PAL-1705) gives notification to the control room operator of the low pressure condition. Plant operator response is then required to find and correct the low pressure.

6. Preventative and Preparedness (P&P) Procedures and Inspection Plan

Equipment inspection, maintenance, and calibrations will be performed on this subsystem based on the manufacturer's recommendations. Surveillance procedures for the ~~GASVIT™~~ R.O. water subsystem will include monitoring of all critical elements as detailed in Table GV-17.

~~**3.18 SUBSYSTEM GV-18, STEAM SUPPLY**~~

~~**1. General Function**~~

~~The steam supply system provides high and low pressure steam for various processes throughout the GASVIT™ facility. High pressure steam (greater than 40 psi) is supplied to use points such as the process chamber, secondary waste evaporator, and the off-gas line steam injector. Low pressure steam (less than 10 psi) is used by the syngas second stage HEPA pre-heater and heat tracing for outdoor piping and components.~~

~~The steam source is an electric back-up boiler. (Text deleted.)~~

~~**2. Reference Documents**~~

~~**Process Flow Diagram:** See drawings 31001-P-057.~~
~~**Piping and Instrumentation Diagram:** See drawings 31001-P-088-01, and 02.~~
~~**Key Components:** See Table GV-18 in the equipment and instrument list in Attachment 9.~~
~~**Key Component Technical Specification:** See the technical specification package enclosed in Attachment 9.~~
~~**Key Control Devices:** See Table GV-18 in the equipment and instrument list in Attachment 9.~~
~~**Key Control Device Technical Specifications:** See the technical specification package enclosed in Attachment 9.~~
~~**Interfacing Subsystems:** process chamber subsystem (GV-03); first stage syngas processing subsystem (GV-05); second stage syngas processing subsystem (GV-06); third stage syngas processing subsystem (GV-07); secondary waste subsystem (GV-11)~~

~~**3. Equipment and Process Description**~~

~~The electric boiler is a packaged, vendor furnished unit designed to supply 350 lbs./hour of steam at pressures up to 100 psi.~~

~~The R.O. water system supplies feed water to the boiler (BLR-1815) via the associated receiver tank and feed pump included in the packaged boiler system. Steam produced by the boiler is regulated to the desired operating pressure and may be distributed to the either the low or high pressure steam headers.~~

~~High pressure condensate is returned to the flash tank (TK-1811) where it is flashed to low pressure steam and reused by the system. Low pressure condensate is returned to the receiver tank (TK-1813) and mixed with the incoming boiler feedwater for pre-heat and reuse.~~

~~The low pressure steam is sent to the steam tank (TK-1820) and then distributed to the use points in the low pressure steam distribution piping. Each distribution header is served by a pressure regulator. The high pressure steam header may be cross-connected to individual steam distribution headers should high pressure steam be required for system cleaning or accelerated heat-up.~~

~~**4. Operation and Control Description**~~

~~Active steam components are included with the vendor furnished package unit and do not directly interface with the GASVIT™ control system.~~

~~Pressure in the low and high pressure steam distribution mains is monitored by pressure transmitters (PIT-1817 and PIT-1818 respectively) which read out locally and at the local process control panel.~~

~~**5. Safety Interlocks**~~

~~Safety interlocks are provided by the vendor to prevent low-level, high-level, and over-pressure conditions in the boiler. For the steam system, a "system low pressure condition" at the process chamber inlet could result from a major steam leak that causes the line pressure to drop below a given setpoint. The drop in line pressure would be sensed by the steam pressure instrument which would then activate alarms at the local process control panel and in the main control room. The alarm signal triggers the specific flow controller to close and isolate the steam header. The steam system would remain in operation. The plant operator is required to investigate and correct the cause of the low pressure condition. No other interlocks are used in the backup steam boiler subsystem.~~

~~**6. Preventative and Preparedness (P&P) Procedures and Inspection Plan**~~

~~Equipment inspection, maintenance, and calibrations will be performed on this subsystem based on the manufacturer's recommendations. Surveillance procedures for the GASVIT™ steam supply subsystem will include monitoring of all critical elements as detailed in Table GV-18.~~

3.1~~9~~0 SUBSYSTEM GV-19, PROCESS COOLING WATER (PCW)

1. General Function

The process cooling water (PCW) subsystem (GV-19) provides cooling water for ~~key GASVIT™~~ equipment exposed to high temperatures. This is a closed loop system with two re-circulating pumps (one redundant) and a plate and frame heat exchanger to which the system rejects heat to the chilled water system (GV-20). After being cooled by the secondary fluid in the heat exchanger, the PCW is sent out through a distribution pipeline to individual pieces of equipment in the plant.

After absorbing heat from the plant loads, the PCW is returned to a vented collection tank. The operating re-circulation pump draws cooling water from the tank and sends it back through the heat exchanger and out to the PCW supply header.

2. Reference Documents

Process Flow Diagram: See drawings 31001-P-058-03.
Piping and Instrumentation Diagram: See drawings 31001-P-089.
Key Components: See Table GV-19 in the equipment and instrument list in Attachment ~~9~~UU.
Key Component Technical Specification: See the technical specification package enclosed in Attachment ~~9~~WW.
Key Control Devices: See Table GV-19 in the equipment and instrument list in Attachment ~~9~~UU.
Key Control Device Technical Specifications: See the technical specification package enclosed in Attachment ~~9~~WW.
Interfacing Subsystems: ~~waste feed subsystem (GV-02); process chamber subsystem (GV-03); first stage syngas processing subsystem (GV-05); second stage syngas processing subsystem (GV-06); third stage syngas processing subsystem (GV-07)~~Evaporator system (TP-16)

3. Equipment and Process Description

The PCW system is designed to operate at a nominal flow rate of 180 gpm. Starting at the circulation pumps, water is boosted from atmospheric pressure to approximately 60 psi. One pump is selected as the primary, the other is placed in off and may be started manually if the primary pump is unavailable. Before being sent to plant equipment, the PCW is cooled by a secondary fluid in a plate and frame heat exchanger. The flow rate of the secondary fluid, chilled water, is set manually by positioning throttle valve #20052. ~~The position for this valve will be determined during initial plant start-up tests based on system temperatures, primarily PCW return temperature with the GASVIT™ system operating at full capacity.~~

PCW system supply temperature and pressure are monitored locally ~~and in the GASVIT™ plant control room~~ on the PLC/computer display panel. Operator response is required to correct any out-of-spec conditions.

Cooling water is sent out to plant equipment in the supply header. Each component served by the PCW system is connected to the main distribution supply and return headers with a flexible high pressure hose and manual isolation valves. Cooling water flow rate to each load is preset manually by positioning the return line isolation valve. Water returning from the system loads is directed into an oversize return header "tank" in which a water heal is maintained. The water ~~heal~~ cools and condenses any steam that is formed as the PCW passes through plant equipment.

The PCW header drains into the collection tank (TK-1901) which is vented out into the atmosphere. The returning water is then drawn into the circulation pump and sent back to the heat exchanger as described above.

4. Operation and Control Description

Collection Tank Level Control: Minor fluctuation in the PCW tank (TK-1901) level is anticipated during system operation due to water temperature changes and resultant expansion or contraction, and steam void formation and collapse (not a normal operating condition). Make-up for any system leakage or evaporation is provided by automatic level control of the collection tank. Pressure transmitter PIT-1901 sends a signal proportional to level to the central PLC/computer. This signal is converted to a level

value and displayed as LI-1901. The control room supervisor would be alerted to an out-of-specification level condition on the associated high- and low-level alarms. Level controller LC-1901 automatically responds to a low-level condition by sending a signal to the normally closed solenoid valve, LCV-1901. The valve opens allowing R.O. make-up water to fill the tank until the level controller LC-1901 is reset at its programmed level.

5. Safety Interlocks

For the process cooling water system, the following abnormal events have the potential to adversely effect normal operation of the ~~GASVIT™~~Evaporation system and are discussed below:

System Pressure Low: A low PCW system pressure condition could result from a significant leak or loss of the operating circulation pump. System pressure is monitored on PIT-1907 and displayed locally and in the control room. The associated low pressure alarm (PAL-1907) will notify the control room supervisor or the low pressure condition. The plant operator would then confirm this indication with one of the local pressure instruments, ensure one of the PCW pumps was running, and perform a visual inspection for cooling water leaks or other abnormal conditions.

Should a situation arise where cooling water is needed and neither pump is available, Valve V-16027 can be opened to introduce a back-up source of cooling water into the system. Process water (city water) is used as the back-up source and system pressure is sufficient to provide the driving head. The back-up water then passes through the process equipment and is then dumped to the sanitary sewer system through valve V-19001.

Abnormal System Supply Temperature: An abnormal PCW supply temperature would be indicated by direct observation of temperature gauge TI-1911, or indirectly by the thermocouples monitoring the temperatures of the process chamber and various plant components cooled by this system. System temperature may be altered by changing the position of the chilled water return valve on the secondary side of the PCW heat exchanger (HX-1913). This allows the operator to modulate the flow of the secondary cooling fluid water through the heat exchanger and adjust the overall PCW supply temperature. Adjustments in the chilled water system (GV-20) supply temperature may also be made to affect the PCW system temperature.

6. Preventative and Preparedness (P&P) Procedures and Inspection Plan

Equipment inspection, maintenance, and calibrations will be performed on this subsystem based on the manufacturer's recommendations. Surveillance procedures for the ~~GASVIT™~~MWTH process cooling water subsystem will include monitoring of all critical elements as detailed in Table GV-19.

3.1~~2~~1~~0~~ SUBSYSTEM GV-20, CHILLED WATER

1. General Function

The chilled water (CHW) System (GV-20) serves as a secondary loop cooling fluid for the process cooling water system (PCW, GV-19). Heat from the PCW system is rejected to the closed loop CHW system in the PCW heat exchanger (HX-1913). Heat transferred to the chilled water is in turn rejected to the atmosphere through a fan-cooled radiator located outside the GVB. For reliability, there is a redundant circulation pump and radiator.

2. Reference Documents

Process Flow Diagram: See drawings 31001-P-058-04.
Piping and Instrumentation Diagram: See drawings 31001-P-090.
Key Components: See Table GV-20 in the equipment and instrument list in Attachment ~~9~~UU.
Key Component Technical Specification: See the technical specification package enclosed in Attachment ~~9~~WW.
Key Control Devices: See Table GV-20 in the equipment and instrument list in Attachment ~~9~~UU.
Key Control Device Technical Specifications: See the technical specification package enclosed in Attachment ~~9~~WW.
Interfacing Subsystems: process cooling water subsystem (GV-19)

3. Equipment and Process Description

The CHW system is designed to operate at a nominal flow rate of 75 gpm. Starting at the circulation pumps, warm water (approximately 80° to 125° Fahrenheit) is drawn from the CHW return header and boosted to approximately 20 psi. One pump is selected as the primary, the other is placed in off and may be started manually if the primary pump is unavailable.

Before being sent to the PCW heat exchanger, heat from the returning chilled water is rejected into the atmosphere in a fan-cooled radiator (RD-2009 or RD-2010). The fan is powered by a variable frequency drive (VFD). A temperature controller controls the fan speed as required to maintain the temperature of the chilled water exiting the radiator within a preset range. Chilled water supply temperature and pressure are monitored locally ~~and in the GASVIT™ plant control room~~ on the PLC/computer display panel. Operator response is required to correct any out-of-specification conditions.

CHW is then sent to the PCW heat exchanger (HX-1913) secondary loop where heat is absorbed from the process cooling water. The CHW returns to the circulating pumps through an air separator (AS-2004). System temperature changes and associated pressure surges are absorbed by the chilled water expansion tank (TK-2002). R.O. water is the make-up water source for the CHW system. The water pressure regulator (V-20003) automatically opens to add make-up water when system return header pressure falls below the preset value (15 psi).

4. Operation and Control Description

Supply Header Temperature Control: Supply header temperature is sensed by TET-2009 (or 2010). This analog signal is transmitted to the PID controller in the VFD. The controller compares this signal to a preset temperature range value and adjusts the electrical power frequency output to the fan. When the chilled water temperature is above the allowable range, the controller increases the fan speed to increase the convective heat loss from the radiator, and vice versa.

System temperature is monitored locally ~~and in the GASVIT™ control room~~ on TI-2011. A high temperature condition would be indicated in the control room by high temperature alarm TAH-2011. Operator response is required to investigate and take corrective action. If necessary, the operator can shift to the standby radiator should a failure of system hardware or control components occur.

5. Safety Interlocks

For the process cooling water system, the following abnormal events have the potential to adversely effect normal operation of the ~~GASVIT™ system~~MWTH Building and are discussed below:

System Pressure Low: A low CHW system pressure condition could result from a significant leak or loss of the operating circulation pump. System pressure is monitored on PIT-2011 and displayed locally and in the control room. The associated low pressure alarm (PAL-2011) will notify the control room supervisor of the low pressure condition. The plant operator would then confirm this indication with one of the local pressure instruments, ensure one of the CHW pumps was running, and perform a visual inspection for cooling water leaks or other abnormal conditions.

Water pressure regulator V-20003 automatically "floats" on the system and provides R.O. make-up water, as required to meet demand. System pressure is maintained by this pressure regulator and the diaphragm expansion tank, TK-2002.

6. Preventative and Preparedness (P&P) Procedures and Inspection Plan

Equipment inspection, maintenance, and calibrations will be performed on this subsystem based on the manufacturer's recommendations. Surveillance procedures for the ~~GASVIT™~~MWTH chilled water subsystem will include monitoring of all critical elements as detailed in Table GV-20.

~~**3.21 NOT USED**~~

3.1~~2~~2 SUBSYSTEM GV-22, BUILDING CONFINEMENT SYSTEM

1. General Function

The building confinement system (GV-22) provides for ~~GVB~~ MWTH exhaust and ventilation, exhaust for the ~~GASVIT™~~Evaporation process (TP-16)~~itself~~, and building pressure control. The system is also intended to be used as a manual smoke control system. The system consists of three supply air units, two main exhaust trains, associated pressure control sensors, controllers, and damper actuators.

A constant volume of exhaust is maintained at all times for fume and contaminant control within the ~~GASVIT™~~MWTH process areas. The volume of fresh outside air admitted to the building is varied to maintain the desired building pressure control schedule. Pressure control is automatically maintained by the system and may be manually controlled if required.

2. Reference Documents

Process Flow Diagram: See drawings 31001-P-059-01 and 02.
Piping and Instrumentation Diagram: See drawings 31001-P-092-01 and 02.
Key Components: See Table GV-22 in the equipment and instrument list in Attachment ~~9~~UU.
Key Component Technical Specification: See the technical specification package enclosed in Attachment ~~9~~WW.
Key Control Devices: See Table GV-22 in the equipment and instrument list in Attachment ~~9~~UU.
Key Control Device Technical Specifications: See the technical specification package enclosed in Attachment ~~9~~WW.
Interfacing Subsystems: ~~waste feed subsystem (GV-02); third stage syngas processing subsystem (GV-07); GASVIT™~~MWTH process vent subsystem (GV-09)

3. Equipment and Process Description

The confinement system maintains the correct building pressure differential by maintaining a constant exhaust flow rate and by modulating dampers in the supply air ductwork. The ~~GASVIT™~~Evaporation

process areas are held at a negative pressure relative to atmosphere, while the control room is held at a positive pressure relative to atmosphere.

Fresh air to the facility is provided by two 30,000 cubic feet per minute (cfm) packaged air supply units. The supply units have direct fired gas heat and direct expansion cooling. ~~Air supply unit #2A serves the GASVIT™ Unit 1 half of the building and air supply unit #2B serves the GASVIT™ Unit 2 area.~~ Each air handler is equipped with a motorized discharge damper for pressure control. The units are located at the South west corner of the building.

General and process exhaust is provided by two independent 40,000 cfm exhaust fans and filter banks located in the ventilation equipment room at the south end of the building. Each filter bank consists of a pre-filter, HEPA filter, and carbon adsorption filter stages.

Ventilation to the first floor electrical room, second floor control room, and the access corridor is provided by air handling unit #3. This is a smaller return air unit, also utilizing gas heat and direct expansion cooling. It is located at the south end of the building next to the larger air handling units. Unit #3 combines fresh air with the air returning from the control room, electrical room, and access corridor. A positive pressure is automatically maintained in these spaces by modulating the outside and return air dampers.

To serve as an engineered smoke control system, control and monitoring of building pressures and supply and exhaust fan operation are provided at the Firefighters Smoke Control Panel (FSCP). As required by the building codes, all automatic functions may be controlled manually from this location.

4. Operation and Control Description

Building Pressure Control: The pressure in the ~~GASVIT™~~MWTH process areas is monitored by differential pressure transmitters PDT-2211 and 2222, for ~~GASVIT™~~MWTH Unit 1 and 2, respectively. Differential pressure controller PDT-2211 (the following control description will be for Unit 1) receives this differential pressure signal, compares it to the programmed set point, and sends out a signal to the supply air damper actuator. Insufficient negative differential pressure of the process area, relative to ambient, will cause the pressure control system to respond by closing the supply air damper on air handler unit #2A until the area differential pressure returns to within the programmed range. Similarly, excessive differential pressure will cause the system to respond by opening the supply air damper as required to maintain set point.

5. Safety Interlocks

The building pressure control system, in concert with remotely controlled dampers on the main exhaust system, functions as a smoke control system in case of a fire or smoke event in the ~~GASVIT™ facility~~MWTH building.

Smoke/Fire Detection: All building ventilation and exhaust equipment can be controlled and monitored from the ~~Firefighter's Smoke Control Panel (~~FSCP~~)~~. Manual override of the automatic pressure control functions will allow pressure in the affected zone to be adjusted to a value more negative than surrounding areas, thereby preventing the spread of smoke.

If either main exhaust unit is inoperable, it may be isolated by closing remotely-operated damper YD-2263 or 2264 either locally or from the FSCP. Remotely-operated damper YD-2260 allows the exhaust headers to be cross-connected so either exhaust unit can serve the entire building. Each exhaust unit is

designed to serve about 60 percent of the total building area. This is not a normal operating configuration but could be used in maintenance or emergency situations to maintain confinement.

Building Confinement Exhaust Failure: A loss of negative pressure in the main building confinement exhaust duct is sensed by PDT-2265 (PDT-2266 for ~~GASVIT™~~MWTH #2) and displayed as an alarm at the FSCP on PDAL-2265. Actuation of this alarm trips interlock ILK-075 and secures the process vent blower (BLO-0925) in system GV-09. This prevents the process vent system from discharging into the building confinement system when sufficient negative pressure is not available.

6. Preventative and Preparedness (P&P) Procedures and Inspection Plan

Equipment inspection, maintenance, and calibrations will be performed on this subsystem based on the manufacturers recommendations. Surveillance procedures for the ~~GVB~~ MWTH confinement subsystem will include monitoring of all critical elements as detailed in Table GV-22.

~~**3.23 NOT USED**~~

~~**3.24 NOT USED**~~

3.~~25~~13 SUBSYSTEM GV-25, BUILDING EXHAUST MONITORING

1. General Function

The building exhaust monitors consists of a continuous air monitor (CAM) and a record sample filter, both collect representative samples of the radioactive particles in the discharge stream. A local alarm will sound if a high radiation level is detected. In addition, the building exhaust monitors provide a continuous readout for the gas flow to the atmosphere.

2. Reference Documents

Piping and Instrumentation Diagram: See drawings 31001-P-95.
Key Components: See Table GV-25 in the equipment and instrument list.
Key Component Technical Specification: See the technical specification package enclosed in Attachment 9.
Key Control Devices: See Table GV-25 in the equipment and instrument list.
Key Control Device Technical Specifications: See the technical specification package enclosed in Attachment 9.
Interfacing Subsystems: building confinement system (GV-22)

3. Equipment and Process Description

The process flow is based on withdrawing an isokinetic record and a continuous sample from the discharge stack using a vacuum pump.

A. Stack Mass Flow Rate

The stack mass flow is calculated by the stack Masstron (Z-2520). The stack static and total pressure is obtained from pitot tube Z-2519. The stack temperature is measure by the temperature element (TE-2515) and transmitted to the Masstron in order to calculate the mass flow with density compensation. A signal linear to the stack mass flow is transmitted to the data logger (LOG-2528) and the control module (CTL-2526). The control module uses the signal in determining isokinetic sampling.

B. Record Sample

The record sample is withdrawn from the stack and passed through the record sample filter holder where particles are collected on a filter paper and iodine is captured by a silver-impregnated zeolite cartridge. The filter enclosure is mounted to the stack to minimize particulate settling in the sample line. After the filter sample is routed into a low-flow measuring station (FE-2523) to measure the mass flow, density compensation is performed using the temperature signal (TE-2524) of the sample. The sample mass flow is determined (Z-2524) and a signal linear to the mass flow is transmitted to the control module (CTL-2526) and data logger (LOG-2528). The temperature signal is also transmitted to the data logger.

The control module (CTL-2526) compares the stack Mass Flow (FIT-2520) to the record sample Mass Flow (FIT-2527), and transmits an output signal to the sample flow control valve (FCV-2525) to modulate the sample flow until the signals are balanced. This is done to allow the record sample flow to remain isokinetic to stack flow, as conditions vary.

C. Radiation Monitor Sample

The radiation monitor sample is withdrawn from the stack and passed through the Eberline radiation sensor. The sensor (CAM-2516) is mounted to the stack to minimize particulate settling in the sample line. The sensor signal is sent to the Eberline AMS-4 monitor (CAM-2516). After the sensor, the sample is routed into a low-flo measuring station (FE-2521) to measure the mass flow. Density compensation is performed using the temperature signal (TE-2522) of the sample. The sample mass flow is determined (Z-2522) and a signal linear to the mass flow is transmitted to the control module (CTL-2526) and data logger (LOG-2528). The temperature signal is also transmitted to the data logger.

The control module (CTL-2526) compares the stack mass flow (FIT-2520) to the radiation monitor sample mass flow (FIT-2525) and transmits an output signal to the radiation monitor sample flow control valve (FCV-2527) to modulate the sample flow until the signals are balanced. This is done to allow the radiation monitor sample flow to remain isokinetic to stack flow, as conditions vary.

D. Sample Vacuum Pump Control

The static pressure of the sample lines is measured by the control module (CTL-2530) after the control valves (FCV-2525 and FCV-2527). A linear signal is transmitted to the data logger (LOG-2528) and is displayed on the local LCD. The controller (CTL-2530) compares the data to an operator setpoint and calculates an output signal to modulate the control valve (PCV-2531) to maintain the desired static pressure.

There are two vacuum pumps used in the sampling system, one is for redundancy. The pump start/stop initiation is interlocked with the exhaust stack fan on/off status (ILK-a).

For clarity in this discussion, pump 1 is assumed to be the primary pump. With the exhaust stack on, interlock ILK-a is satisfied, and with HS-2534 in "start", the control module (CTL-2532) begins its start sequence. The exhaust stack "on" signal is also sent to the data logger (LOG-2528).

The control module (CTL-2532) positions the pump selection valve (FV-2536 and FV-2537) for pump 1 operation. After a time delay (to ensure that the valves are positioned), the control module (CTL-2532) signals pump #1 (PMP-2534) to start and illuminates the "Pump 1 on" light. A "pump 1 on" signal is also sent to the data logger (LOG-2528). As vacuum pump 1 creates its vacuum, the vacuum switch (PSL-2534) contact opens, satisfying ILK-c. Five seconds are allowed for this action. Pump 1 will continue to

run until a pump failure occurs or the system is shut down manually. Failure of pump 1 to maintain a sufficient vacuum on the vacuum switch pump selection (PSL-2534) will cause the pressure switch to signal the control module (CTL-2532) that a failure has occurred.

Upon receiving the failure signal, the control module (CTL-2532) will turn off pump 1 and reposition the selection valves (FCV-2536 and FCV-2537) for pump 2. The pump 1 signal to the data logger will turned off and a fault light (YA-2507) will be illuminated. Once the valves (FCV-2536 and FCV-2537) are repositioned for pump 2, pump 2 will be started. Pump 2 will run until vacuum failure of manual shut down. If there is a vacuum failure (PSL-2534), and the pump #1 (PMP-2534) low pressure alarm is not cleared, then ILK-h will shut down Pump #2 (PMP-2535) and pump #1 (PMP-2534) will not be started due to ILK-c.

Under normal conditions, the lead pump can be changed to standby status by operating the pump selection switch (HS-2537). This switch is disabled when a pump failure fault occurs.

Sample Flow Alarms

An Isokinetic alarm occurs when either the record sample flow or the radiation monitor sample flow exceed 10 percent over or under the required flow to remain isokinetic for more than 5 minutes. This calculation is performed within the data logger. The data logger (LOG-2528) will record the alarm and energize the fault alarm light (QA-2528). The condition is cleared when isokinetic flow resumes.

Eberline AMS-4 will sound an alarm during conditions of high-radiation or monitor failure. A local and remote alarm (AAH-2516) is energized for both functions, as well as recording the event on the data logger (LOG-2528).

4. Operation and Control Description

The Operator will turn on the power to the control panel. To initiate sampling, the operator selects which pump is to be the primary vacuum pump. The corresponding pump is then turned on. Sampling commences if the exhaust fan is running (ILK-a, b). If exhaust fan is operating, the operator needs to wait approximately 10 seconds to insure that the pump does create a vacuum. The operator then enters the static pressure setpoint. Once a vacuum is initiated, the system is operating. Operator interface is not required, unless an event occurs.

If the primary pump fails, an alarm will sound, and the secondary pump will automatically be started. If it fails also, another alarm will sound and sampling will end. At the sound of the first alarm, the operator will check the cause of failure (e.g. valve position, pinched line, power loss). The operator will make the necessary adjustments to remedy the problem.

If isokinetic sampling is lost for more than 5 minutes, an alarm will sound. The operator will go to the data logger to determine the cause and then remedy the situation. The remedy may include changing the Record Sample filter or increasing the static pressure setpoint of the sampling train.

If the high radiation alarm is activated the operators will follow the procedure guidelines for radiation leakage.

5. Safety Interlocks

Exhaust Fan On (Tag ID: ILK-a): The Exhaust Fan On interlock is designed to ensure that the

sampling of the stack is done when there is flow. Pump #1 (PMP-2534) is prevented from starting, and the data logger (LOG-2528) is signaled not to log. This will prevent the data logger from unnecessary logging, erroneous sampling, as well as protecting the equipment from attempting to match a zero sample flow rate.

Exhaust Fan On (Tag ID: ILK-b): The Exhaust Fan On interlock is designed to ensure that the sampling of the stack is done when there is flow. Pump #1 (PMP-2534) is prevented from starting and the data logger (LOG-2528) is signaled not to log. This will prevent the data logger from unnecessary logging, erroneous sampling, as well as protecting the equipment from attempting to match a zero sample flow rate.

Primary, Stand by (Tag ID: ILK-c): The Primary/Stand by interlock is designed to prevent Pump #1 (PMP-2534) from starting, thereby preventing a potential over-vacuum on the filter media (FLT-2517 and FL-2518).

Primary, Stand by (Tag ID: ILK-d): The Primary/Stand by interlock is designed to prevent Pump #2 (PMP-2535) from starting, thereby preventing a potential over-vacuum on the filter media (FLT-2517 and FL-2518).

Pump #1 Vacuum Low Cutout (Tag ID: ILK-e): The Pump #1 (PMP-2534) Vacuum Low Cutout interlock is designed to alert the operator of a vacuum fault, prevent damage to the vacuum pump #1 (PMP-2534), and switch to the standby pump: pump #2 (PMP-2535).

Pump #1 Vacuum Low Start of Pump #2 (Tag ID: ILK-f): The Pump #1 (PMP-2534) Vacuum Low Start of Pump #2 (PMP-2535) interlock is a permissive to allow vacuum pump #2 (PMP-2535) to start if there is low pressure on pump #1 (PMP-2534).

Pump #1 Vacuum Low Start of Pump #2 (Tag ID: ILK-g): The Pump #1 (PMP-2534) Vacuum Low Start of Pump #2 (PMP-2535) interlock is a permissive to allow vacuum pump #2 (PMP-2535) to start if there is low pressure on pump #1 (PMP-2534).

Pump #2 Vacuum Low Start of Pump #1 (Tag ID: ILK-h): The Pump #2 (PMP-2535) Vacuum Low Start of Pump #1 (PMP-2534) interlock is a permissive to allow vacuum pump #1 (PMP-2534) to start if there is low pressure on pump #2 (PMP-2535).

6. Preventative and Preparedness (P&P) Procedures and Inspection Plan

The operator should remove the data logger paper and record sample filter and cartridge filter after a process batch has been completed. The filters will be taken to a lab for analysis and the memory chip of the data logger downloaded to the administrative computer for emission calculations once the lab analysis is complete.

Equipment inspection, maintenance, and calibrations will be performed on this subsystem based on the manufacturer's recommendations. Surveillance procedures for the ~~GVB~~ MWTH exhaust monitoring subsystem will include monitoring of all critical elements as detailed in Table GV-25.

~~4. OPERATIONAL DESCRIPTION~~

~~This section provides operational information for the GASVIT™ system under three different modes of operation: 1) first time start-up of the GASVIT™ process, or cold standby; 2) start-up of the process from hot standby under both normal operating conditions or under a recovery scenario after an AWFCO~~

~~event; and 3) normal operations. The general operation description for individual process components is described in section 3.0 with reference made to the operation of the individual subsystems.~~

~~4.1 System Start-up~~

~~The GASVIT™ system will require start-up from cold conditions during the initial system start-up or following a system maintenance event. During the cold start-up procedure, the system will require auxiliary heating elements (a pre-heater) strategically placed within the process chamber. This will allow for a controlled temperature increase during start-up operations. Once the temperature in the primary process chamber reaches a level at which the glass in the hearth becomes electrically conductive, an electric path between the joule-heating electrodes exists. As the process chamber temperature continues to rise, the fraction of heating shifts from the start-up pre-heater elements to the joule-heating electrodes. Once a condition exists where all the idling power can be supplied by joule-heating, the start-up pre-heater elements are removed from the process chamber and the system is in an idle condition. If waste processing activities are not being conducted, the GASVIT™ process will always be idling in the joule-heated operational mode.~~

~~The following provides a summary description of the start-up procedure and a transition from start-up to an idling mode of operation.~~

~~4.1.1 GASVIT™ System Preheating~~

~~After completing the set-up and check-out of the equipment listed below start up the equipment according to the listed sequence.~~

- ~~The building HEPA filter fan~~
- ~~The syngas process fan~~
- ~~The equipment cooling water~~
- ~~The instrument air system~~
- ~~Nitrogen Supply~~
- ~~First Stage Syngas processing system operational~~
- ~~Second stage syngas processing system operational~~
- ~~Building Ventilation System~~

~~Start-up of the system from a cold condition requires the process chamber to be slowly preheated. Slow heat-up of the GASVIT™ chamber minimizes thermal shock to the refractories lining the chamber. The preheating sequence will be performed in the sequence listed below:~~

- ~~An initial charge of glass forming materials is placed into the hearth.~~
- ~~Silicon carbide heating elements (or their equivalent) are placed into the process chamber through the provided port in the process vessel.~~
- ~~Predetermined temperature ramp rates are programmed into the PLC for ramp-rate control.~~
- ~~Assurance of normal operating conditions for the first and the second stage syngas process systems.~~
- ~~The pre-heat system for the process chamber is placed in to operation to gradually raise the chamber temperature to the point where the furnace start-up charge (i.e. a granular glass frit which is pre-charged to the chamber) becomes electrically conductive. This normally occurs near the glass transition temperature for the given composition of the start-up charge.~~

~~Joule heating is initiated when the start-up charge becomes electrically conductive.~~

~~Start-up pre-heater elements are removed.~~

~~Process idling parameters are established to bring GASVIT™ chamber to normal idling conditions.~~

~~4.2 GASVIT™ SYSTEM READINESS MODES~~

~~When waste is not being processed, the GASVIT™ system will be in one of the following readiness modes: Idling, hot standby, and AWFCO. Each one of these modes is described below.~~

~~4.2.1 System Idling Mode~~

~~The GASVIT™ system is placed in an idle mode during system maintenance or other prolonged scheduled process feeding shut downs. Process idling can be conducted for extended periods of time if desired. When the system is in idle mode, the following general conditions are maintained:~~

~~The joule-heating system is used to control the temperature in the process chamber.~~

~~The temperature of the molten bath is kept between 880° - 1100° Celsius.~~

~~The process chamber vacuum is kept at (-)2 inches of water.~~

~~The first and second stage syngas subsystems are placed in an idle mode.~~

~~A constant flow of nitrogen is introduced into the process chamber environment to keep the system in an inert (i.e., nitrogen atmosphere) condition. This condition provides corrosion protection for key components such as the joule-heated electrodes.~~

~~4.2.2 Hot Standby Mode~~

~~The GASVIT™ process is placed in hot standby mode during short feeding interruptions. At hot standby mode, the system is ready to process waste. Placing the GASVIT™ system from an idling mode to a standby mode involves raising the melt temperature to normal processing temperatures (1,200° to 1,450° Celsius) with the joule-heating device, initiating start-up of the required subsystem, and starting up the plasma arc operations according to the following sequence:~~

~~Use the joule-heating device to raise the glass temperatures of the process chamber in to the normal operating range.~~

~~Ensure that the nitrogen supply system is fully operational and that the appropriate purging is introduced to the plasma arc electrode enclosure, the joule-heating electrodes, and the process chamber.~~

~~Ensure that a steam supply is available to the main process chamber steam injector and to the first stage syngas processing system.~~

~~Confirm the normal operation of first stage syngas process subsystem, including all secondary solids filtration systems.~~

~~Confirm the normal operation of second stage syngas process subsystem, including all secondary solids filtration systems.~~

~~Confirm the normal operation of third stage syngas process subsystem.~~

~~Confirm the normal operation of cooling water supply system.~~

~~The DC arc system start-up procedure is initiated. Prior to the operation of the DC plasma arc system, all subsystem operational parameters must be within the specified ranges.~~

~~Start the steam feed subsystem.~~

~~System is ready to receive feed material from one of the three feed systems.~~

~~Once the plasma arc has stabilized, and the temperature in the process chamber is in the specified range (i.e. 1,800° - 2,700° Fahrenheit) feeding of the GASVIT™ process can be initiated. The feeding operations are specified in subsystem GV-02 in section 3.~~

~~4.2.3 AWFCO Mode~~

~~When an AWFCO event has caused the interruption of waste processing, the system will revert to a hot standby as described in the previous section. Prior to starting waste processing, the operator must:~~

~~Resolve the AWFCO situation.~~

~~Confirm system readiness parameters listed under the hot standby mode.~~

~~Re-establish all permissive operating parameters.~~

~~The system is again ready to receive feed material from one of the three feed systems. The feeding operations are specified in subsystem GV-02 in section 3.~~

~~4.3 WASTE PROCESSING MODE~~

~~Once the GASVIT™ system parameters are established during the hot standby mode, waste is fed to the process chamber, as described in subsystem GV-02 in Section 3. During the waste processing mode, the operator must monitor the power setting of the joule heating and the plasma heating units to ensure that the chamber temperature is maintained within the operating range. When a processing campaign has been completed, the system is placed in one of the shut down modes described later on in this section.~~

~~4.4 PRODUCT DISCHARGE~~

~~Molten product is discharged from the process chamber from either a side or bottom drain valve. Operation of the product discharge is presented in subsystems GV-04 in Section 3.~~

~~4.5 SECONDARY WASTE PROCESSING~~

~~Secondary waste is routinely generated in the first and second stage syngas processing. This waste consists of either solid material blown down from the first stage syngas filter or solid-laden liquid from the blow down of the scrubber system. The secondary waste streams are separately treated in the secondary waste treatment area. The solids are stabilized, and the liquids are concentrated by evaporation, and the resultant solids stabilized. Operation of the secondary waste processing is presented in subsystems GV-05 and GV-11 in Section 3.~~

~~**4.6 SYSTEM SHUT DOWN**~~

~~When waste processing is stopped or when it is desired by the operator, the system can be shut down and placed in a desired readiness mode, as described below.~~

~~**4.6.1 Shut Down to Hot Standby Mode**~~

~~The system is placed in a hot standby mode through the following sequence of shut down steps.~~

- ~~Normal operation of the system continues until all the waste in the process chamber is treated and all organic constituents are pyrolyzed.~~
- ~~All feed systems are isolated and locked out to ensure no additional feed enters the process chamber.~~

~~**4.6.2 Shut Down to Idling Mode**~~

~~The system is brought to an idling mode by the following sequence of shut down steps:~~

- ~~The normal processing operation of the system continues until all the waste in the process chamber is processed and all organic constituents are pyrolyzed.~~
- ~~All feed systems are isolated and locked out to ensure no additional feed enters the process chamber.~~
- ~~The plasma arc is extinguished and the electrodes are raised to the idle position.~~
- ~~The first and second stage syngas treatment systems are stopped initiating a flush cycle to clear slurry from the piping and scrubber internals~~
- ~~The syngas converter/boiler is shut down.~~

~~**4.7 COLD SHUTDOWN**~~

~~A cold shut down of the GASVIT™ system will be conducted for major system repairs. Cold shut down is conducted after placing the system in the idling mode. Next the molten product is drained and the process chamber temperature is gradually reduced to ambient levels.~~

5. SYSTEM MONITORING AND CONTROL DESCRIPTION

5.1 ~~MAIN PROCESS CONTROL (SUBSYSTEM GV-24)~~

~~The GASVIT™ system uses a centralized main process control (MPC) subsystem encompassing computers, programmable logic controllers (PLC), Proportional-Integral-Derivative (PID) controllers, and other devices to monitor, control, and alarm system parameters relative to the operating limits specified in the permit. A brief description of the equipment and software used in the MPC subsystem is presented below.~~

~~**Computer Units:** Computer units are used in the feed preparation subsystem, the control room, and the administrative building. The computers are linked to the GASVIT™ network in order to efficiently and timely share data. The network is linked to the Man-Machine-Interface (MMI) software server which allows the operator to control the process. The uses for each computer will be discussed later.~~

~~**Recorders/Storage:** All data which is monitored by the MPC/PLC can be stored on electronic media for later use. At a minimum, all AWFCO and feed control parameters specified in the permit operation limits will be recorded and stored. The stored data can be recovered by feed preparation, the control room, or the administrative computer. The administrative computer will be used for data analysis to ensure permit compliance and to monitor plant efficiency during a campaign. The discharge monitoring panel records its data at a local data logger containing a memory chip. The memory chip can be downloaded into the administrative computer, which along with the loading of the record filter will determine the discharge amount.~~

~~**PLC Controller:** A Siemens 505 Programmable Logic Controller (PLC) is the central controller of the process (MPC/PLC). The PLC contains the controlling logic for the process and the plant monitoring. The control room computer interfaces with the PLC for visual monitoring and operator interface. For redundancy, there is a second standby PLC, to which the process control is transferred if the primary PLC should fail.~~

~~• **PID Controllers:** The PID controllers are stand alone units which will operate with only an input and output signal. The PID controllers are linked to the MPC/PLC network as remote I/O, allowing the operator to view and adjust parameters in the PID controllers from the control room.~~

~~**Inventory Control System:** The inventory control system includes bar-code scanners, a computer server and terminals, printers, and a software package. The system will maintain an electronic record of the incoming and outgoing waste. The system interfaces with the GASVIT™ feed processing subsystem (GV-10) and will provide reports and data needed for submittals to the generators and the regulatory agencies.~~

~~5.2~~ CONTROLS FOR ANCILLARY AND UTILITY SUBSYSTEMS

~~GASVIT™~~The evaporation system (TP-16) ancillary and utility subsystems are either operated from the main process control panel or from a series of local control panels. For each subsystem, parameters important to safety and reliability are monitored at both the local and central control panel locations. When necessary, these parameters are annunciated in the main control panel. Control panels and control scope for each subsystem is depicted in the P&ID drawings provided for the given subsystem. A brief description of the control panels for the major subsystems is below.

~~**Feed Preparation Subsystem (GV-01):** The shredder, scales, computer terminal, conveyors, and sorting tables have a local control panel. Motor control start-stop, speed control, and other devices for the shredder, conveyor, and sort table are located adjacent to the equipment. A computer terminal is located at the weighing and labeling station and is connected to the plant network. The computer terminal is used to enter the weight characteristics of the waste container and print a unique bar-code label. The label is later read by the scanners at the feed subsystems. The scale at the weighing and labeling station has a local indication and keyboard for data entry into the computer. The scale at the container inspection area is used to verify the manifest.~~

~~**Feed Subsystem (GV-02):** There are four different types of feeders in the GASVIT™ system. The liquid feeder, the continuous solids feeder, the redundant batch feeder, and the flux feeder. Each are operator-controlled from local panels which interface with the MPC/PLC. Some of the equipment is equipped with a VFD or vendor panel. The local control panel houses alarm lights/horns and hand switches for local operation of the equipment. The bar-code scanners at each waste feeder are used to indicate to the MPC/PLC which bag of waste is being processed. This allows the MPC/PLC to calculate the required feed rates.~~

~~**Process Chamber Subsystem (GV-03):** The process chamber DC (direct current) arc plasma zone is controlled through the MPC/PLC. The operator enters the desired power setpoint of the arc, and the MPC/PLC adjusts the electrode voltage and current according to length and power supply, respectively. The AC joule-heated zone is also controlled from the MPC/PLC. A power setpoint is entered to the MPC/PLC and the AC power supply adjusts the current output to the joule electrodes to maintain the power level setpoint. At start-up, globars are connected to the joule electrode AC power supply and power is adjusted using the MPC/PLC control loop for the joule electrodes. Temperatures, pressures, and alarms are displayed at a local panel.~~

~~**Product Handling Subsystem (GV-04):** The bottom freeze valve is controlled from the MPC/PLC. The operator enters the temperature setpoint of the high frequency power supply. The power supply turns off once the vitrified product is flowing allowing only the metal product to drain. The MPC/PLC can override the shutdown of the power supply for additional draining of the vitrified product. The MPC/PLC controls the required valves and winch to replace a full discharge drum. The side drain itself can flow when the vitrified product level is high enough. The flow can be increased or decreased by variations in the temperature or pressure of the side and main process chamber. The drain enclosure fans are controlled from a local control panel tied to the MPC/PLC.~~

~~**Syngas Processing (GV-05, 06, and 07):** The first stage syngas process filter is controlled from a local panel. The second stage scrubbing train is controlled from a vendor local panel with some ties to the MPC/PLC. The third stage heat recovery boiler is controlled from the vendor provided local panel. The panel provides outputs for the control of the quenching RO water and service air valves.~~

~~**Syngas Sampling Subsystem (GV-08):** This subsystem extracts a continuous steam of syngas which is analyzed for CO and CO_2. The sampling is controlled with a local panel while transmitting information to the MPC/PLC, as required for the control of the process (i.e. steam injection control).~~

GASVIT Process Vent Subsystem (GV-09): The vent system has no active controls. The blower is started by the hand switch in the motor control center (MCC) panel. There are differential pressure gauges for local indication of venting at the equipment.

~~**GASVIT System Feed Control Subsystem (GV-10):** As indicated above, all controls for the feed rate control and AWFCO requirements are placed in the MPC/PLC.~~

~~**Secondary Waste Treatment Subsystem (GV-11):** The waste evaporator is a vendor provided unit and has a local process control panel which accepts control inputs from the scrubber bottom storage tank level and distillate tank level. The drum fill station has a local control switch to stop the concentrate transfer pump once the drum is full.~~

~~**Caustic Addition (GV-12):** The bulk caustic tank and pump controls are from a local control panel. Pressure and flow alarms are transmitted to the MPC/PLC for monitoring.~~

Utility Subsystems: Controls for the utility subsystems include:

Service/Instrument Air (GV-13): There are vendor provided control panels on the air compressors. There is also a local panel to indicate tank pressure, service, and instrument air header pressure. The pressure signals are transmitted to the MPC/PLC.

Nitrogen Supply (GV-15): There is a vendor control panel for the N_2 tank fill control. The MPC/PLC receives header pressure indicators and alarms. The local panel only displays the pressure alarms.

Process Water Supply (GV-16): There are no controls on the process water supply. There are two active devices and two totalizers.

R.O. Water Supply (GV-17): The R.O. skid is provided with a vendor supplied control panel. The control of the R.O. tank level is located by the MPC/PLC. The PLC also monitors the tank level alarms and the R.O. header supply pressure and alarms.

~~**Steam (GV-18):** A steam boiler is provided to supply steam required for the GASVIT and other systems.~~

Process Cooling Water (GV-19): The process cooling water tank level and pumps are controlled by the MPC/PLC. The MPC also displays the tank level, alarms, header pressure, and temperature.

Chilled Water (GV-20): The MPC/PLC monitors the chilled water supply header temperature, pressure, and alarms. The chilled water radiators are vendor supplied with a local control panel. The chilled water pumps are controlled from the MCC hand switch.

Confinement Subsystem (GV-22): The GASVIT™ building ventilation subsystem controls are located in a local control panel. The supply air to the plant is controlled by three PID controllers. The controllers modulate the inlet vanes of the AHUs to control room pressure. The building exhaust fan control either on or off, by hand switches, in a local panel. The local panel also has hand switches for the positioning of the exhaust dampers.

Electrical Power Distribution (GV-23): Power distribution throughout the plant has only one tie to a control panel: the generator. The generator has its own control panel plus an automatic-transfer switch (ATS). The ATS will switch the critical plant systems to the generator power in the event of a power outage. There is also an uninterruptible power supply for smaller critical loads which cannot be off-line for the 10 second generator start time (i.e. the MPC/PLC and the control room).

Building Exhaust Monitors (GV-25): The monitoring system is a complete vendor supplied package with a local control panel. The panel displays the flows, stack temperatures, and any alarms present. The local panel houses the data logger, vacuum pumps, flow controller, flow valves, and Eberline monitor. The Eberline sensor and record sample filter will be mounted on the stack next to the sampling point. The MPC/PLC will be alerted to a failure of the instruments or radiation detection.

Table 1.1: List of key subsystems installed in the ~~GASVIT™~~MWTH building.

~~Subsystem~~	~~Reference PFD Drawing~~	~~Reference P&ID Drawing~~
~~GV-01, Feed Preparation~~	~~31001-P-050~~	~~31001-P-071-01 & 02~~
~~GV-02, Feed~~	~~31001-P-050~~	~~31001-P-072-01 through 04~~
~~GV-03, Process Chamber~~	~~31001-P-051~~	~~31001-P-073-01 through 09~~
~~GV-04, Product Handling~~	~~31001-P-051~~	~~31001-P-074-01 & 02~~
~~Gv-05, 06, & 07, Syngas Processing~~	~~31001-P-051~~ ~~31001-P-052-01 & 02~~	~~31001-P-075~~ ~~31001-P-076-01 through 04~~ ~~31001-P-077~~
~~GV-08, Syngas Sampling~~	~~31001-P-051~~	~~31001-P-078~~
GV-09, ~~GASVIT™~~MWTH Process Vent	31001-P-053	31001-P-079-02
~~GV-10, GASVIT™ Process Feed Control/AWFCO~~	~~NR~~	~~31001-P-080-01 & 02~~
~~GV-11, Secondary Waste~~	~~31001-P-054~~	~~31001-P-081~~
~~GV-12, Caustic Addition~~	~~31001-P-052-01~~	~~31001-P-082~~
GV-13, Service & Instrument Air	31001-P-055	31001-P-083-01 & 02
GV-15, Nitrogen Supply	31001-P-056	31001-P-085
GV-16, Process Water	31001-P-058-01	31001-P-086
GV-17, R.O. Water	31001-P-058-02	31001-P-087
~~GV-18, Steam Supply~~	~~31001-P-057~~	~~31001-P-088-01 & 02~~
GV-19, Process Cooling Water	31001-P-058-03	31001-P-089
GV-20, Chilled Water	31001-P-058-04	31001-P-090
GV-22, Building Confinement	31001-P-059-01 & 02	31001-P-092-01 & 02
GV-23, Electrical Power Distribution	NR	NR
~~GV-24, Main Process Control Panel~~	~~NR~~	~~NR~~
GV-25, Building Exhaust Monitors	NR	31001-P-095
GV-26, Building Containment	NR	NR
GV-27, Building & Structures	NR	NR
~~GV-28, Area Monitors~~	~~NR~~	~~NR~~

~~**Table 1.2:** Boiling or sublimation temperatures for metals, metal chlorides, and metal oxides.~~

	~~Metal~~	~~Boiling or Sublimation Temp. °C~~			~~Most Probable Deposition Location~~				
		~~As Metal~~	~~As Chlorides~~	~~As Oxide~~	~~Vit 1300-1650°C~~	~~H.T. 650-760°C~~	~~Scrub 80°C~~	~~HEPA <100°C~~	~~Carbon <100°C~~
~~HAZARDOUS RAD~~	~~Antimony~~	~~1,750~~	~~283~~	~~1,550~~	~~a,c~~		~~b~~		
	~~Arsenic~~	~~613(s)~~	~~130~~	~~465~~	~~a,c~~		~~b~~		
	~~Barium~~	~~1,640~~	~~1,560~~	~~2,000~~	~~a,b,c~~				
	~~Beryllium~~	~~>3,000~~	~~520~~	~~3,900~~	~~a,c~~		~~b~~		
	~~Cadmium~~	~~762~~	~~960~~	~~1,559(s)~~	~~a,c~~	~~b~~			
	~~Chromium~~	~~2,672~~	~~1,300(s)~~	~~4,000~~	~~a,c~~				
	~~Lead~~	~~1,740~~	~~950~~	~~NA~~	~~a~~	~~b~~			
	~~Mercury~~	~~357~~	~~400(s)~~	~~100(d)~~			~~a,b,c~~		
	~~Nickel~~	~~2,732~~	~~973(s)~~	~~1,990~~	~~a,c~~	~~b~~			
	~~Selenium~~	~~685~~	~~130(d)~~	~~180~~	~~a,b,c~~				
	~~Silver~~	~~2,212~~	~~1,550~~	~~300(d)~~	~~a,b~~		~~c~~		
	~~Thallium~~	~~303~~	~~720~~	~~875~~	~~a,c~~		~~b~~		
	~~Ce~~	~~3,426~~	~~1,727~~	~~NA~~	~~a,b~~				
	~~Cs~~	~~678~~	~~1,290~~	~~400(d)~~	~~c~~	~~b~~	~~a~~		

~~Missing text~~

Mixed Waste Facility

Please see Construction Drawing Volume for this Attachment RR