Mobile Volume Reduction System

Topical Report No. AECC-4-NP
May 1, 1984

Prepared For:
Office of Nuclear Reactor Regulation
Division of Reactor Licensing
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Aerojet
Energy Conversion
Company

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OFFICE OF NUCLEAR REACTOR REGULATION
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AEROJET ENERGY CONVERSION COMPANY
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Proprietary information has been deleted from this report and is presented in the companion proprietary report, Topical Report No. AECC-4-P. The information deleted from this report is:

(1) Figure 3. Material Balance Flow Diagram for the AECC Mobile Volume Reduction System.

(2) Figure 5. Piping and Instrumentation Diagrams for the AECC Mobile Volume Reduction System.

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ABSTRACT

This Topical Report describes the Aerojet Energy Conversion Company (AECC) Mobile Volume Reduction System (MVRS). This system is capable of processing low-level combustible radioactive wastes that are generated during the operation of commercial BWR and PWR nuclear power plants and effecting substantial volume reduction of the wastes. The combustible wastes include dry active wastes and contaminated oil. The system employs a controlled air incinerator and a liquid off-gas cleanup system. The process converts the radioactive wastes to an ash which is packaged in a High Integrity Container (HIC), or other suitable container, prior to shipment to a burial site or storage onsite by the utility. The volume reduction factors achieved are a function of the waste type, but are approximately 80 for uncompacted combustible solid wastes.

A detailed description of the system is presented, which includes the following: process description, equipment description and general arrangement, materials of construction, instrumentation and control system, and the design and operating conditions. The Quality Assurance Program is also described.

Descriptions of expected waste streams from commercial nuclear power plants amenable for processing by the AECC MVRS are examined. Volume reduction factors and overall system decontamination factors for the AECC MVRS are presented. The expected annual release of radioactive material from the system is also projected. System benefits are presented.

The following conclusions were reached:

(1) The AECC Mobile Volume Reduction System is capable of safely processing combustible radioactive wastes generated at BWR and PWR commercial nuclear power plants and converting these wastes to an ash, effecting substantial volume reduction of the waste.

(2) An overall system decontamination factor of 4×10^6 for particulate and 100 for iodine will be achieved during operation, and expected annual releases and plant site boundary concentrations of all radicisotopes are several orders of magnitude below the limits prescribed by federal regulation.

(3) Many benefits are associated with operation of the AECC Mobile Volume Reduction System, including substantial reduction in the annual waste disposal costs, conservation of valuable shallow-land disposal sites, and minimal impact on the onsite storage facility capacity.

1.0 INTRODUCTION

Aerojet Energy Conversion Company (AECC) has submitted three Topical Reports to the NRC (References 1, 2 and 3) on its Radioactive Waste Volume Reduction (VR) System which is offered for permanent installation at commercial nuclear stations. These Topical Reports describe a fluid bed system for processing low-level liquid and combustible radioactive wastes generated at central station BWR and PWR nuclear power plants. The first Topical Report was accepted for referencing in utility licensing applications by the NRC in December, 1975 (Reference 4). Topical Reports No. 2 and No. 3 are under active review by the NRC.

The AECC Mobile Volume Reduction System (MVRS) consists of a controlled air incinerator and a liquid off-gas cleanup system. The MVRS is capable of processing combustible wastes such as the dry active wastes and contaminated oil generated at commercial nuclear power stations. The MVRS is mounted on three trailers so that it can be moved from site to site to process the available wastes.

The AECC MVRS described in this Topical Report results in several benefits, such as a reduction in annual waste disposal costs, conservation of valuable shallow-land disposal sites, and minimal impact on the onsite storage facility capacity. Since the amount of waste to be packaged, handled, stored, and shipped to the burial site is substantially reduced, AECC believes that the in-plant dose exposure associated with these operations will also be reduced.

The purpose of this Topical Report is to describe the design and operational characteristics of the AECC MVRS and to obtain NRC approval to reference this document in utility licensing applications.

The first section of the Topical Report is the process description of the MVRS. The next four sections present data on equipment description, the design basis and process parameters, the equipment general arrangement, and radiation monitoring equipment.

Section 7 describes the Quality Assurance Program in effect during the design and fabrication of the system. Section 8 describes the codes, standards, Federal Regulations, Regulatory Guides, and NRC branch technical positions followed in the design of the system. The last section presents the expected release rates during operation of the MVRS.

2.0 PROCESS DESCRIPTION

The Aerojet Mobile Volume Reduction System is a trailer-mounted unit composed of: (1) a controlled air incinerator, (2) a wet off-gas cleanup system, (3) an off-gas discharge system, and (4) an ash handling system. This system is depicted in a simplified manner by the process schematic diagram given in Figure 1. The following sections provide a general system description, and detailed information on the MVRS subsystems, system operation, interface services required, the material balance flow diagram, and the piping and instrument diagram of the system.

2.1 GENERAL SYSTEM DESCRIPTION

The controlled air incinerator is a two-stage combustion device which is based on proven LASL technology. The primary combustor operates at negative pressure under air-limiting underfire conditions and at a modest fixed temperature (about 1600°F) which is controlled by firing a supplemental burner. The secondary combustor operates at negative pressure, high excess air (about 100%) and high temperature (about 2100°F) conditions which are controlled by closed-loop modulation of the secondary air flow and by modulation of a second-stage supplemental burner to provide complete combustion. The incinerator is batch-fed compacted, shredded or non-compacted trash with a small quantity of concentrated scrub liquor via an air-lock feeder and ram arrangement. Contaminated oil is fed to the primary chamber by a separate burner or by incremental batch feeding along with the input trash. The total disposable product from the system is removed as ash from the primary chamber.

The off-gas from the secondary combustion chamber is quenched and scrubbed of particulates and acid-gases in a liquid venturi scrubber. The scrub liquor is separated from the gases in a vessel which contains a liquid sump, a gas-liquid de-entrainment section, and a demister. This system automatically provides proper scrub liquor recirculation, scrub liquor concentration to about 20% wt solids, and automatic control of sump level and pH.

The gas discharge system draws the cleaned, saturated off-gas from the wet scrubber, heats it slightly by compression in an induction fan, passes it through a filter/adsorber assembly, and releases it to the atmosphere.

The ash plow is operated intermittently to remove ash from the primary combustor vessel and deliver it to an ash hopper. The ash is then metered to a densifier, where the ash is formed into larger particles. The densified product is then fed to a High Integrity Container for packaging.

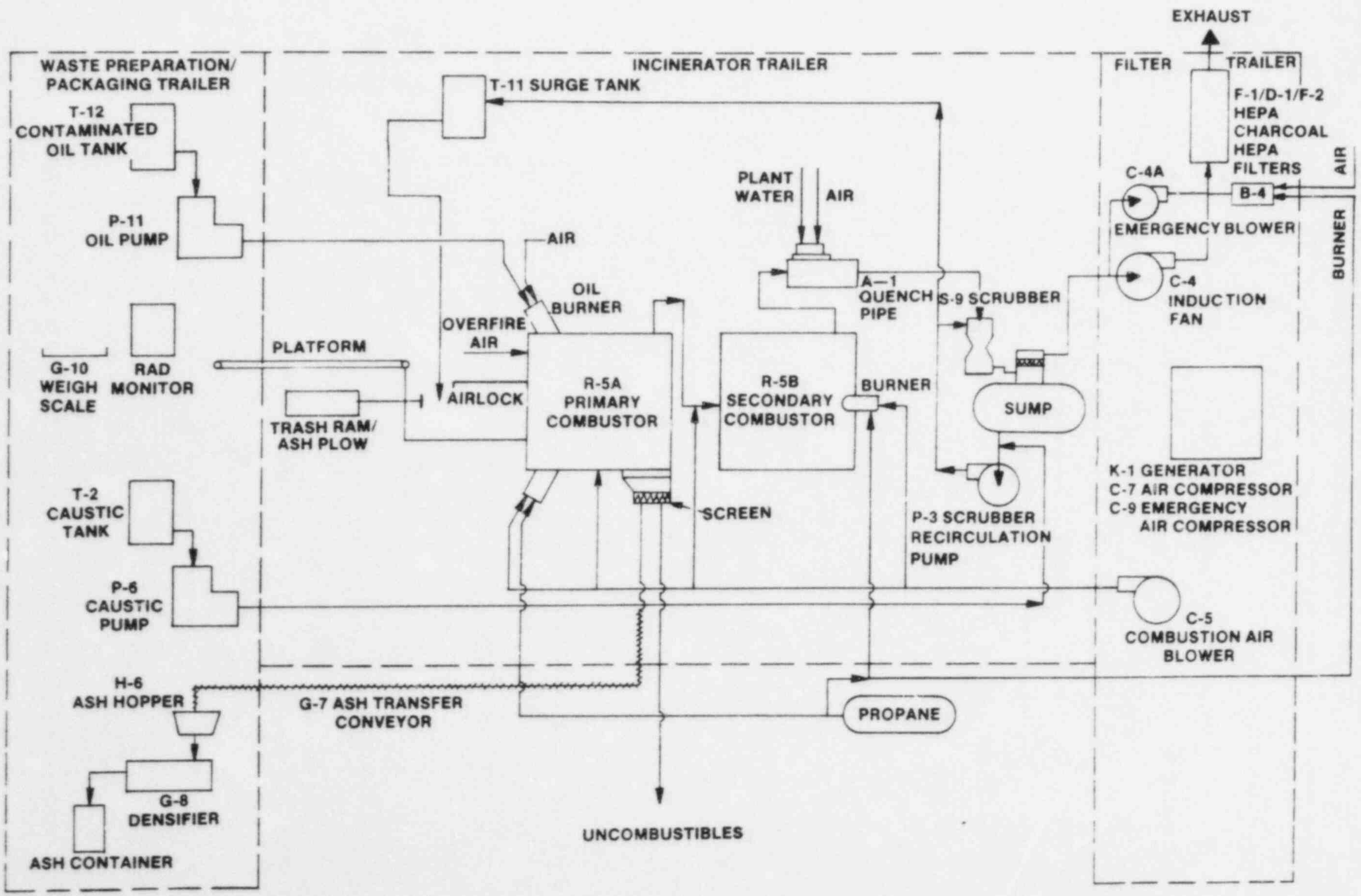

Figure 1. AECC Mobile Volume Reduction System Schematic

2.2 SUBSYSTEM DESCRIPTIONS

The Mobile Volume Reduction System is comprised of several subsystems, each of which is described in the following section.

2.2.1 Incinerator and Feed Systems

The incinerator is designed to process typical dry active waste composed of rags, paper, plastics, rubber, and wood. The waste can contain 5% by weight halogenated plastics and 1% sulfur as a nominal design point condition. The system will automatically accommodate various amounts of Cl or S bearing wastes within these limits. The waste package is designed around a standard 55-gallon drum volume. Metal drums cannot be charged to the incinerator; however, combustible drums such as fiber board can be used in this service. The drums of waste are first checked with a radiation monitor, weighed, and the weight recorded. The dry active waste packages are then placed into the waste ram feeder system. This is a process interlocked ram feeder contained in its own airlock for incinerator pressure control. The waste packages are charged one at a time into the incinerator via automatic actuation of the feed cycle. The waste packages are physically pushed into the primary incinerator chamber by the ram feeder. During a charging cycle, the supplementary fuel burner is reduced to a low fire position, and the underfire air is reduced, so as to minimize ash entrainment in the gas leaving the incinerator.

Once the waste package is charged into the incinerator and the firedoor is closed, the burner is modulated to a firing position based on primary chamber temperature. This serves to ignite the waste package. The combustion air to the primary chamber is restricted to give air-limited combustion. The dry active waste is decomposed to CO, CO_2, H_2O, and some partially oxidized organic compounds. These compounds pass via the gas stream to the secondary chamber which is maintained very air-rich at a higher temperature for the purpose of completing the oxidation of the gaseous combustion products. The off-gas then leaves the incinerator and passes through the wet scrub system for particulate removal.

Approximately 95% of the ash content of the incoming dry active waste package remains in the primary chamber. Ash is gradually moved down the hearth by the action of the incoming waste boxes. A secondary method of advancing the ash pile is provided by the ash plow system which is used mainly for ash cleanout of the incinerator after an operating

2.2.1 (cont.)

campaign. The ash drops through an ash port in the end of the primary chamber furthest from the dry active waste feeding door into a retention chamber that is pressure-sealed using a hydraulically actuated knife edged gate valve. The ash then passes into a metering chamber through a bar screen for catching any large uncombusted objects. These objects can be removed manually through an access door in the ash holdup hopper. The ash is then metered to the densifier prior to loading in a high integrity container for final disposal.

Concentrated blowdown scrub solution from the wet off-gas cleanup system is converted to dry salt/ash in the incinerator in the following manner. The concentrated blowdown stream is returned from the off-gas cleanup system via a density monitoring loop. The solution is collected in the blowdown solution surge tank located near the incinerator ram feeder system. A small amount of blowdown solution is injected into each waste box prior to charging to the incinerator. By injecting the blowdown liquid directly into the waste box, re-entrainment in the off-gas is prevented, thereby decreasing the overall particulate load to the scrub system. The blowdown liquid is converted to dry salt by the heat in the primary chamber and remains with the ash pile on the lower chamber hearth. In this manner, no secondary liquid waste is generated in the process.

Small volumes of contaminated oil can be processed in the incinerator by placing the oil in a waste container filled with a combustible adsorbant material such as sawdust. This waste package is then directly charged into the incinerator using a normal waste charging cycle. If larger amounts of oil require processing, they may be transferred to a contaminated oil feed tank for subsequent injection through a separate waste oil burner. An LPG piloted burner is designed specifically for the waste oil combustion, resulting in adequate processing capacity with flame safeguard controls and stable combustion characteristics.

2.2.2 Off-Gas Cleanup System

The off-gas cleanup system employed in the MVRS is based on the proven and efficient wet scrubber/concentrator developed for the Aerojet Fluidized Bed VR System. This simple subsystem accomplishes four important functions: (1) combustion gas quenching, (2) particulate removal, (3) acid-gas scrubbing, and (4) scrub liquor concentration. These

2.2.2 (cont.)

functions are performed in a subsystem consisting of a venturi scrubber, a scrub liquor sump, a gas/liquid separator, a scrub liquor recirculation pump, automatic sump level, pH, and density controls, and an ancillary caustic supply.

The unique feature of this system is that it produces very concentrated scrub liquor (approximately 20% dissolved and suspended solids), resulting in the production of a very small quantity of scrub liquor (<16 gal/hr even under worst-case conditions, i.e., 5% halogenated plastics and 1% sulfur in the DAW). It is thus practical to reprocess the scrub liquor in the system by introducing it back into the incinerator with the incoming DAW. In this manner, the incinerator can utilize an efficient and simple wet off-gas cleanup system without net production of any liquid waste.

Referring to the Process Schematic Diagram in Figure 1, the off-gas cleanup system operates as follows. The hot incinerator off-gases enter the quench pipe, where the gas temperature is dropped to about 1000°F. Then, the off-gases enter the wetted-wall venturi scrubber, where they are cooled and scrubbed of particulates and acid-gases (HCl and/or SO_2) by contact with a recirculating stream of causticized scrub liquor. The gas-liquid mixture passes into a separator vessel where the liquid phase drops out due to centrifugal and gravitational forces into a scrub liquor sump while the cooled, clean gases flow upward through a demister and out of the gas cleanup system through the filter system.

The scrub liquor in the sump is controlled automatically with respect to liquid level, pH, and density, and is constantly recirculated back to the venturi scrubber. The liquid level in the scrubber sump tends to decrease because of scrub liquor evaporation (approximately 3 gal/min), which occurs while cooling the hot incinerator gas in the venturi. This liquid loss is compensated by the continuous addition of make-up water under the automatic control of a sump level controller and pneumatic control valve in the make-up water supply line. To assure efficient scrubbing of any acid gases in the incinerator exhaust, the scrub liquor is automatically kept caustic (pH approximately 8-9) by the addition of aqueous NaOH via a pH controller which modulates a caustic metering pump. The scrub liquor concentration is monitored by a density transmitter and indicator. When it reaches a given set-point, it provides a signal that allows the concentrated scrub liquor to be transferred to a surge tank for subsequent injection into the trash when a new charge is

2.2.2 (cont.)

introduced to the incinerator. This provides the means of bleeding-off particulates and dissolved solids that accumulate in the scrub system and converting them to incinerator ash. The scrub liquor recirculation flowrate is varied over a limited range by modulation of a control valve in the recirculation line. This accommodates somewhat varying incinerator exhaust gas flow rates and thereby maintains the prescribed negative pressure in the primary incinerator chamber.

2.2.3 Off-Gas Discharge System

The off-gas discharge system is simple in design and uses only proven components. This subsystem takes the cooled, scrubbed, saturated off-gas from the cleanup system and releases it to the atmosphere after final cleanup and reheat. It consists of an induction fan and a HEPA filter/charcoal adsorber/HEPA filter assembly.

The induction fan draws the saturated off-gases from the wet cleanup system and compresses them to slightly above atmospheric pressure. This fan also heats the gases sufficiently to prevent any condensation from occurring during their passage through the HEPA filter/charcoal adsorber/HEPA filter assembly. This assembly is similar to those utilized in Aerojet's Fluidized Bed VR System.

2.2.4 Ash Handling System

The ash handling system consists of an ash transfer conveyor, ash hopper and metering screw, and an ash densifier which delivers the densified ash directly to a High Integrity Container for final disposal. Salt/ash generated by the incineration process is accumulated in an ash container located below the primary combustor. The salt/ash mixture is then conveyed by the ash transfer conveyor to the ash hopper. The ash is metered to the densifier where it is mixed with a binder such as water or other appropriate binder material. The densifier causes the finely divided salt/ash mixture to be formed into much larger particles which prevents the ash from becoming airborne. The densified product is then metered directly to a High Integrity Container for final packaging prior to storage in an onsite storage facility, or shipment to a burial site. Approximately 350 lbs. of densified salt/ash will be packaged in a 55-gallon capacity polyethylene High Integrity Container.

2.2.5 Instrumentation and Control System

2.2.5.1 Electrical Control System

The electrical control system is based on the use of a Texas Instrument PM-550 programmable process controller. The process controller provides PID control to the following feedback control loops:

Combustion Air Flow
Primary Chamber Temperature
Primary Chamber Pressure
Secondary Chamber Temperature
Gas Quencher Outlet Temperature
Scrubber pH
Preconcentrator Sump Level

Local burner controls are provided for fuel/air ratio control, flame detection, and purge and start sequencing. In addition, the process controller provides alarm annunciation and safety shutdown if out of tolerance conditions prevail.

A standby engine generator is included to provide power to critical equipment in the event of utility power outage. Controls of critical equipment are hard-wired to hand switches on the main control panel to provide backup in the event of a process controller failure.

Operator control is provided by hand switches and a control loop access module on the main control panel. Process status is provided by process indicators, strip chart recorders and alarm annunciator. In addition, all analog data is printed at specified intervals.

2.2.5.2 Electric Motors

All process electric motors are totally enclosed fan cooled. Motors located in high ambient temperature areas are rated for 65°C ambient temperature.

2.2.5.3 Heat Tracing

Heat tracing is provided for tank, pumps and piping of the scrubber, caustic addition, and off-gas systems. The heat tracing is self-limiting on heatup to prevent over-temperature.

2.2.5.4 Trailer Wiring

All assembly wiring is installed in moisture tight, zinc coated, rigid steel conduit according to the National Electric Code. Conduits and wiring between equipment and junction boxes are continuous. Junction boxes and enclosures are NEMA 12. Power wiring is No. 10 AWG minimum, stranded, 600 volt flame retardant insulation, 90°C rated, Type XHHW. Control wiring is No. 14 AWG minimum, stranded, 600 volt flame retardant insulation 90°C rated, Type XHHW. Instrument wiring on cables are shielded twisted pairs, No. 16 AWG minimum, stranded, 600 volt flame retardant insulation with one overall Hypalon jacket. Wire terminations are ring-type self-insulated barrel compression lugs.

2.3 SYSTEM OPERATION

The following sections describe the operation of the MVRS, which is designed to be operated by a single operator.

2.3.1 Waste Reception

The utility will allocate space at the power plant to store at least one month's supply of DAW for the MVRS. Each month, after notification from the utility that a sufficient quantity of waste has been accumulated, AECC will staff the MVRS to process all of the accumulated DAW in an around-the-clock operation.

The utility will deliver the waste to the waste preparation/packaging trailer in quantities representing 24-36 hours of operation in the system. The utility will verify that the surface dose rate of the DAW packages is below 25 mRem per hour before the waste is transported to the MVRS.

After receiving the waste, the MVRS operator will weigh the waste and re-check the waste with a radiation monitor. Acceptable waste (less than 25 mRem per hour dose rate and less than 250 pounds) will then be set aside for processing in the MVRS. Waste that exceeds the dose rate or weight limitations will be returned to the utility for alternate

2.3.1 (cont.)

processing and disposal. Contaminated oil will be delivered to the MVRS storage tank by the utility. Processing of the contaminated oil will then be the responsibility of the MVRS operator.

2.3.2 Startup Cycle

The MVRS operator will follow a detailed procedure for startup of the MVRS. Key elements of the startup procedure are as follows:

(1) Confirm that off-gas system is operating.

(2) Confirm that the airlock and fire doors are closed and locked.

(3) Begin heatup of incinerator at the prescribed rate.

2.3.3 DAW Incineration

(1) Operator will load waste package into airlock.

(2) After securing the airlock, the operator will inject scrub solution into waste package if needed.

(3) Check for proper operating conditions:

a. Primary chamber temperature and pressure

b. Secondary chamber temperature

c. Off-gas system operation

(4) Initiate the charge cycle either manually via a handswitch or automatically via a cycle timer.

(5) Prepare the primary chamber for a waste charge:

a. Reduce the underfire air

b. Reduce the overfire air

c. Switch primary burner to low fire setting

(6) Open fire door and charge waste package.

(7) Check ram face for fire and close fire door.

(8) Restore the primary chamber operation to regular conditions.

(9) Repeat the above procedure for each waste package.

2.3.3 (cont.)

(10) Ash removal is automatic during operation, since each waste package moves the ash generated from earlier charges.

2.3.4 Waste Oil Incineration

The MVRS operator will follow a detailed procedure for incineration of the waste contaminated oil. Key elements of the procedure are as follows:

(1) Confirm that the airlock and fire doors are closed and locked.

(2) Confirm that the DAW incineration mode is locked out.

(3) Confirm that the primary burner is operating.

(4) Confirm that the secondary chamber afterburner is in operation.

(5) Initiate flow of contaminated oil to the incinerator.

(6) Confirm that the continuous LPG pilot is operational as this provides positive ignition of the waste oil.

(7) Conduct ash removal at the end of the processing campaign using the ash plow.

2.3.5 Ash Discharge

The ash will be discharged from the primary chamber automatically as additional waste packages are charged. Residual ash can be removed by use of the ash plow. Procedure is as follows:

(1) Confirm that the airlock door is closed and locked.

(2) Adjust the primary chamber conditions as follows:

a. Reduce underfire air
b. Reduce overfire air
c. Reduce primary burner firing rate
d. Confirm that primary chamber temperature is 1400°F

(3) Confirm that off-gas cleanup system is in operation.

(4) Open fire door.

(5) Cycle the ash plow.

2.3.5 (cont.)

(6) Close the fire door.

(7) Cycle the ash gate valve.

(8) Activate bridge breaker

(9) Remove ash with the ash transfer conveyor.

2.3.6 Shutdown Cycle

During shutdown, the off-gas cleanup system will continue to operate. The airlock and fire doors will be closed and locked. The incinerator primary burner will be cooled at a rate that insures long life of the refractory and will allow carbon burnout in the ash pile.

2.3.7 Ash Packaging

Figure 2 is a schematic diagram of the ash packaging system provided with the AECC MVRS. The MVRS operator will conduct the complete ash packaging operation from the Ash Handling Local Control Panel (CP-3). He will be able to visually observe the complete operation from the control panel. Incinerator ash is accumulated in a receptacle located beneath and at the far end of the primary combustor. Ash is generated and accumulated at a variable rate of 11-42 lbs per hour, depending on the sulfur and halogen content of the incoming waste. At frequent intervals the ash will be transferred from the ash receptacle (incinerator trailer) to the ash hopper (H-6) located on the waste preparation/packaging trailer. The ash transfer conveyor (G-7) will be used to transfer the ash between the two trailers.

The ash hopper has a working capacity of about 2.8 ft.^{3}, which is equivalent to about 60 lbs of incinerator ash. This hopper is equipped with a variable frequency vibrator to aid in completely discharging the ash from the hopper. The ash is discharged from the hopper into a metering auger located at the inlet of the densifier, also referred to as an agglomerator. The densifier receives the ash from the metering auger and combines the ash with a binder such as water or other appropriate binder material. The ash and binder are mixed at high speed. The product produced in the densifier has a density of about 50-60 lbs per cubic foot. Furthermore, this end product no longer has the ability to become airborne. The densifier discharges the agglomerated ash via gravity directly into the High Integrity Container through a fill hood assembly.

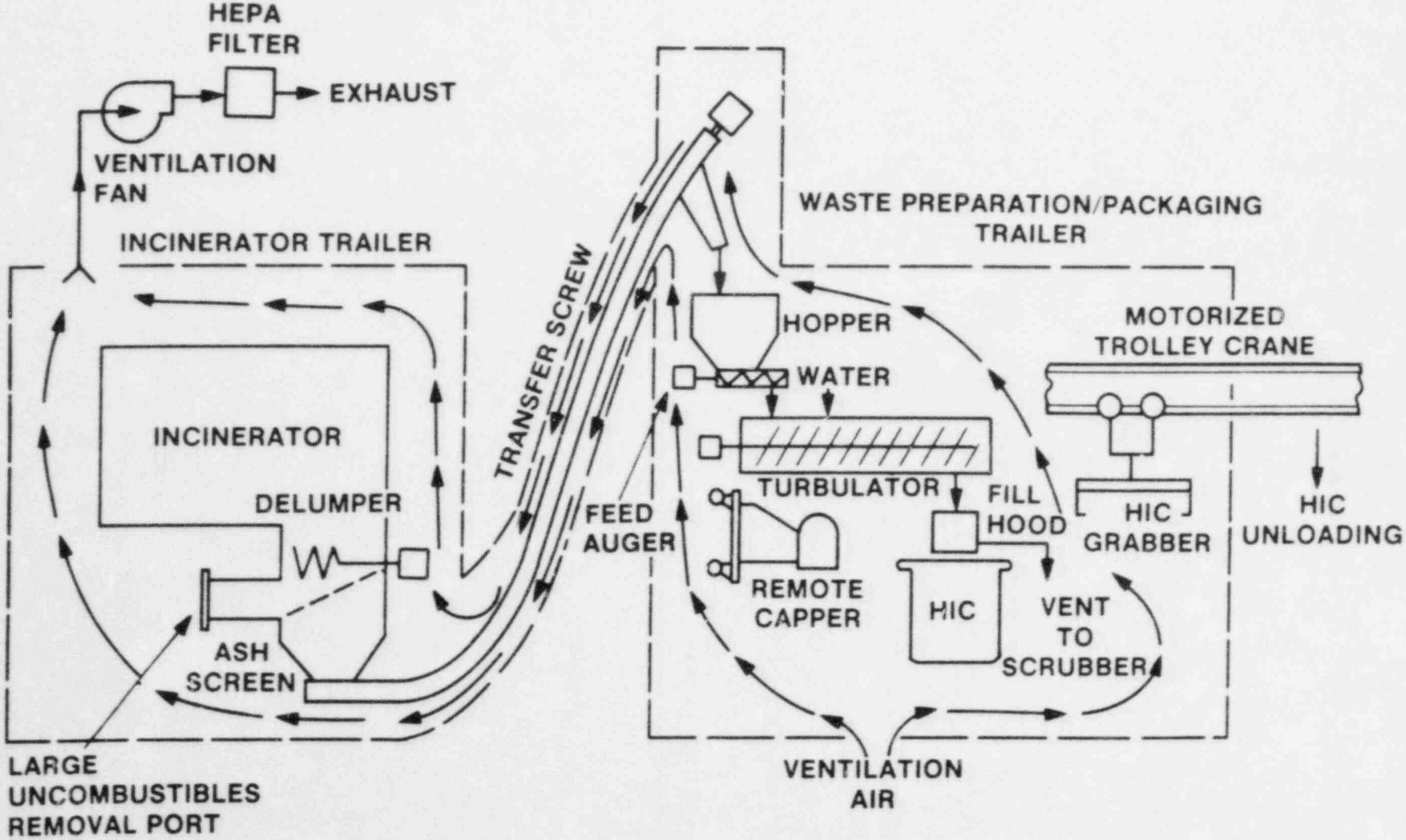

Figure 2. Ash Packaging System

2.3.7 (cont.)

The fill hood is attached to an elastomer boot which is fastened directly to the discharge of the densifier. The hood is moved up and down onto the HIC by three air bags which supply enough force to seal the hood onto the HIC. The hood and drum assembly are evacuated, and the displaced air is vented back to the scrubber system. This fill hood assembly assures that no leakage of ash will occur during the filling cycle. The fill hood utilizes a fluidic level sensor to identify when the HIC is filled.

Prior to filling the HIC with ash, the HIC is placed in the Container Cart (T-13) which is capable of holding two HICs. The container cart is a 2-inch thick leaded wall container that provides necessary shielding to reduce the dose rate to the operator to an acceptable level. To assure optimum packaging of the ash in the HIC, a vibrator is located within the container cart and in contact with the HIC during the ash filling operation. The above procedure for transferring ash from the incinerator primary chamber to the HIC will likely be repeated several times before the HIC is completely filled with ash. The HIC can hold up to 350 lbs incinerator ash.

When the HIC is filled with ash, it is ready for capping. Two container cappers (G-11A, B) are provided for this function, one for each of the two HICs on the trailer. The capper is designed to carry a threaded plastic cap coated with sealant from the control area to the HIC and to lower and tighten the cap onto the HIC. This system utilizes a manually operated trolley to move the capper from the control area to the HIC, where it is indexed precisely over the HIC. The capper with the cap attached is lowered onto the HIC, and the cap is tightened to the required torque.

Two monorail cranes (G-9A, B) are provided to lift the HIC from the container cart and transfer it approximately 6 feet outside of the trailer for loading onto a vehicle supplied by the utility for transfer to the radwaste facility. This loading operation represents the interface with the utility for disposing of filled HICs. The monorail crane is also used to replenish the container cart with an empty HIC.

A 12" x 12" opening is provided on either side of the trailer opposite the ash packaging area to allow the utility to take smear samples from the top of the HIC prior to transferring the HIC from the container cart onto the utility vehicle.

2.4 INTERFACE SERVICE REQUIREMENTS

There are five auxiliary services required to operate the MVRS. AECC provides three of them as part of the scope of supply of the system: air, fuel, and caustic. The other two, electricity and water, are interfaces with the power plant receiving the incineration service. The following table summarizes the electrical loads for the MVRS:

	Connected Load (KW)	Operating Load (KW)
Combustion Blower	18	14
Process Fan	80	64
Scrubber Recirculation Pump	2	1.5
Caustic Supply Pump	.5	.4
Contaminated Oil Pump	.5	.2
Scrub Recycle Tank Mixer	.5	.4
Air Compressor	40	32
HVAC	20	16
Miscellaneous Loads	50	43
Intermittent Loads	30	--
Total	241.5	171.5

In addition to the electricity, the requirements for plant water to provide quenching and scrubbing of the exhaust gas and for fire protection are as follows:

Process water

Flowrate:	6 gpm nominal, 20 gpm maximum
Pressure:	90 psig
Quality:	< 1000 ppm dissolved solids, no suspended solids > 25 μ
pH:	Approximately 7

Fire protection water

Flowrate:	12 gpm
Pressure:	30 psig

2.5 MATERIAL BALANCE FLOW DIAGRAM

The Material Balance Flow Diagram for the MVRS is shown in Figure 3 (AECC Drawing No. 1194903). This diagram indicates the important pressures, temperatures and flowrates of gases, liquids, and solids throughout the system during normal operation.

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Topical Report No. AECC-4-P.

Figure 3. Material Balance Flow Diagram for the AECC VR System (AECC Drawing No. 1194903, Sheet 1 of 3)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Topical Report No. AECC-4-P.

Figure 3. Material Balance Flow Diagram for the AECC VR System (AECC Drawing No. 1194903, Sheet 2 of 3)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Topical Report No. AECC-4-P.

Figure 3. Material Balance Flow Diagram for the AECC VR System (AECC Drawing No. 1194903, Sheet 3 of 3)

2.5 (cont.)

Figure 4 is a simplified diagram, showing the flow of materials onto and off the Trash Preparation and Ash Handling Trailer. Table I summarizes important capacity, use rate, and replacement rate data for the dry trash, contaminated oil, caustic, and the incinerator ash/salt product.

The characteristics of the two effluents from the MVRS: ventilation air and process air, are shown in Table II.

Table I

MATERIAL FLOWS

(See Figure 4)

Material	Storage Capacity	Use Rate	Replacement Rate
Dry trash	Utility Trailer TBD	280 lb/hr 6700 lb/day	6700 lb/day
Contaminated oil	80 gallons	15 gph (5 hours)	75 gal/day
Caustic	850 gallons	Min. 0.5 gph Max. 2.5 gph	Every 10 weeks Every 2 weeks
Ash/salt	340 lb per HIC	Min. 11 lb/hr = 264 lb/day, < 1-HIC per day Max. 42 lb/hr = 1000 lb/day, 3-HICs per day	

Table II

EFFLUENTS

Ventilation air:		3000 SCFM
Process air:	Dry Active Waste	Contaminated oil
Flow	2200 SCFM	2100 SCFM
Temperature	212°F	212°F
Dew point	177°F	174°F
Relative humidity	49%	45%

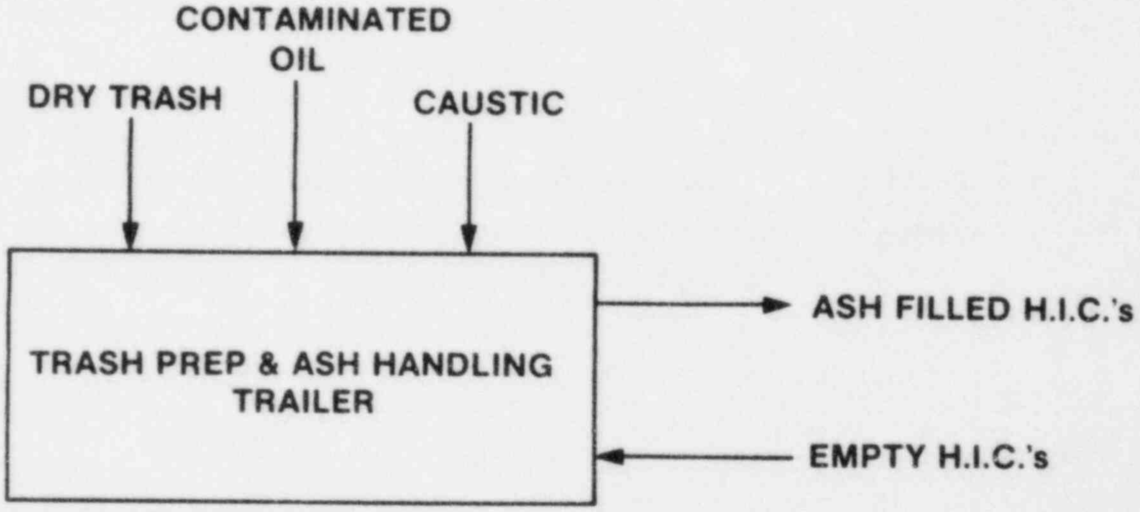

Figure 4. Simplified Material Flow Diagram

2.6 PIPING AND INSTRUMENT DIAGRAM

The Piping and Instrument Diagram for the MVRS is shown in Figure 5 (AECC Drawing No. 1194901, 5 sheets). This diagram shows the location and type of all required instrumentation for safe operation of the system.

2.7 FIRE PROTECTION

Fire protection is provided within the AECC MVRS in the following manner:

(1) Temperature sensors are provided on the charcoal adsorbers, and an alarm will sound in the control room in the event of a high temperature indication. A deluge spray system is provided for the charcoal adsorber in the event of a fire. The deluge spray system draws its water from the interface connection for fire protection water provided by the utility at the trailer pad. A hose will run from the interface connection to the charcoal adsorber deluge spray system nozzles. Water flow to the system is manually initiated by the operator. A drain plug is also provided on the charcoal adsorber for removal of the water.

(2) Two portable Halon-type fire extinguishers are provided on the trash preparation trailer and two additional on the filter trailer.

(3) Smoke detectors are provided in each trailer. Local and control room alarms are provided for each trailer.

(4) Access will be provided to a utility-supplied fire hose station.

2.8 TRAILER GROUNDING

For grounding purposes, the three trailers will be connected to each other. Then a final connection will be made to a grounding lug provided by the utility at the trailer pad.

2.9 TELEPHONE COMMUNICATION

The AECC MVRS control room will be equipped with a telephone for ready communication with the plant and external to the plant.

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Topical Report No. AECC-4-P.

Figure 5. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (AECC Drawing No. 1194901, Sheet 1 of 7)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Topical Report No. AECC-4-P.

Figure 5. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (AECC Drawing No. 1194901, Sheet 2 of 7)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Topical Report No. AECC-4-P.

Figure 5. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (AECC Drawing No. 1194901, Sheet 3 of 7)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Topical Report No. AECC-4-P.

Figure 5. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (AECC Drawing No. 1194901, Sheet 4 of 7)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Topical Report No. AECC-4-P.

Figure 5. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (AECC Drawing No. 1194901, Sheet 5 of 7)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Topical Report No. AECC-4-P.

Figure 5. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (AECC Drawing No. 1194901, Sheet 6 of 7)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Topical Report No. AECC-4-P.

Figure 5. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (AECC Drawing No. 1194901, Sheet 7 of 7)

3.0 EQUIPMENT DESCRIPTION

3.1 GENERAL

The AECC MVRS consists of a feed system, a controlled-air incineration system, an off-gas cleanup system, an off-gas discharge system, and a waste transfer/ash handling system. Table III lists the components that make up the complete system.

Table III

MOBILE VOLUME REDUCTION SYSTEM COMPONENTS

	Component	No. Required
1.	Gas Quencher (A-1)	1
2.	Modulating Burners (B-1,2)	2
3.	Contaminated Oil Burner (B-3)	1
4.	Induction Fan (C-4)	1
5.	Emergency Fan (C-4A)	1
6.	Combustion Air Blower (C-5)	1
7.	Process Air Compressor (C-7)	1
8.	Emergency Air Compressor (C-9)	1
9.	Main Control Panel (CP-100)	1
10.	Incinerator Local Control Panel (CP-2)	1
11.	Ash Handling Local Control Panel (CP-3)	1
12.	Drum Handling & Capping Local Control Panels (CP-4A,B)	2
13.	HEPA Filter/Charcoal Adsorber/HEPA Filter Assembly (F-1/D-1/F-2)	1
14.	Ash Transfer Conveyor (G-7)	1
15.	Densifier (G-8)	1
16.	Monorail Cranes (G-9A, B)	2
17.	Trash Weigh Scale (G-10)	1
18.	Container Cappers (G-11A, B)	2
19.	Fill Hood (G-12)	1
20.	Ash Hopper (H-6)	1
21.	Standby Power System (K-1)	1
22.	Motor Control Center (MCC-1)	1
23.	Scrubber Recirculation Pump (P-3)	1
24.	Caustic Pump (P-6)	1
25.	Contaminated Oil Pump (P-11)	1

3.1 (cont.)

Table III (cont.)

MOBILE VOLUME REDUCTION SYSTEM COMPONENTS

	Component	No. Required
26.	Primary Combustor (R-5A)	1
27.	Secondary Combustor (R-5B)	1
28.	Trash Ram	1
29.	Ash Plow	1
30.	Scrubber/Preconcentrator (S-9, S-10)	1
31.	Caustic Tank (T-2)	1
32.	Surge Tank (T-11)	1
33.	Contaminated Oil Tank (T-12)	1
34.	Exhaust Air Blower (C-8)	1
35.	HVAC Filter (F-3)	1
36.	Container Cart (T-13)	1
37.	Hydraulic Power Unit	1
38.	Incinerator Trailer (IT-1)	1
39.	Filter Trailer (IT-2)	1
40.	Waste Preparation/Packaging Trailer (IT-3)	1
41.	Radiation Monitors	1 set

3.2 COMPONENT DESCRIPTION

Each of the major components in the Mobile Volume Reduction System is described below.

3.2.1 Combustor (R-5A, B)

The first adaptation of Controlled Air Incineration (CAI) for radioactive waste service was made by the Los Alamos Scientific Laboratory (LASL). The Aerojet CAI design uses the LASL technology and equipment design as a starting point in the design of a mobile volume reduction system. Improvements in the basic LASL design have been made in the following areas:

(1) All vessel and piping connections are made with substantial (ASA 150 lb) flanges.

3.2.1 (cont.)

(2) Incinerator design to withstand -10 inches W.C. internal pressure to minimize shell flexing, hence promote a longer refractory life-time.

(3) Improvements in refractory selection due to better refractory materials being available since the LASL CAI was constructed.

(4) Large double glazed incinerator chamber sightports isolated by slide gate valves.

(5) Redesign of the underfire and secondary air injection manifolds for even better mixing, hence more efficient combustion.

(6) Use of preheated combustion air for better thermal efficiency.

(7) The use of a separate burner with its own flame safeguards, combustion air, atomizing air, and flame holder for better combustion of waste oils.

(8) Use of industrial grade valves and control elements, not the domestic grade currently furnished by incinerator vendors.

(9) Improved control system design, reliability, and process response.

(10) Single combustion air blower and manifolds rather than multiple small dedicated blowers.

(11) Redesign of all incinerator closures to minimize inleakage.

The primary chamber (R-5A) consists of a castable refractory lining with a firebrick hearth, both backed up by low density block insulation. The shell of the unit is painted carbon steel with an impermeable mastic liner on the inside surfaces to prevent acid attack on the carbon steel shell. The secondary chamber (R-5B) is constructed similarly, with the exception that no firebrick hearth is necessary in the secondary chamber. The off-gas duct leaving the secondary chamber and connecting to the quench pipe system is also castable refractory lined with low density block insulation. The shell is painted carbon steel with a mastic inner liner.

All burners (B-1, B-2, B-3) are commercially available off-the-shelf units that meet UL and Factory Mutual safety standards. The incinerator can be supplied with either oil

3.2.1 (cont.)

fired or gas fired main chamber burners. The waste oil burner is specifically designed to atomize waste oil and is provided with a LPG pilot.

The dry active waste charging airlock is constructed of stainless steel for ease of decontamination and is pressure tested at the design incinerator pressure of -1.5 inches W.C. The waste charging ram is also constructed of stainless steel for ease of decontamination and the pusher face is refractory lined for temperature resistance. The feed system is fully interlocked to the incinerator and off-gas systems to assure proper operation.

The ash removal system knife gate valve is a commercially available heavy duty valve designed for solids service. The ash discharge screw is also made of stainless steel construction for ease of maintenance, as are all the ash discharge housings.

The scrub solution blowdown injection system is constructed of Incoloy for improved corrosion resistance. It is also equipped with a decontamination water line for flushing prior to transport of the equipment.

3.2.2 Scrubber/Preconcentrator (S-9, S-10)

The unit consists of a venturi throat section and a disentrainment column as follows:

(1) A wetted-wall Incoloy venturi scrubber is employed to contact the hot exhaust gases with the scrubbing liquid to simultaneously collect both the particulate and the acid-gases.

(2) A flooded elbow is provided below the venturi throat to allow a liquid cushion for the high velocity gas stream to eliminate erosion in the elbow.

(3) A cyclonic disentrainment section is used to separate the scrubbing liquid from the gas stream.

(4) A demister is provided above the disentrainment section to eliminate liquid droplet carryover from the unit. The demister is equipped with a flushing and emergency cooling mechanism.

(5) A sump is provided to collect the scrubbing liquid for recirculation and injection into the incinerator as required.

3.2.3 Scrubber Recirculation Pump (P-3)

The pump is a centrifugal process pump with a double mechanical seal. The pump is fitted with isolation valves, drain connections, vibration isolating expansion joints, and is direct coupled to the drive motor. Seal cooling water is routed directly into the scrubber to provide a portion of the makeup for the scrubbing liquid.

3.2.4 Combustion Air Blower (C-5)

The unit is a multi-stage centrifugal type blower with outboard bearings and a housing. It has the following design characteristics:

(1) Outboard spherical bearings requiring semi-annual lubrication.

(2) Unit is designed to have less than 1.5 mils of vertical movement at 3600 rpm.

(3) Output pressure is 2 psig at operating conditions.

3.2.5 Induction Fan (C-4)

The unit is a multi-stage centrifugal type fan with outboard bearings. The unit is designed to have less than 1.5 mils of vertical movement at 3600 rpm and delivers a differential pressure of 99" W.C. at rated flow.

3.2.6 Filter System (F-1/D-1/F-2)

The assembly is comprised of a HEPA filter, charcoal adsorber, and a final filter and consists of:

(1) Housing and externals which are fabricated of 304 SS.

(2) HEPA filters that are high efficiency-type rated for 99.9% collection of 0.3 micron diameter dust. The filter is the "BAG IN - BAG OUT" type and designed to be incinerated when replacement is required.

(3) A charcoal adsorber that is a deep bed of impregnated charcoal with a minimum 0.25 second retention time. It is rated to remove 99.9% of any elemental iodine.

(4) Equipment housings that are designed to withstand 1 psig pressure.

3.2.6 (cont.)

(5) An assembly tested for a minimum of 99.9% efficiency with a dioctylphthalate (DOP) test conducted in accordance with MIL-STD-282, Method 102.9.1.

(6) Unit is fitted for fire protection.

(7) A final filter that is designed to capture any charcoal elutriated from the adsorber. The filter is also designed to be incinerated.

3.2.7 Caustic Tank (T-2)

This 800 gallon tank is a dished bottom, flat top, cylindrical type. It is fabricated from carbon steel and contains: fill port, vent, drain, discharge and cleanout nozzles. It also contains a level transmitter, level recorder, and high and low level alarms. The tank is designed for atmospheric pressure and is 4.5 feet in diameter by 8 feet tall.

3.2.8 Caustic Pump (P-6)

The pump is a variable speed, double diaphragm pump. The body of the pump is fabricated from 316 stainless steel and the pump diaphragms are made of teflon. Flow control is provided by an SCR speed controller and adjustable stroke settings.

3.2.9 Contaminated Oil Tank (T-12)

This is a conical bottom cylindrical tank of 80 gallons capacity fabricated of A-36 carbon steel. Its dimensions are 2.5 feet diameter x 3.5 feet height. The tank is supplied with an agitator, level indicator, and low-level switch. A strainer is provided at the inlet, and a flame arrestor is provided on the vent.

3.2.10 Contaminated Oil Pump (P-11)

This is a 2-stage progressive cavity pump which delivers the contaminated oil from the contaminated oil tank to the contaminated oil nozzle mounted on the incinerator. It operates over a range of 0-25 gph, 15 gph being the nominal flow rate. It is driven by a 1/3 Hp variable speed motor.

3.2.11 Surge Tank (T-11)

This is a flat bottom cylindrical tank of 50 gallons capacity, fabricated of Incoloy 825. Its dimensions are 2 feet diameter x 3 feet height. The tank is supplied with an agitator, level transmitter, level recorder, and high- and low-level alarms.

3.2.12 Gas Quencher (A-1)

The gas quencher reduces the incinerator exit gas temperature from 2100°F to 1000°F at a flow rate of 1175 SCFM by use of sonic water spray nozzles. The gas quencher chamber is fabricated of A-285C-FB and is refractory-lined similar to the incinerator. The nozzle assembly is fabricated of Series 300 SS with a Hastelloy C resonator.

3.2.13 Main Control Panel (CP-100)

The main control panel houses the MVRS process controller and provides the main operator interface with the MVRS, including handswitches, indicators, recorders, control loop access module, and annunciators. The MVRS process controller is a microprocessor based state-of-the-art control system, and performs the system control logic and closed loop control for the MVRS. A schematic of the main control panel is shown in Figure 6.

3.2.14 Incinerator Local Control Panel (CP-2)

The Incinerator Local Control Panel contains the local operator controls and process control instrumentation required to operate the incinerator airlock door and the scrub liquor injection system and to locally monitor and control the incinerator combustion process. Controls and instrumentation include air flow monitors, manual loading stations, hand switches, and instrumentation required for local control and interface with the process control system.

3.2.15 Ash Handling Local Control Panel (CP-3)

This panel contains all the fuses, starters, frequency controllers, transformers, timers, handswitches, and interlocks to operate the densifier system. These controls are for ash and binder metering and HIC filling. The equipment is mounted on a NEMA 12 enclosure and located approximately 10 feet from the HIC's behind a steel wall. The panel is about 2 ft. x 3 ft. x 1 ft. high.

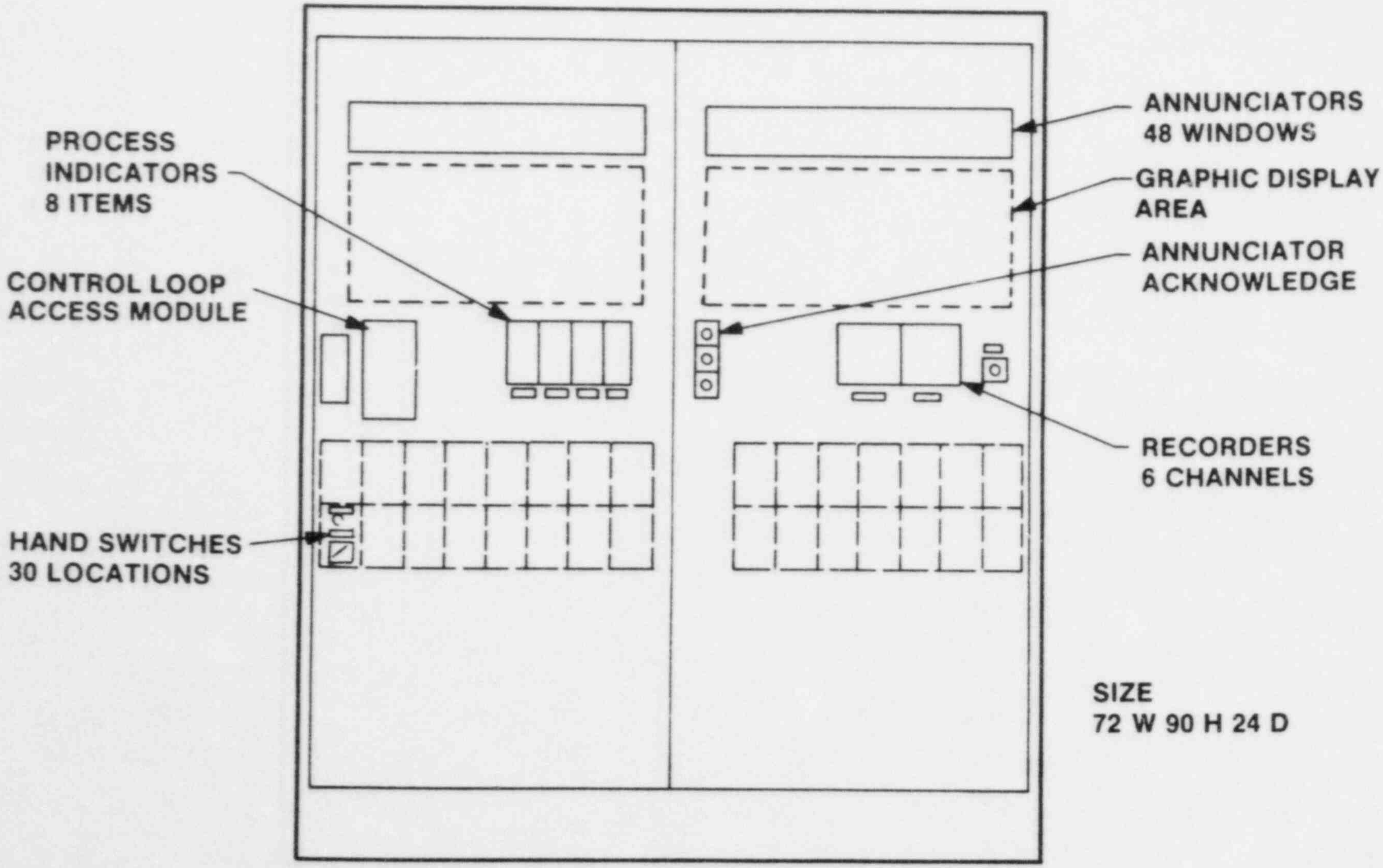

Figure 6. Main Control Panel Schematic

3.2.16 Drum Handling and Capping Local Control Panel (CP-4A/B)

There are two panels, one for each monorail crane and capper. Each panel has the lifting/lowering and trolley controls for the monorail crane and the valving for the pneumatic HIC grabber. The panel also has the valving for lowering the capper into place and actuating the air driven cap fastening motors. These panels are about 1 ft. wide x 2 ft. high x 1 ft. deep.

3.2.17 Process Air Compressor (C-7)

The process air compressor includes the rotary screw air compressor, air/coolant separator, receiver, air dryer, and controls. The process air compressor supplies atomization air to the contaminated oil burner and quench pipe cooling water, actuation air to the air operated valves, combustion air to the B-4 burner, pressurizing air for caustic unloading and T-11 pressurization, and purge air for various instruments, lines and view ports. Only instrument and sight port purge air is dried.

3.2.18 Exhaust Air Blower (C-8)

The exhaust air blower provides for ventilation of the ash packaging section of the trash handling trailer and ventilation and equipment cooling for the incinerator trailer. The exhaust air blower takes suction from a duct from the top of the incinerator, thus creating forced convection cooling for the incinerator shell. The blower discharges through the F-3 filter to atmosphere.

3.2.19 HVAC Filter (F-3)

The F-3 filter consists of two conventional 24" x 24" x 11-1/2" HEPA cartridges installed in a housing such that the flow through the cartridges is parallel. The housing has provisions for a prefilter and is equipped with a ΔP gage to indicate when filter changeout is required. The HEPA cartridge frames are combustible to maximize the feasability of burning the cartridges in the incinerator.

3.2.20 Standby Power System (K-1)

The Standby Power System (K-1) is a propane fired emergency system capable of providing 30 KW of continuous power to the MVRS in the event of electrical power failure to

3.2.20 (cont.)

the MVRS. The system is designed to run the Emergency Fan (C-4A), the Emergency Air Compressor (C-9), the Incinerator Hydraulic System, the Main Control Panel (CP-100), Radiation Monitors, Fire Detectors, the Incinerator Trailer Ventilation Fan (C-8), the Scrubber Recirculation Pump (P-3), Emergency Heat Tracing, and Trailer Lighting. A schematic of the Standby Power System is shown in Figure 7.

3.2.21 Ash Transfer Conveyor (G-7)

The conveyor is a metal tube trough with hollow spiral round wire flighting. The flighting is free-floating within the tube and is driven by a motor at the discharge end. There are no bearings or seals at the feed end. The conveyor is capable of passing 1/2" particles on a continuous basis. Interlocks are provided to stop the conveyor when the incinerator feed hopper is at low level or when the conveyor discharge ash hopper (H-6) is full. The entire conveyor is located within a ventilation duct which ventilates the ash system into the incinerator trailer. In this way any possible leakage of dust will pass into the incinerator trailer and through the ventilation system HEPA filters (F-3).

3.2.22 Densifier (G-8)

The densifier is a pin mill type device which combines the ash with the binder and mixes the product at high speed. The densifier system contains metering subsystems for both the ash and the binder with interlocks and controls to assure the correct mixture. In addition, during the densification procedure the dusty particles are agglomerated and the product is essentially dust free. The unit is about 12 inches in diameter by 3 feet long and driven by a 5 Hp motor. The densifier discharges directly into the High Integrity Container through a fill hood assembly.

3.2.23 Monorail Crane (G-9A,B)

The monorail cranes are designed to lift the High Integrity Containers from the container cart and transfer them approximately 6 feet outside of the trailer for loading on a transfer device supplied by the utility. The cranes are 1/2 ton capacity electric motor driven cranes with 19 ft. lift at 15 feet per minute and a 30 feet per minute trolley speed. The unit is complete with brakes, travel limits and a pneumatically operated drum grab. Two monorail cranes are supplied to remove each of the two HIC's off the trailer and to replenish the cart with empty HIC's.

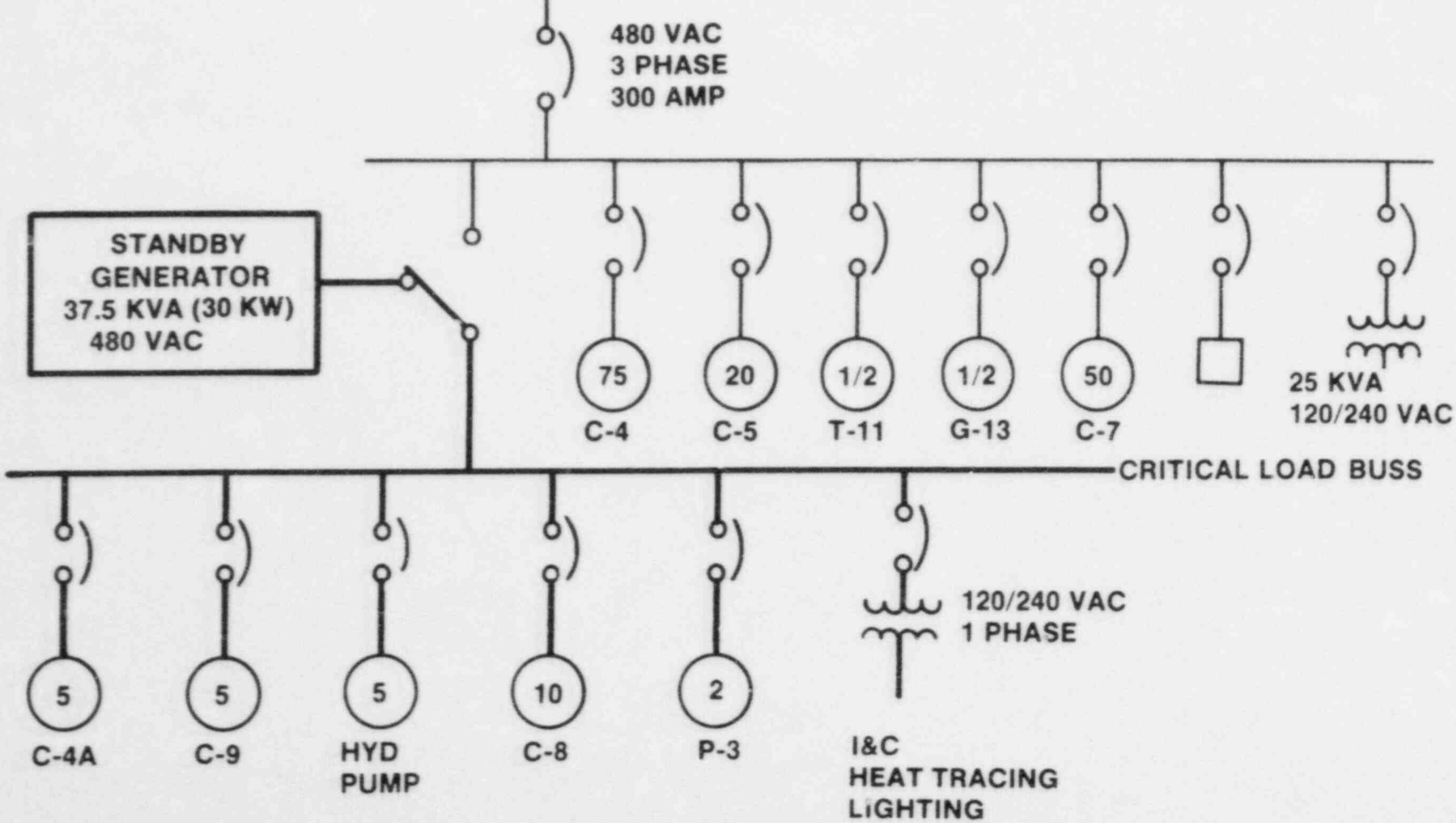

Figure 7. Standby Power System Schematic

3.2.24 Container Cart (T-13)

The cart is a 2-inch thick leaded wall container capable of holding two High Integrity Containers or 55 gallon drums. The cart can index the containers from the monorail crane pickup to the ash fill hood and back to the crane for removal.

3.2.25 Trash Weigh Scale (G-10)

The trash weigh scale is a 24" x 28" platform, mounted flush with the trailer floor. The scale will weigh up to 1,000 lbs with a 0.2 lb resolution. The trash drums will be weighed while on the drum dolly. The scale is provided with a printer which will provide a journal tape of each weighing, printing gross, tare, and net weights, time, date, and identification numbers. The printer has accumulating capability.

3.2.26 Container Capper (G-11A,B)

The capper is designed to carry a plastic cap coated with a sealant from the control area to the container cask and to lower and tighten the cap on the High Integrity Container. This system utilizes a manually operated trolley to move the capper from the control area to the HIC, where it is indexed precisely over the HIC. The capper with the cap attached is lowered onto the HIC using pneumatic cylinders. An air driven motor is reversed to align the threads on the cap with the HIC and then operated clockwise to tighten the cap until the stall torque required is achieved. Two systems are supplied, one for each of the two HICs on the trailer.

3.2.27 Fill Hood (G-12)

The fill hood is attached to an elastomer boot which is fastened directly to the discharge of the densifier. The hood is moved up and down onto the HIC by three air bags which supply enough force to set the hood onto the HIC. The hood and drum assembly is evacuated and the gas is vented into the scrubber body. This provides a reserve mechanism to the hood seal on the HIC, and assures no leakage of ash during the filling cycle. The hood is made of two eccentrically located pipes, the outer pipe for evacuation and the inner pipe for filling, with a fluidic level sensor to identify when the HIC is filled and prevent overfilling. The assembly is approximately 11" in diameter by 6" high.

3.2.28 Ash Hopper (H-6)

The ash hopper has a working capacity of about 2.8 $ft.^3$. It is an inverted pyramid shaped hopper with a plastic coating (UHMW polyurethane) on the interior surface to prevent bridging of the ash. The hopper is also fitted with a variable frequency vibrator to aid in discharging the hopper completely. The hopper discharges into the metering auger located at the inlet of the densifier. The hopper has high and low level switches to prevent overfilling and stop the densifier on low level.

3.2.29 Motor Control Center (MCC-1)

The Motor Control Center houses the 480 volt, 3 phase motor starters and power distribution equipment for the MVRS. The Motor Control Center consists of two separate centers which supply both normal and emergency power distribution requirements.

3.2.30 Emergency Fan (C-4A)

The Emergency Fan (C-4A) is designed to provide continuous gas flow through the incinerator chambers in the event of loss of power to the Induction Fan (C-4). The unit is a multi-stage centrifugal type fan with outboard bearings, and is designed to have less than 1.5 mils of vertical movement at 3,600 rpm.

3.2.31 Emergency Air Compressor (C-9)

The Emergency Air Compressor (C-9) is designed to provide a back-up air supply to the MVRS control system in the event of loss of power to the Process Air Compressor (C-7).

3.2.32 Radiation Monitors

See Section 6.0 for a discussion on radiation monitoring equipment for the MVRS.

3.2.33 Hydraulic Power Unit

The hydraulic power unit consists of a hydraulic reservoir, hydraulic pump, and associated controls and provides hydraulic power to the trash ram, ash plow, fire door, airlock door, and the scrub solution injection system. It is located on the Waste Preparation/Packaging Trailer near the contaminated oil tank.

3.2.34 Waste Preparation/Packaging Trailer

This consists of a single-drop-deck tandem-axle, van semitrailer.

3.2.35 Incinerator Trailer

This consists of a single-drop-deck, triaxle, van semitrailer.

3.2.36 Filter Trailer

This consists of a standard-platform, tandem-axle, van semitrailer. All three trailer designs conform to Department of Transportation regulations stated in 49CFR393 and 49CFR571. The trailers are designed to support a payload capacity of 60,000 pounds over its total length. Nominal dimensions of each of the three trailers are 45 feet in length and 8 feet in width. The trailers are constructed of non-combustible materials.

4.0 DESIGN BASIS AND PROCESS PARAMETERS

4.1 GENERAL

The design bases of the AECC Mobile Volume Reduction System relating to waste processing rate and capacity were derived from the expected annual waste volumes of dry active wastes and contaminated oil from BWR and PWR nuclear power plants. Several documents cited below present the expected volume and activity of these waste streams.

4.2 DEFINITION OF DRY ACTIVE WASTES AND CONTAMINATED OIL

AECC's Mobile Volume Reduction System is designed to process the combustible dry active wastes and contaminated oil generated at nuclear power plants.

The dry active wastes (DAW) consist of paper, cardboard, wood, clothing, plastic, ventilation air filters, and other miscellaneous materials. This type of waste normally contains much lower concentrations of radioisotopes than the wet wastes such as evaporator concentrates and spent resins. Furthermore, a significant portion of the dry active wastes is combustible. Contaminated hardware such as equipment, tools, and other metal items are excluded from this discussion. Such materials are not processed by the AECC MVRS.

Contaminated oil represents the second type of waste that can be processed in the AECC MVRS. Contaminated oil is expected to be of several types: (1) lubricating oil from pumps, (2) No. 4 fuel oil, and (3) a fire-resistant oil known commercially as FIREQUEL which is used both for lubrication and in hydraulic systems. The lubricating oil is expected to be a pure hydrocarbon and is readily combustible. Fuel oil will contain up to 1.5% sulfur. FIREQUEL will contain up to 8% phosphorus. During incineration, the sulfur and phosphorus will become volatile, be removed in the scrubber, and subsequently reprocessed in the incinerator to dry Na_2SO_4 and Na_3PO_4.

4.3 EXPECTED VOLUMES AND ACTIVITIES OF WASTE

The characteristics of radioactive waste from BWR and PWR nuclear power plants can be described within reasonable generic ranges, although they vary considerably among plants. Radwaste volumes and radionuclide content have been estimated and reported. One of the most complete reports is ONWI-20, "A Waste Inventory Report for Reactor and Fuel

4.3 (cont.)

Fabrication Facility Wastes" (Reference 5). Data from this report was utilized to summarize the expected annual volumes and activity of the combustible dry active wastes from a 1000 MW(e) Plant. This data is presented below in Table IV. NUREG-0782 (Reference 6) was also reviewed. This report, however, references ONWI-20.

Table IV

CHARACTERISTICS OF DRY ACTIVE WASTE PROCESSED BY THE AECC MVRS
(Based on Reference 5)

	Annual Volume*		Activity		Density
Plant Type	Ft^3	m^3	Ci/yr	µCi/cc	$\#/ft^3$
BWR	7,800	221	5.2	0.024	10
PWR	7,600	216	4.9	0.023	10

* 1000 MW(e) Plant.

No isotopic distribution was given in ONWI-20 for the dry active waste. However, the most commonly reported isotopes found in DAW are Cr-51, Mn-54, Co-58, Co-60, Zn-65, Cs-134, and Cs-137.

Recently, the Electric Power Research Institute (EPRI) funded Gilbert Associates, Inc. to conduct a survey of waste types and volumes generated and shipped from nuclear power stations (Reference 7). This EPRI study contains detailed information on the actual annual volumes of dry active wastes shipped from both BWR and PWR nuclear stations, the activity per drum, and the isotope distribution. The average annual volumes of compactible DAW shipped during the period 1978 - 1981 for BWR and PWR plants are shown in Table V. The isotopes present in DAW and their % distribution are shown in Table VI. The specific activity of the compacted dry active waste is also shown in Table VI.

4.3 (cont.)

Table V

AVERAGE ANNUAL VOLUMES OF COMPACTIBLE DRY ACTIVE WASTES SHIPPED FROM BWR AND PWR NUCLEAR STATIONS 1978-1981 (Based on Reference 7)

Plant Type	Annual Volume Shipped, Cubic Feet per Unit
BWR	14,300
PWR	4,800

Table VI

ACTIVITY OF DRY ACTIVE WASTES FROM BWR AND PWR NUCLEAR STATIONS 1978-1981 (Based on Reference 7)

Isotope	BWR, %	PWR, %
Cr-51	5.4	1.5
Mn-54	8.1	3.3
Co-58	1.1	31
Co-60	55.8	41.0
Zn-65	4.6	--
Sr-90	0.01	0.05
Nb-95	0.1	--
Zr-95	0.1	0.5
Ru-106	--	0.4
Sb-125	--	0.1
Cs-134	8.4	6.1
Cs-137	16.4	15.8
Specific Activity of Compacted DAW	0.25 mCi/ft.^{3}	0.7 mCi/ft.^{3}

4.3 (cont.)

It is instructive to compare the data from ONWI-20 and the very recent EPRI study:

Annual Volume - ONWI-20 (Table IV) shows 7800 $ft.^3$ per year for a BWR and 7600 $ft.^3$ per year for a PWR. These are uncompacted (untreated) volumes. The EPRI study (Table V) shows 14,300 $ft.^3$ per year for a BWR and only 4,800 $ft.^3$ per year for a PWR. These are as-shipped volumes. It is assumed these wastes were compacted. Assuming an average VR factor of 3 for compaction, the values in the EPRI study are approximately equivalent to 42,900 $ft.^3$ per year for a BWR and 14,400 $ft.^3$ per year for a PWR, based on uncompacted volume of the dry active wastes. Thus, the EPRI values are much greater than those presented in the ONWI study. It will be shown shortly, however, that the AECC MVRS is designed to process the expected annual volume from several nuclear stations. Basing the design on the EPRI data provides a high degree of assurance that the AECC MVRS will have adequate capacity for its design objective.

Annual Activity - ONWI-20 (Table IV) indicated that the BWR dry wastes contain 5.2 Curies per year while the PWR dry wastes contain 4.9 Curies per year. The EPRI study indicated a specific activity of 0.25 mCi per cubic foot for compacted wastes from a BWR and 0.7 mCi per cubic foot for compacted wastes from a PWR. On an annual basis this is equivalent to 3.6 Curies for a BWR and 3.4 Curies for a PWR. This represents reasonable agreement with the ONWI-20 data. Both data bases document the small amount of activity associated with the dry active wastes.

Isotope Distribution - ONWI-20 listed only the most commonly occurring isotopes in dry active wastes, whereas the EPRI study listed the isotope distribution and activity. Thus, for shielding calculations, the EPRI data is very useful.

Data on contaminated oil is very sketchy. Discussions with several nuclear utilities indicated that the annual volume of contaminated oil generated is generally a few hundred cubic feet per year. As a result, the design of the AECC MVRS is based on annual expected volume of DAW. The AECC MVRS will be able to easily accommodate several hundred cubic feet per year of contaminated oil in addition to the DAW.

4.4 PROCESSING RATE

In order for the MVRS to be cost beneficial to the nuclear power industry, it must be capable of processing the waste from several plant sites annually. Consequently, AECC's MVRS has been designed to process waste quantities substantially larger than those identified in Table V for a "typical" single unit, 1000 MW(e) plant.

By designing the system with a heat release rate of 3.0×10^6 Btu/hr, the MVRS has the capability of processing between 272 and 500 pounds of waste per hour, assuming a heating value between 6000 and 11,000 Btu/pound. If the system is operated for 5000 hours each year, between 1.36×10^6 and 2.5×10^6 pounds of waste can be processed. These quantities are equivalent to approximately 136,000--250,000 ft^3/year of uncompacted waste, based on a density of 10 lbs per cubic foot. Thus, the AECC MVRS could process the combustible DAW from 3 to 6 BWR units in a year based on the EPRI data shown in Table V. Far more PWR units could be serviced per year due to the lower waste generation rate. Contaminated oil will be processed at a nominal rate of 15 gph.

Table VII shows typical MVRS operating conditions for dry active wastes at two different heating values. Table VIII shows typical MVRS operating conditions for contaminated oil as a function of the oil content.

It is AECC's intent to schedule MVRS services at no more than 8 to 10 1000 MW(e) nuclear power plants per year per mobile unit. This schedule will provide a substantial amount of time for maintenance, decontamination, and transportation, while providing reserve capacity to handle periods of unexpectedly high demand by the utility client.

Table VII

SYSTEM OPERATING CONDITIONS FOR DAW (3×10^6 Btu/Hr.)

Heat Value of Trash Btu/Lb	Trash Composition %Ash/%PVC/%S	Trash Feedrate Lb/Hr	Ash Generation Lb/Hr	Salt Generation Lb/Hr	Time To Fill "HIC"
8,000	3/0/0	375	11	0	30
11,000	6/5/1	273	17	25	8

4.4 (cont.)

Table VIII

SYSTEM OPERATING CONDITIONS FOR CONTAMINATED OIL
(2×10^6 Btu/Hr.)

% Anions	Ash/Salt Produced (Lb/Hr)	Time of Continuous Operation (Hr)*
0%	0.06	3600 (Lubricating Oil)
1.5% S	8	28 (No. 4 Fuel Oil)
4% P	40	5 (50% Lube Oil, 50% FIREQUEL)
8% P	80	2.5 (FIREQUEL)

*Assumes initial scrubber salt concentration of 10% and stops processing when concentration reaches 20%.

5.0 EQUIPMENT ARRANGEMENT

5.1 SYSTEM ASSEMBLY/DISASSEMBLY

The General Arrangement of the components comprising the MVRS is shown in Figure 8, which is AECC Drawing No. 1194902 (6 sheets). The MVRS is housed on 3 trailers, identified as follows:

(1) Trash Preparation and Ash Handling Trailer - Contains the control room, frisking room, trash preparation area, ash handling area, contaminated oil system, and caustic system.

(2) Incinerator Trailer - Contains the two-stage controlled air incinerator, including the trash ram, quench pipe, and venturi-scrubber preconcentrator.

(3) Off-Gas Trailer - Contains the main induction fan, emergency blower, combustion air blower, HEPA filters, charcoal adsorber, process air compressor, emergency air compressor, and engine generator.

The 3 trailers are housed on a concrete pad supplied by the utility in the configuration shown in Figure 8 (Sheet 1 of AECC Drawing No. 1194902). Positioning of the three trailers on the pad and installation of all necessary mechanical and electrical interconnections will be carried out in the following order (refer to Figure 9):

(1) Position and level the Incinerator Trailer.

(2) Position, adjust height, and level Off-Gas Trailer to fit interconnecting off-gas duct.

(3) Install the 12-inch process gas piping between the Incinerator Trailer and the Off-Gas Trailer.

(4) Install the 8-inch combustion air piping between the Incinerator Trailer and the Off-Gas Trailer.

(5) Assemble the ash cupola to the roof of the Ash Handling Trailer. Position and level the Ash Handling Trailer to fit the interconnecting Ash Conveyor/-Ventilation Duct.

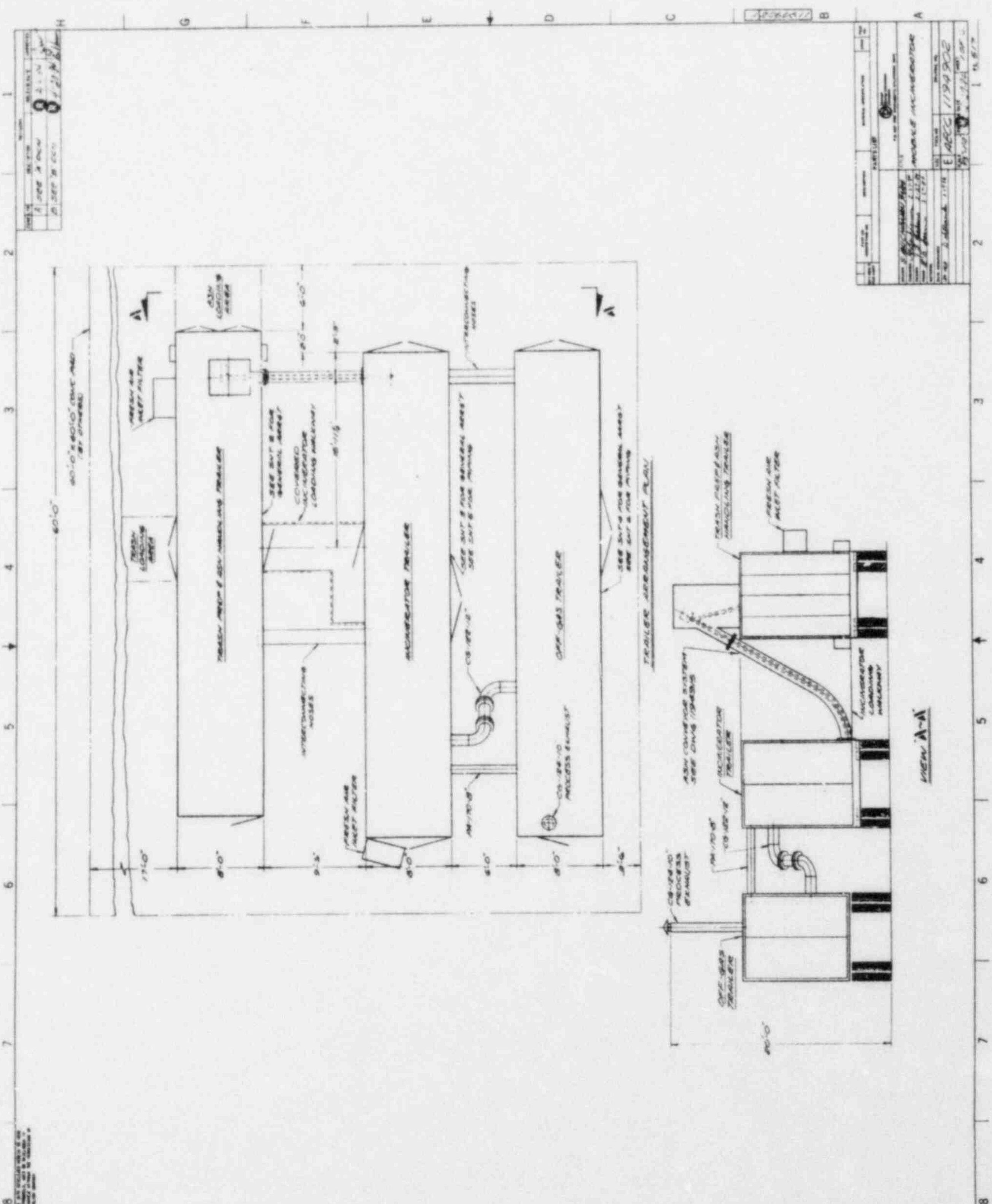

Figure 8. General Arrangement of Mobile Volume Reduction System (AECC Drawing No. 1194902, Sheet 1 of 6)

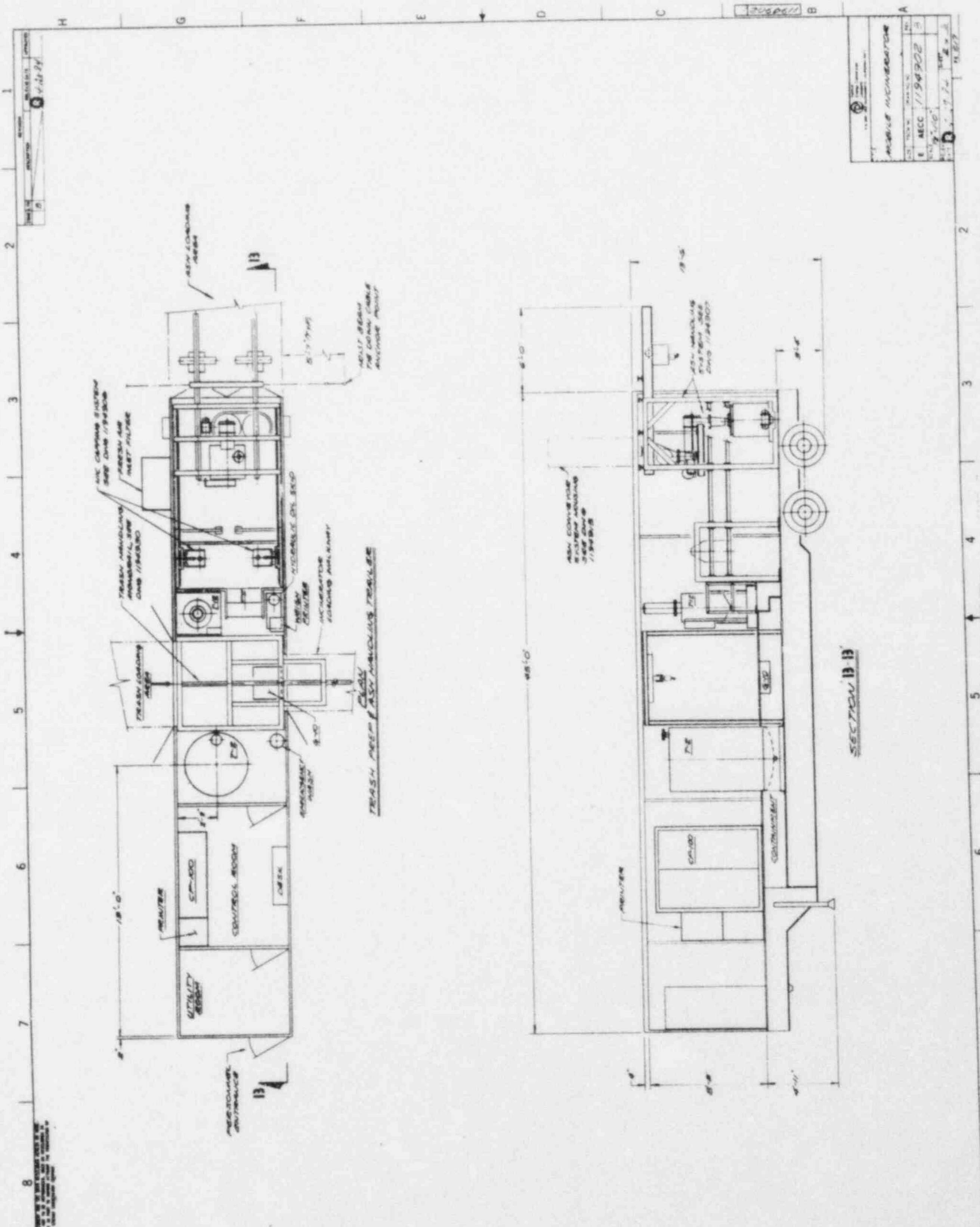

Figure 8. General Arrangement of Mobile Volume Reduction System (AECC Drawing No. 1194902, Sheet 2 of 6)

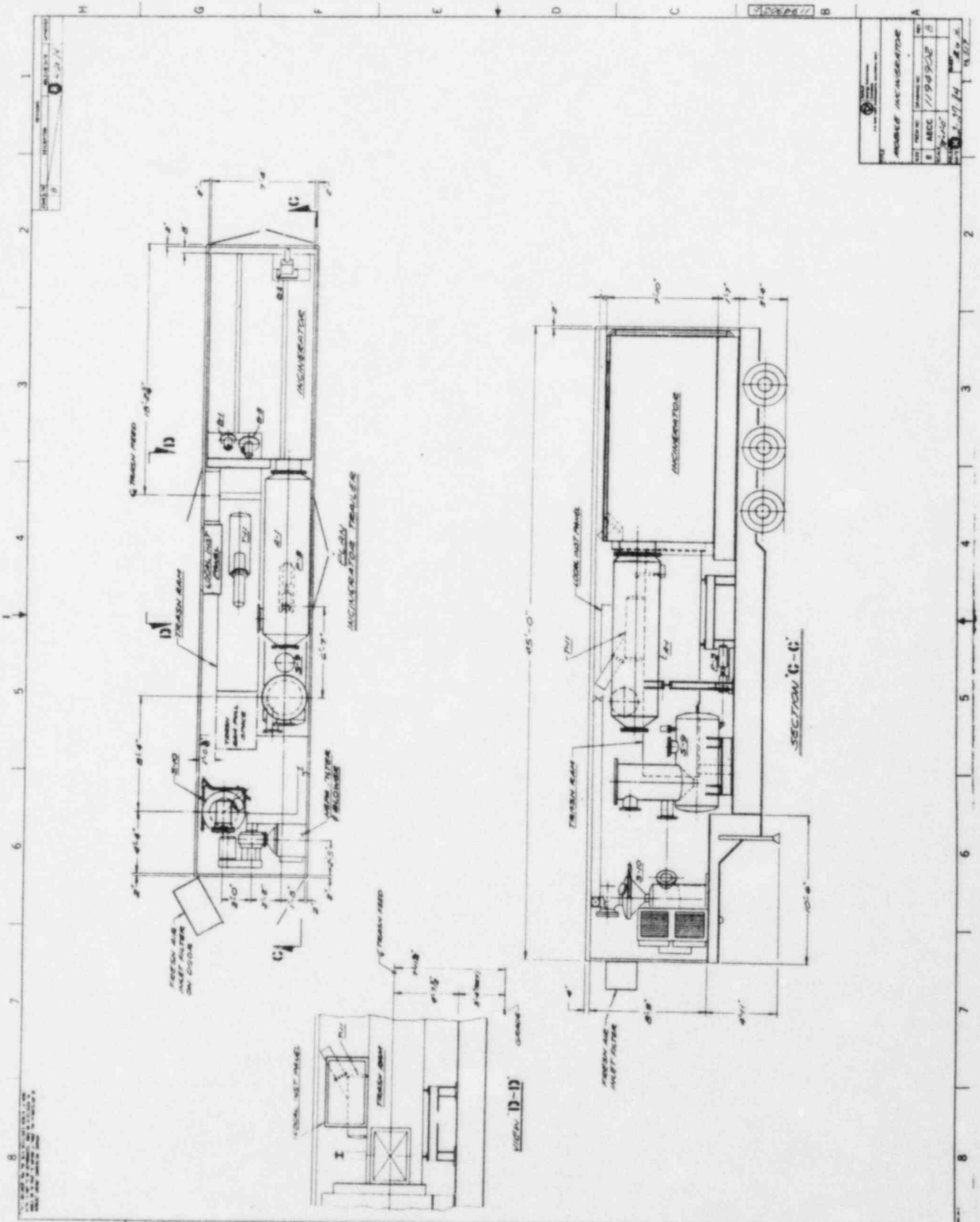

Figure 8. General Arrangement of Mobile Volume Reduction System (AECC Drawing No. 1194902, Sheet 3 of 6)

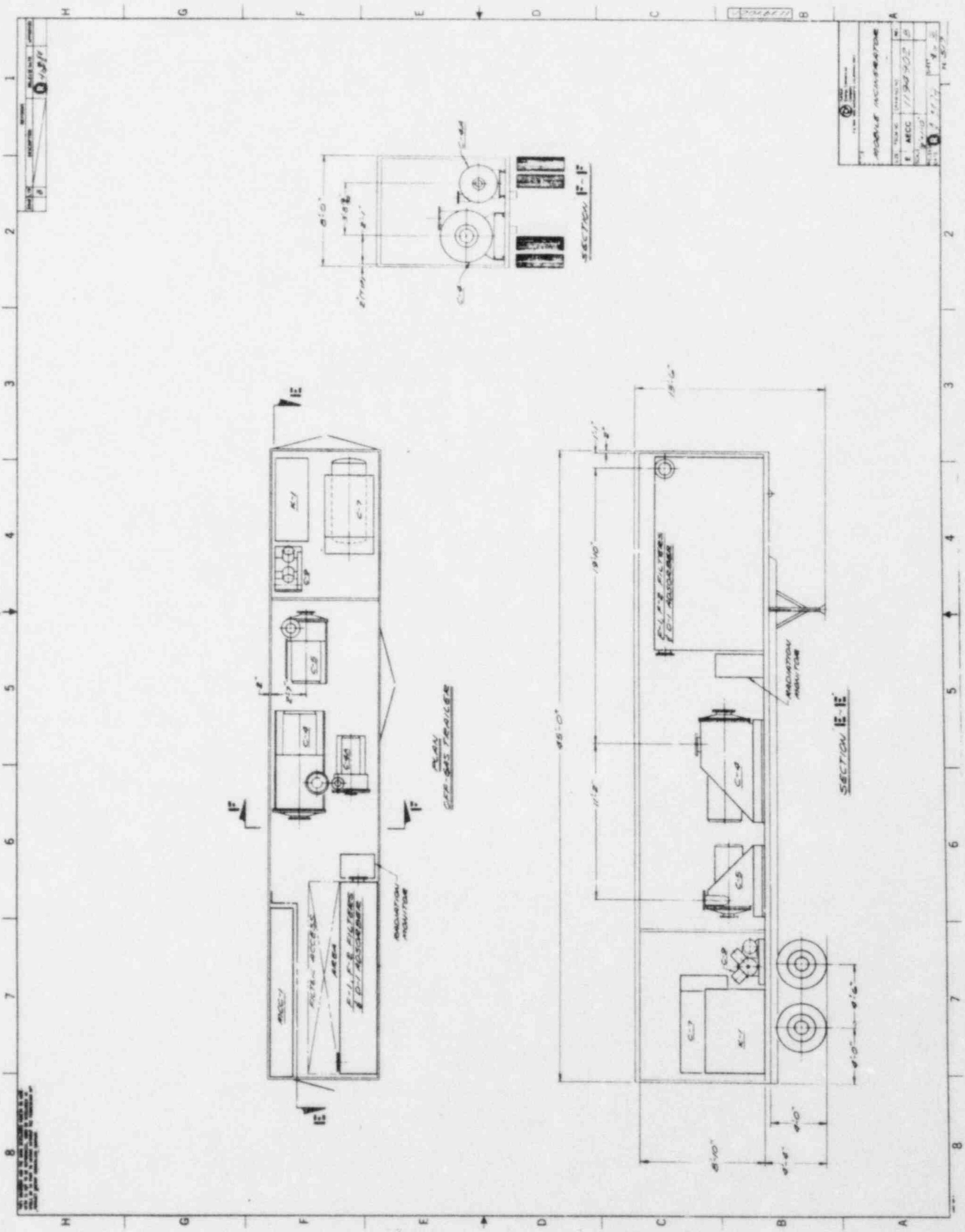

Figure 8. General Arrangement of Mobile Volume Reduction System. (AECC Drawing No. 1194902, Sheet 4 of 6)

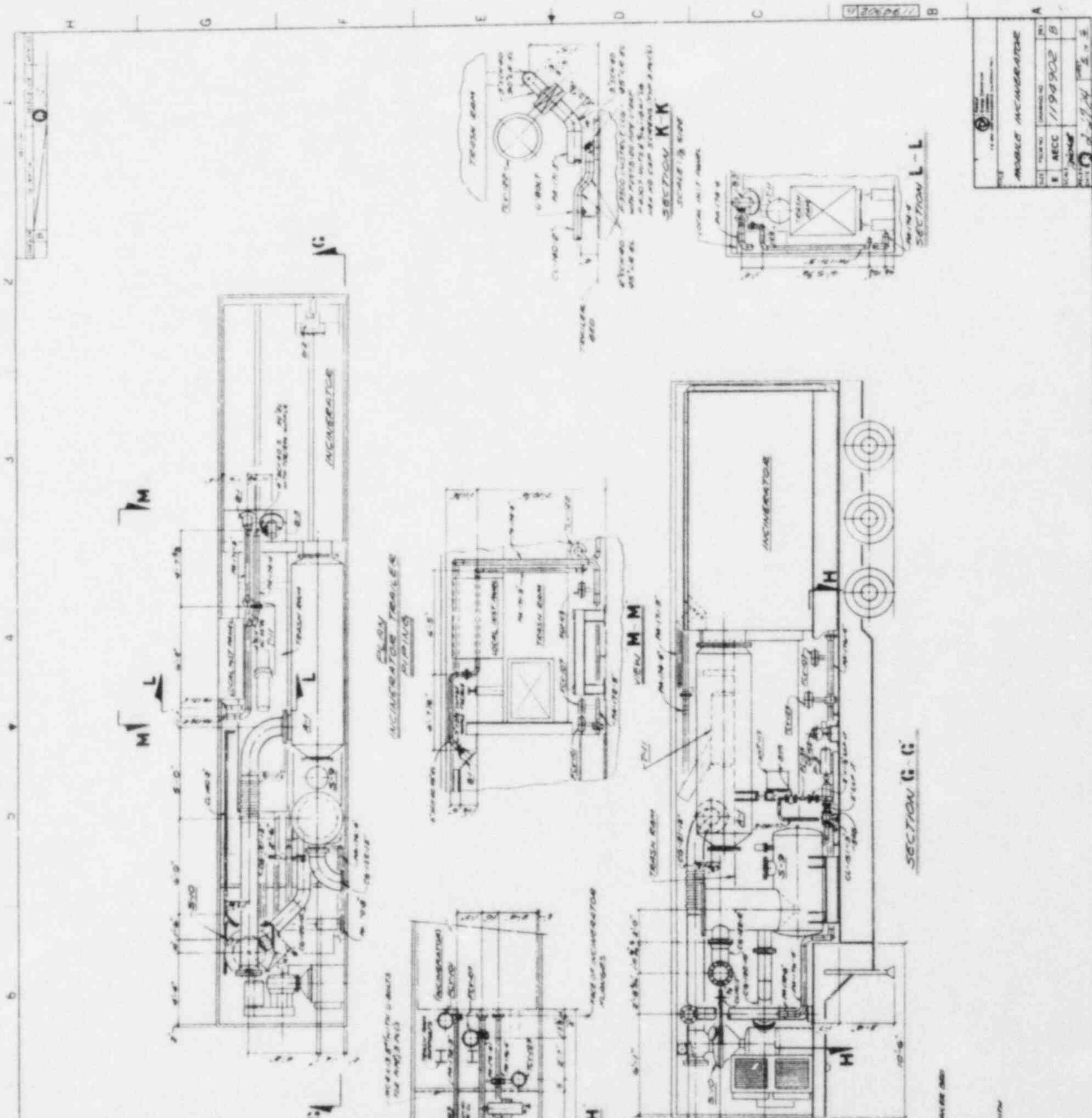

Figure 8. General Arrangement of Mobile Volume Reduction System (AECC Drawing No. 1194902, Sheet 5 of 6)

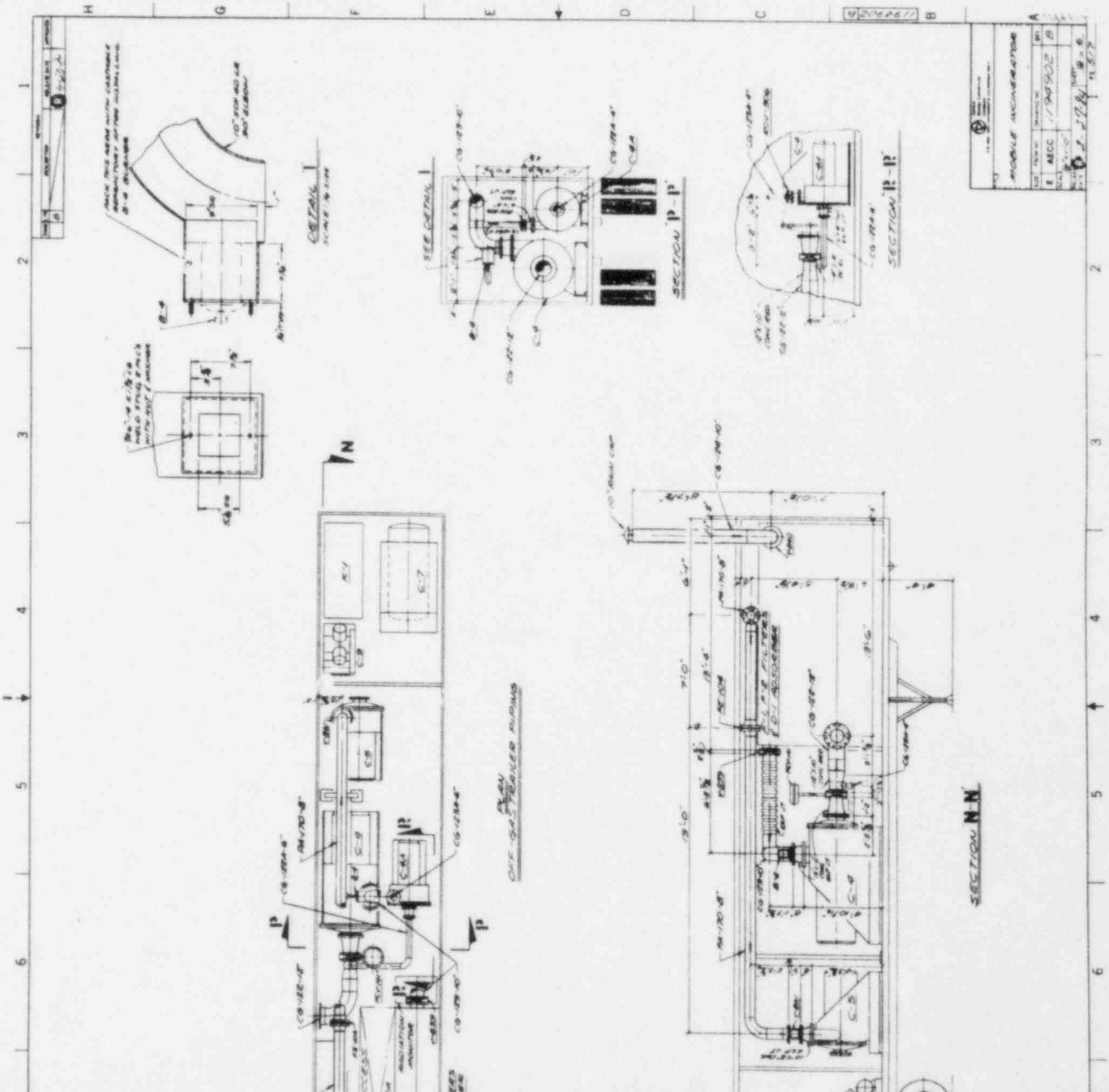

Figure 8. General Arrangement of Mobile Volume Reduction System (AECC Drawing No. 1194902, Sheet 6 of 6)

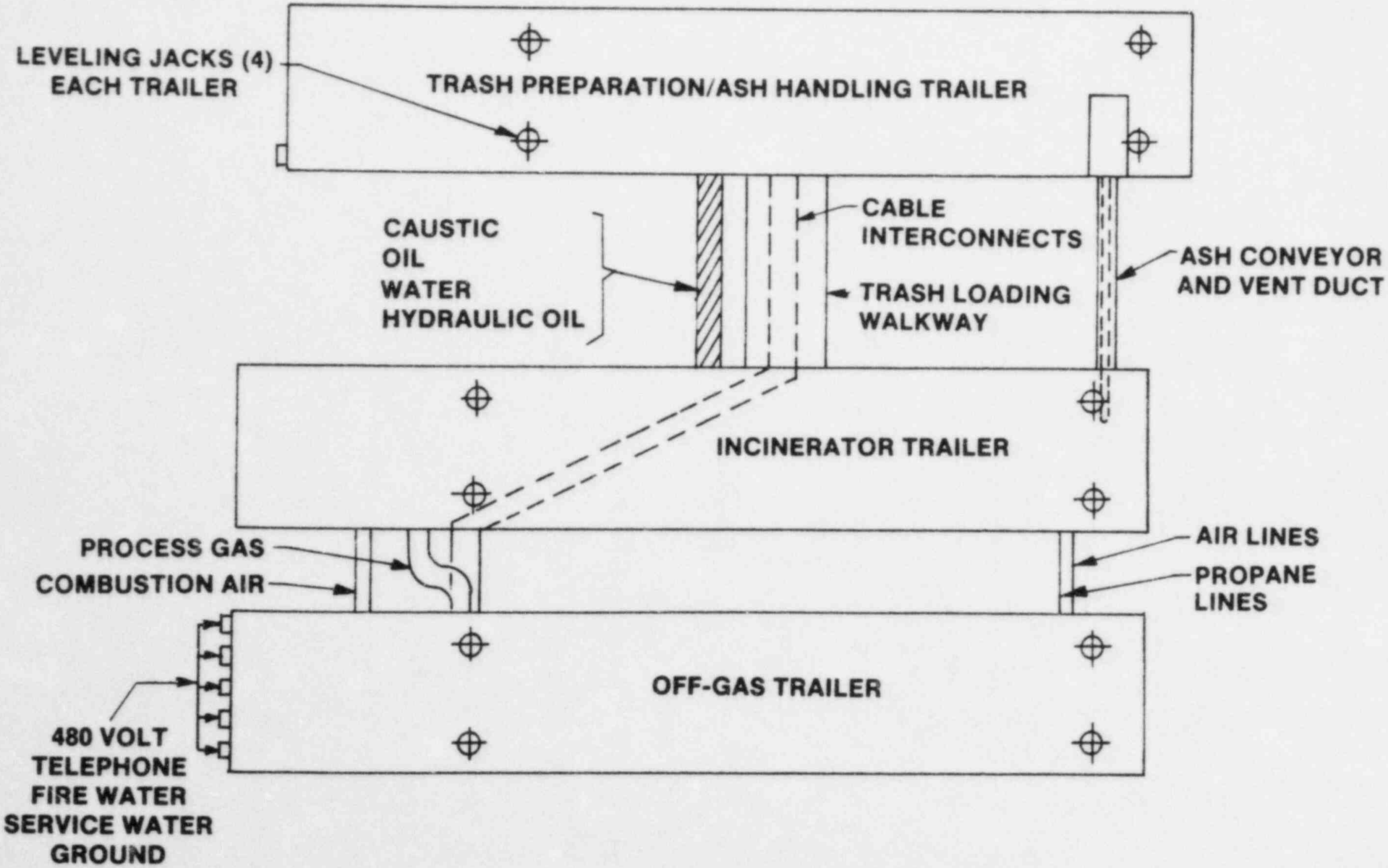

Figure 9. Trailer Installation and Interfaces

5.1 (cont.)

(6) Attach all remaining interconnecting electrical, gas, and liquid lines.

(7) Install and enclose the trash loading walkway.

(8) Interface MVRS to facility connections for electrical power, grounding lug, and process/fire protection water supply.

(9) Make local provisions for telephone hook-up, caustic supply, and propane supply.

Table IX summarizes the piping interconnections between trailers. Figure 10 shows schematically the electrical cable interconnections between trailers. Cables are 600 volt extra flexible built to IPCEA and NEMA standards. Major features of the electrical cable interconnections are summarized as follows:

(1) Incoming electrical service supplied by the utility is 480 volts, 3 phase, 4 conductor, 300 amp, 15 feet, 4 wire cable with Crouse-Hines AP40458 plug to mate with Crouse-Hines circuit breaking receptacle.

(2) Power cables originate at the Off-Gas Trailer.

(3) Instrument and control cables originate at the Trash Preparation Trailer.

(4) No cables originate at the Incinerator Trailer.

(5) Cables are hard wired to the originating trailer.

(6) Connections are made using 600 volt heavy duty cylindrical connectors, Bendix QWLD, or equal.

(7) Proper cable connection is assured by (a) mechanical interlock by shell rotation (5 positions); (b) color coding of panels and cable plugs, and (c) tagging cables and receptacles.

The electrical cable interconnections are summarized in Table X.

The plant must provide electrical power and a water supply for operation of the MVRS. These utility requirements are listed in Section 2.4.

5.1 (cont.)

Table IX

TRAILER PIPING INTERCONNECTIONS

	Line	Size	Type/Length	Connection
Trash Trailer to Incinerator Trailer	Caustic	1/2"	Hose/10'	2-way shutoff coupling
	Contaminated oil	3/4"	Hose/10'	2-way shutoff coupling
	Water	3/4"	Hose/10'	1-way shutoff coupling
	Hydraulic oil in/out	3/4"	Hose/10'	2-way shutoff coupling
	Hood vent	1"	Hose/10'	1-way shutoff coupling
	Ash screw	2-1/2"	Tube	Bolted
	Ash containment duct	12"	Flex duct	Bolted
Incinerator Trailer to Off-Gas Trailer	Combustion air	8"	Pipe	Flange
	Process air	12"	Pipe	Flange
	Instrument air	3/4"	Hose/4.5'	1-way shutoff coupling
	Compressed air	1-1/2"	Hose/4.5'	1-way shutoff coupling
	Propane	1"	Hose/4.5'	1-way shutoff coupling

Table X

TRAILER ELECTRICAL CABLE INTERCONNECTIONS

Power cables from Off-Gas Trailer

(1) 3 conductor #10 AWG to Trash Preparation Trailer

(4) 12 conductor #12 AWG to Trash Preparation Trailer

(5) 12 conductor #12 AWG to Incinerator Trailer

Control cables from Trash Preparation Trailer

(5) 12 conductor #14 AWG to Off-Gas Trailer

(6) 12 conductor #14 AWG to Incinerator Trailer

Instrument cables from Trash Preparation Trailer

(2) 18 conductor #16 AWG to Off-Gas Trailer

(4) 18 conductor #16 AWG to Incinerator Trailer

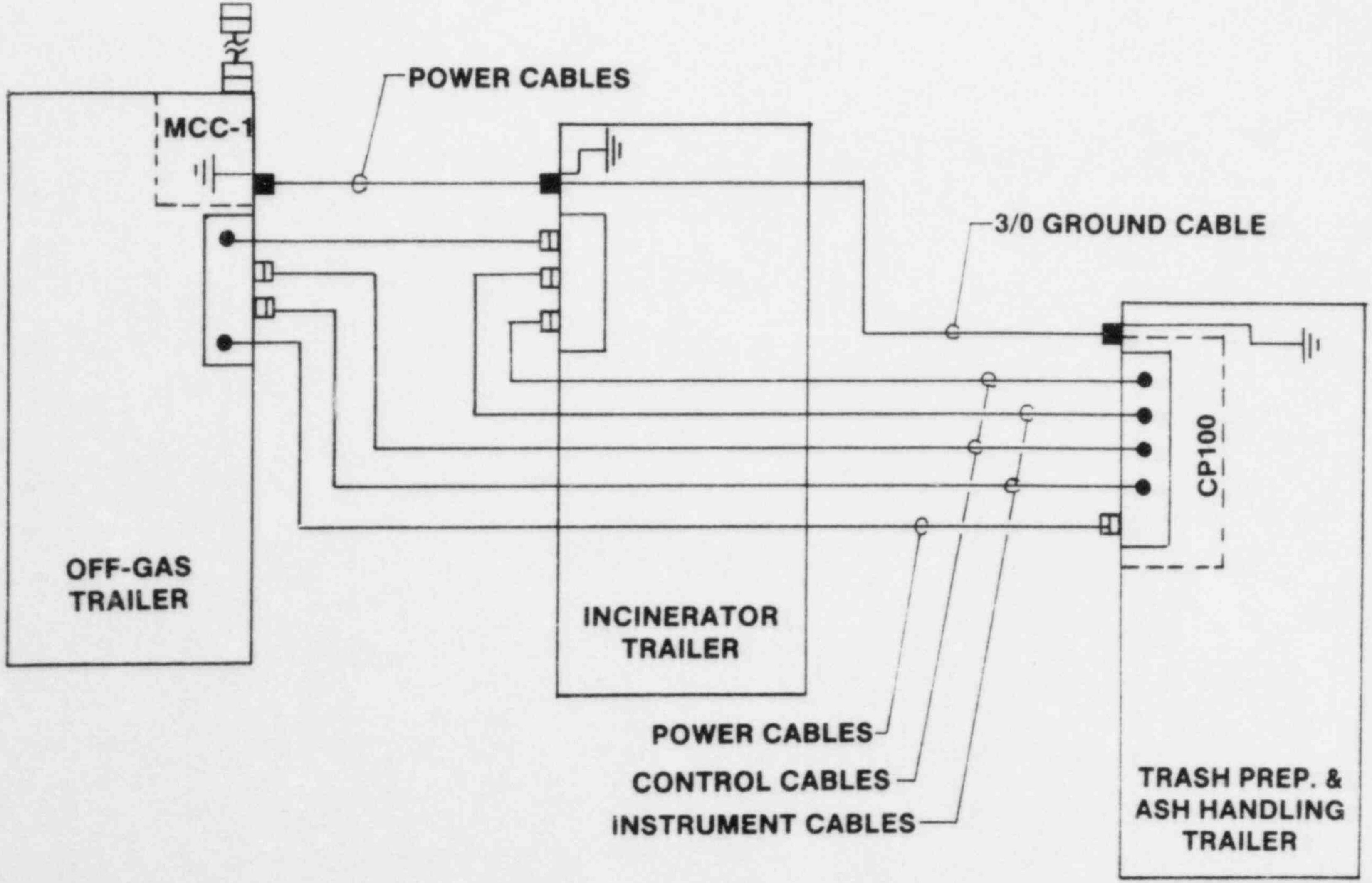

Figure 10. Trailer Electrical Interconnections

5.1 (cont.)

Assembly of the three trailers on the utility's concrete pad, assembly of the walkway and interconnecting piping, and tie-in with the plant's electrical power supply and water supply can be accomplished in approximately 1 day.

System disassembly is accomplished in a similar fashion. However, before movement of the trailers to another site, decontamination of the equipment will be conducted. This decontamination consists of the following operations:

(1) Cycling of the ash plow to push the bulk of the incinerator ash out of the incinerator and into the ash hopper.

(2) Vacuuming of the excess ash from the incinerator chamber, if required.

(3) Emptying of the liquid scrub solution from the venturi-scrubber preconcentrator.

(4) Removal and disposal of the HEPA filters and charcoal adsorber, if required.

(5) Decontamination of the walkway and trash storage area, if required.

5.2 SYSTEM LAYOUT

Figure 8 (Sheets 1 through 4 of AECC Drawing No. 1194902) will be referenced in the following discussion. Considerable time and thought have been expended on the General Arrangement of the components of the MVRS on the 3 trailers, with the following objectives:

(1) Provide a process that can be easily operated and controlled by one operator.

(2) Compliance with the ALARA philosophy.

(3) Easy access to the 3 trailers for required maintenance.

Objective 1 above is discussed in this section, while Objectives 2 and 3 are discussed in the following sections.

Sheet 2 of Figure 8 is a layout of the Trash Preparation and Ash Handling Trailer. It is expected that the utility will provide dry active wastes and contaminated oil for processing at regular intervals. The DAW will likely be delivered via truck or van to the

5.2 (cont.)

area indicated as "Trash Loading Area" on Sheet 2 of Figure 8. Contaminated oil may be delivered in drums in the same manner, or can be delivered in bulk via an oil storage truck. The MVRS operator will move 2-3 drums or boxes of DAW from the Trash Loading Area into the Trash Storage Area of the trailer. The storage on the trailer is limited to minimize dose rates to the operator from the individual drums which could read as high as 25 mRem per hour at the surface. The drums can weigh as much as 250 pounds, and will be moved by a trolley hoist by the operator. The drum dose rate will be checked to be certain it is less than 25 mRem per hour at the surface. Then the drum will be weighed and moved onto the incinerator loading walkway for transfer to the Incinerator Trailer. The drum can be easily rolled from the walkway and loaded into the airlock by the operator. This procedure will be repeated approximately every 45 minutes for each drum of DAW to be incinerated.

Contaminated oil will be pumped from the filled drums of oil or the oil storage truck provided by the utility to the Contaminated Oil Feed Tank (T-12). Contaminated oil will be fed directly from T-12 to the incinerator for processing. The Trash Storage Area also contains the Caustic Tank (T-2) which provides necessary caustic to the scrubber preconcentrator to maintain the pH at the required level of 9.

The Trash Preparation and Ash Handling Trailer also contains a frisking area, control room, and the ash handling/loading area. The ash handling area is isolated and shielded from the remainder of the trailer due to the higher dose rates associated with the incinerator ash packaged in High Integrity Containers (HIC).

Refer to Sheet 3 of Figure 8. As each drum of DAW is consumed by the incinerator, another drum is charged into the incinerator via the trash ram. The movement of each drum into the incinerator pushes the ash generated from earlier drums along the length of the incinerator hearth. At the far end of the hearth, the ash is pushed into an ash receptacle which is located below the primary combustor. The Ash Transfer Conveyor (G-7) is used to convey the ash from the incinerator primary chamber to the Ash Hopper (H-6) located on the Trash Preparation and Ash Handling Trailer. The ash is then transferred to the Densifier (G-8) where the ash is agglomerated. Agglomerated ash is then metered to a HIC for final packaging. During filling, the HIC is placed in a shielded cask (2" lead). Filled HICs will be picked up by the utility in the ash loading area and shipped to a burial site or stored onsite.

5.2 (cont.)

Off-gas from the primary combustor is further treated in the secondary combustor, passed through the quench pipe to reduce its temperature, and scrubbed in the venturi-scrubber preconcentrator. At this point the off-gas is transferred from the Incinerator Trailer to the Off-Gas Trailer.

See Sheet 4 of Figure 8. The off-gas is routed through the Induction Fan (C-4) and then pulled through the final filter package consisting of a HEPA filter/charcoal adsorber/-HEPA filter for final filtration and cleanup prior to discharge via the system stack. The Combustion Air Blower (C-5) is also located on the Off-Gas Trailer and provides air for the combustion of the DAW and contaminated oil.

A separate ventilation system is provided for a portion of the trailers. Air in the ash handling area is drawn out of this area into the Incinerator Trailer via a separate blower located on the Incinerator Trailer. This air is passed through a HEPA filter package and then exhausted to the atmosphere. This ventilation system removes any ash particulate that may have become airborne in the ash handling area, and provides frequent air changes throughout the Incinerator Trailer where the main processing hardware components are located. The change room, utility room, control room, and trash storage area are not serviced by the ventilation system. The Off-Gas Trailer is also not part of this ventilation system. However, in the Off-Gas Trailer, fresh ambient air is continually drawn from the trailer by the combustion air blower and provided to the incinerator.

5.3 COMPLIANCE WITH ALARA

Arrangement of the MVRS components is based on maintaining the operator dose exposure to a level "As Low As Reasonably Achievable" (ALARA), consistent with U.S. NRC Regulatory Guide 8.8. This has been accomplished in many ways. First, the trash storage area on the trailer is used to store only 2-3 drums of DAW at any time, to reduce operator dose exposure. It is estimated that the dose rate in this area will be 5-10 mRem per hour, based on a maximum surface dose rate of 25 mRem per hour on each drum of DAW. By limiting the number of drums in this manner, it is also possible to maintain the dose rate in the control room to 0.1 mRem per hour. The ash filling area will potentially have the highest dose rates, on the order of 500-600 mRem per hour. This corresponds to the surface dose rate of a HIC filled with incinerator ash. Dose rates in this area are substantially reduced during the filling of the HIC by providing a shielded cask (2" lead) that encloses the

5.3 (cont.)

HIC during the incinerator ash filling process. It is only during the removal of the HIC from the shielded cask during transfer of the HIC to the utility that maximum dose rate of 500-600 mRem per hour would be present. The operator remotely transfers the HIC to the utility vehicle.

The major source of activity in the Incinerator Trailer is the ash contained in the incinerator. However, the incinerator structure and refractory provide some shielding. The expected dose rate at the surface of the Incinerator Trailer is expected to be in the 3-4 mRem per hour range during operation.

The major source of activity on the Filter Trailer is the particulate trapped on the HEPA filters. The expected dose rate at the surface of the Filter Trailer is expected to be 3-6 mRem per hour during operation.

Three radiation exposure classifications have been imposed on the MVRS, as follows:

(1) Unrestricted area - no control required.

(2) Restricted area - controls required for entry.

(3) Restricted area - high radiation levels, controls required for entry.

Figure 11 shows a simple schematic of the 3 trailers. The expected dose rates in and around these areas during operation are noted. Finally, the applicable Radiation Exposure Classification for each area is shown. It is readily seen that the ash filling area will have the highest dose rates due to presence of 2 containers filled with incinerator ash.

Table XI lists the conservatively calculated total annual expected radiation exposure to an MVRS operator. Maximum accumulated dose is obtained in the Trash Preparation Area where the operator is required to monitor, weigh, and load each drum of DAW into the incinerator. This amounts to 1.0 Rem annually.

The dose rates referenced in this section have been calculated utilizing the ISOSHIELD code developed by ORNL. The activity of the incoming DAW and isotope distribution was based on Table VI. The larger specific activity of 0.7 $mCi/ft.^3$ based on PWR wastes was used as a design basis. The corresponding ash activity was calculated to be 1.27 $\mu Ci/g$.

DESIGN REQUIREMENTS

1. CLASSIFY EACH AREA OF THE MVRS TO DETERMINE CONTROLS REQUIRED FOR ENTERING AND LEAVING THE AREA
2. EASE OF OPERATION FOR THE MVRS OPERATORS

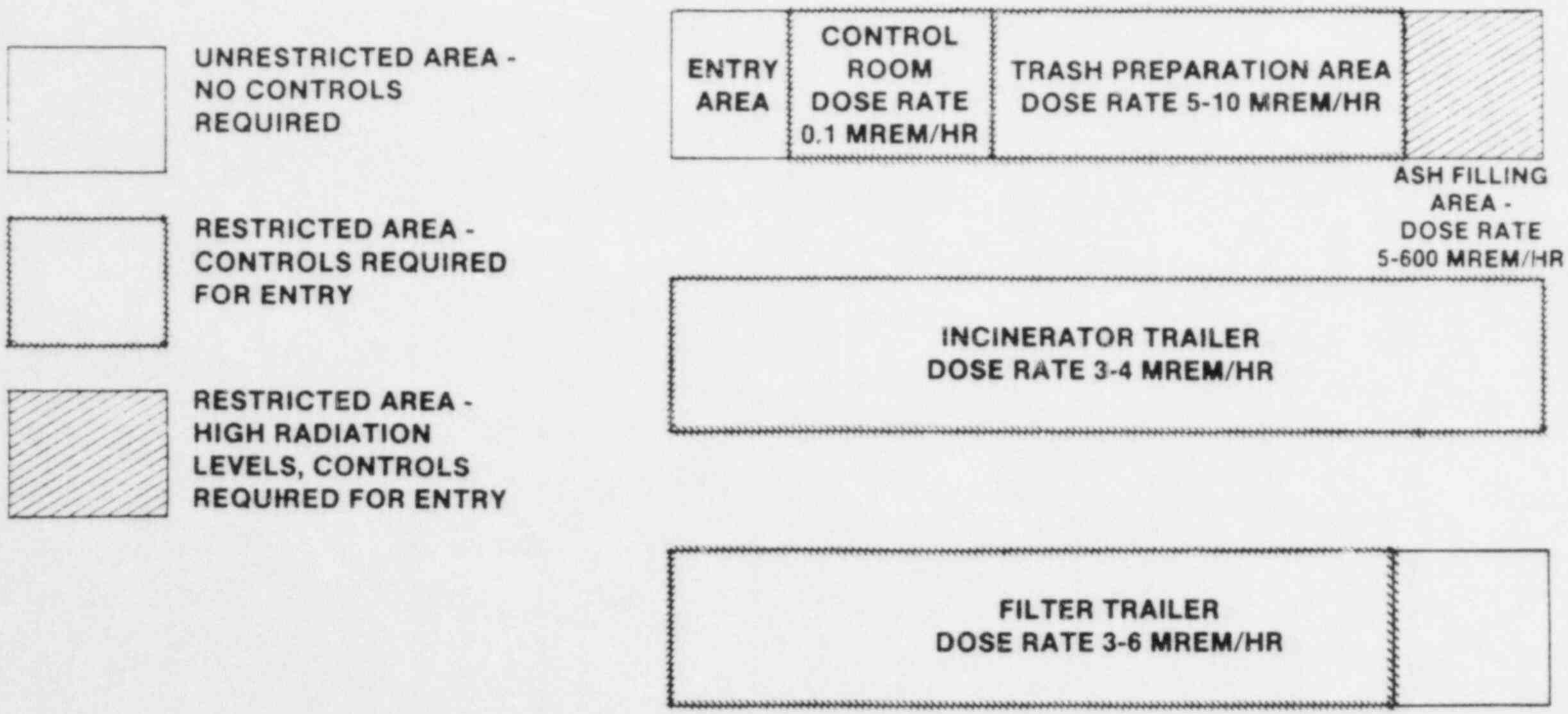

Figure 11. Radiation Exposure Classifications

5.3 (cont.)

Table XI

TOTAL ANNUAL EXPECTED RADIATION DOSE FOR THE MVRS OPERATOR

Location	Hours/Yr	Dose Rate Mrem/Hr	Dose Rem
Control Room	1,000	0.1	0.1
Trash Preparation Area	100	10	1.0
Incinerator Trailer	50	4	0.2
Filter Trailer	50	6	0.3
Ash Filling Area	25	10	0.25
	Total Annual Dose		1.85

5.4 MAINTENANCE ACCESSIBILITY

The major process equipment is housed on the Incinerator Trailer and the Filter Trailer. The Incinerator Trailer is provided with the following access points for ready maintenance:

(1) Incinerator access doors located at the end of the trailer -- these double doors provide ready access to the incinerator for maintenance.

(2) Access doors at the opposite end of the trailer -- these doors provide access to the venturi-scrubber preconcentrator and the ventilation system blower/HEPA filter.

(3) Additional access doors are provided on both sides of the trailer to allow maintenance of the trash ram and quench pipe.

(4) A scrubber access hatch is provided on the roof of the trailer.

5.4 (cont.)

The Filter Trailer is provided with the following access points for ready maintenance:

(1) Double doors at one end of the trailer for ready access to the filter package, main induction fan, emergency blower, and the combustion blower.

(2) Double louvered access doors at the opposite end of the trailer which provide access to the emergency electrical generator (propane fueled), air compressor, emergency air compressor, and the air dryer.

Prior to scheduled or unscheduled maintenance, the major sources of activity such as incinerator ash will be transferred from the component requiring maintenance to another location. Residual ash will be vacuumed.

6.0 RADIATION MONITORING EQUIPMENT

The following radiation monitoring equipment is included with the MVRS and will be supplied either by AECC or the utility, as noted.

6.1 CONTROL ROOM (supplied by AECC)

a. A shelf-mounted area monitor capable of detecting up to 100 mrem per hour will be provided in the control room. An example is the Eberline Model EC4-1 with the DA1-1 Detector.

b. A shelf-mounted continuous air sampler and monitor for operator protection will also be provided in the control room. An example is the Eberline Model AMS-3 Beta monitor.

6.2 PROCESS EXHAUST (supplied by AECC)

Release rates during normal operation of the AECC MVRS are discussed in Section 9.3 and 9.4 and are shown to be several orders of magnitude below the limiting concentrations specified in 10CFR20, Appendix B, Table II, Column I. Nevertheless, AECC will provide a gross stack monitoring system for particulate at the process exhaust, along with a continuous sampling system that is analyzed periodically. The system is located in the section of the filter trailer near the emergency generator. A convenient readout is provided in the control room.

6.3 HVAC EXHAUST (supplied by AECC)

AECC will provide a gross stack monitoring system for particulate at the HVAC exhaust without the sampling feature. This system will be identical to that provided for the process exhaust with a similar location on the filter trailer.

6.4 TRASH MONITOR (supplied by Utility)

A hand-held portable monitor will be supplied by the utility for monitoring the dose rate of the incoming waste packages. An example is the Eberline Model E-140 with a HP-270 probe.

6.5 FRISKING EQUIPMENT (supplied by Utility)

A frisking monitor will be supplied by the utility and located near the step-off pad in the Trash Preparation/Ash Handling Trailer. An example is the Eberline Model RM-14 with a HP-210T probe.

6.6 PORTABLE AREA MONITORS (supplied by Utility)

One or more hand-held portable area monitors will be provided by the utility for surveying the exterior of the MVRS trailers, including the ash packaging area. An example is the Eberline Model EC4-X monitor (range 1-10,000 mRem per hour). However, it is expected that the model will be unique to each site.

7.0 QUALITY ASSURANCE PLAN

7.1 SCOPE AND SUMMARY

The project for the Mobile Volume Reduction System involves a low production volume of large items. This Quality Plan places emphasis on the control of individual items to assure compliance of these items to the system requirements. This document will establish code and equipment requirements for the major items of the system. Miscellaneous items will have their requirements determined at the design release.

The Aerojet Energy Conversion Company (AECC) Quality Assurance Program is designed to define and control those elements of AECC and supplies performance which affect quality throughout all areas of contract performance.

The Quality Assurance Program has been developed to follow the guidelines as described in Nuclear Regulatory Commission Regulatory Guide 1.143 Revision 1, dated October 1979, "Design Guidance for Radioactive Waste Management Systems, Structures and Components Installed in the Light-Water-Cooled Nuclear Power Reactor Plants." Paragraph 2.1.1 of the above document recommends the system be designed and tested to the requirements set forth in the codes and standards listed in Table 1. This table which addresses pressure vessels, atmospheric tanks, 0-15 psig tanks, heat exchangers, piping, valves and pumps, does not provide any code recommendations for equipment operating at negative pressure. AECC has selected codes and standards, as applicable, for equipment listed in the table. For equipment not listed in the table, AECC has specified appropriate standards based on the equipment service conditions. The data sheets in Section 7.4 specify the codes and standards applicable to each equipment item.

The implementation of the Quality Assurance Program is the responsibility of the Manager, Quality Assurance organization who reports directly to the Vice-President, Waste Management Systems, AECC.

7.2 CONTROLS

A Quality Assurance Requirements (QAR) document (Figure 12) will be completed for major component and systems of the Mobile Volume Reduction System in compliance with the recommendations of NRC 1.143. In addition, in Section 7.4 of this plan, a Quality

Aerojet Energy Conversion Company

QAR No. ____________ Date: ____________

Approved: ____________ (AECC)

ENERGY SYSTEMS QUALITY ASSURANCE REQUIREMENTS

ATTENTION: Quality Assurance Manager

1. This form applies to: AECC Requisition No. ____________ ; AECC Purchase Order No. ____________
   Part No. ____________ ; Revision ________ ; Part Description ____________

2. The following apply to this order:

☐ ☐ ASME CODE SECTION VIII ☐ ASME CODE SECTION IX ☐ ANSI ____________ ☐ API ____________

☐ ASTM ____________ ☐ ASME CODE SYMBOL ________ STAMP REQUIRED ☐ COMMERCIAL ☐ AECC ____________

3. The following items denoted by an "X" and subsequent revisions are to be submitted to AECC for approval prior to use.

X	SUBJECT	X	SUBJECT
	INSPECTION TEST PLAN		CODE MATERIAL FABRICATOR
	NDE PROCEDURE		
	NDE PERSONNEL QUALIFICATION		
	WELD PROCEDURE SPECIFICATION (WPS)		
	PROCEDURE QUALIFICATION RECORD (PQR)		
	WELDER/WELD OPERATOR QUALIFICATION RECORD QW 484		
	DRAWING REVIEW		
	CODE CALCULATIONS		
	WELD METAL CERTIFICATION		

4. The following items denoted by an "X" in the adjacent block are to accompany the shipment to AECC.

X	SUBJECT	X	SUBJECT	X	SUBJECT
	ASME DATA REPORT		ELECTRICAL TEST REPORT		
			CERTIFICATE OF CONFORMANCE		
	HYDROSTATIC REPORT		FUNCTIONAL TEST REPORT		
	WELD LOCATION DRAWING		FIRST ARTICLE REPORTS		
	MATERIAL CERTIFICATES				
	AS-BUILT DRAWINGS				
	OPERATIONAL DATA				
	MAINTENANCE DATA				
	PNEUMATIC TEST REPORT				

SUPPLIER NOTE:
All Certifications/Test Reports must reference the AECC Purchase Order/Change Order.

5. ☐ Mandatory hold point (showing AECC/AECC Customer, and Authorized Inspector Requirements at the Supplier's facility) may be provided to the Supplier by Purchase Order Change Notice after receipt, review and approval of Supplier's Inspection Test Plan.

   ☐ Supplier shall maintain records for a minimum of _____ years, and at the conclusion of this period shall contact AECC for disposition.

6. Special Requirements: All code material must be fabricated to code requirements and so certified.

Figure 12. Energy Systems Quality Assurance Requirements Document

All Certificates of Conformance shall refer to AECC Part Number & Serial Number

7.2 (cont.)

Instruction has been completed for certain components of the mobile incinerator which includes documentation and surveillance requirements for compliance by AECC and AECC suppliers.

7.2.1 Identification

Materials and equipment are identified with equipment and part numbers. Supplier furnished documents are maintained in a supplier file along with the results of the Quality Assurance surveillance.

Surveillance or certification records are maintained until assembled and tested. Subsequently they are forwarded to archives for permanent storage for the life of the units. Suppliers are required to retain records as specified in the Quality Assurance Requirements Form.

7.2.2 Design Control

7.2.2.1 Change Control

AECC issues engineering drawings and/or specifications which define for the project the required configuration at the time of issue. Changes to these documents are processed and maintained to assure the specified requirements are implemented. These documents are used by Quality Assurance to review production and purchasing documents and assure that configuration requirements are accurate. Quality Assurance reviews and approves all design disclosure of modules and equipment.

7.2.2.2 Supplier Configuration Control

Documents for purchase of supplied components are reviewed by Quality Assurance and compared to the certified engineering drawings and/or specification requirements. These requirements with other characteristics are included in the planning for acceptance of delivered components and materials. For the supplier with component design cognizance, drawing change control will be implemented through his established procedures with AECC review of proposed changes required.

7.2.3 Procurement Control

7.2.3.1 Approval of Suppliers

All potential fabrication of major equipment may be visited by Quality Assurance and Materiel to assure that the supplier is capable of providing a quality product for the Mobile System.

7.2.3.2 Specification of Quality Requirements

All procurement documents for equipment and materials are subject to Quality Assurance review and acceptance prior to release. Design disclosure documents will be prepared for each element of the Mobile Volume Reduction System which contain the quality assurance requirements. Required documentation certifying acceptability are forwarded to AECC by the manufacturer in compliance with Paragraph 7.4 of this document and the Quality Assurance Requirements Form (Figure 12).

7.2.4 Surveillance and Acceptance

Surveillance coverage will be provided for selected equipment. The representative will either be an AECC Supplier Quality Representative (SQR) or a representative authorized by AECC. The source surveillance representatives shall:

a. Review inspection plans and requirements for documentation.

b. Review fabrication records including specific required data.

c. Ensure conformance to requirements based on records.

d. Ensure discrepancies were documented and dispositioned per contract requirements.

e. Ensure discrepancies requiring AECC review were submitted for approval and properly closed out.

f. Surveillance of selected dimensional characteristics of equipment and interfaces.

g. Review test data and records.

h. Approve the complete required data package, accept the equipment and release the equipment for shipment.

AECC reserves the right to waive any of the above surveillance points due to the nature of the equipment being supplied.

7.3 MATERIALS, WELDING AND NONCONFORMING COMPONENTS

7.3.1 Material

Material shall be procured to ASTM standards and should the material depart from the requirements of ASTM standards, the supplier shall determine if the material is acceptable for use.

7.3.2 Welding

Welding will be performed per AWS D1.1-79 unless ANSI B31.1 or ASME Section VIII is required, then the welding shall be per ASME Section IX.

Weld repairs for AWS D1.1-79 shall be stated in Paragraph 6.6.2 of AWS D.1.1-79.

Weld repairs for ASME Section IX shall comply with the full intent of the required code.

7.3.3 Nonconforming Components

When a nonconformance to the requirements of the fabrication drawing occurs, the supplier shall review the nonconformance to determine if the nonconformance violated the interface dimensions. If the nonconformance does not violate the interface dimensions, the supplier shall process the nonconformance within their system. If the nonconformance violate the interface dimensions, the supplier shall inform AECC and propose a repair of the nonconformance. AECC will approve, recommend an alternate, or reject the repair.

7.4 SURVEILLANCE POINTS AND DATA SHEETS

Data sheets for each equipment module indicate the basic design and fabrication requirements, and define the proposed inspection points, documentation requirements, and acceptance criteria that will be used to assure the conformance of the equipment to the appropriate requirements. A sample data sheet for the Venturi Scrubber (S-10) is shown in Table XII. A brief description of each surveillance point is as follows:

7.4.1 Drawing Review

If required by the data sheet of the specification or the QAR, each supplier fabricating a piece of equipment shall submit fabrication drawings to AECC for review and

Table XII

MVRS INSPECTION POINTS, DATA, AND ACCEPTANCE CRITERIA
(Sample Sheet for the Venturi Scrubber, S-10)

INSPECTION - QUALITY CONTROL - ACCEPTANCE

EQUIPMENT ITEM - Venturi Scrubber (S-10)

BASIC DESIGN AND FABRICATION REQUIREMENTS Design - ASME Section VIII, Material - ASTM, Welding - ASME Section IX, Inspection and Testing - ASME Section VIII

	AECC	AUTHORIZED INSPECTOR	TEST CONDITIONS
A. INSPECTION POINTS			
1. Design Calculations (Submitted to AECC prior to fab.)	X	X	
2. Drawing Review (Submitted to AECC prior to fab.)	X		
3. Review of material certifications		X	
4. Selected weld fitup		X	
5. Radiographic (if applicable) film negatives and reports		X	
6. Weld repairs	X	X	
7. Hydrostatic/Pneumatic test	X	X	
8. Electrical tests			
9. Final Inspection (interface dimension check) and review of required documentation	X	X	
10. Packaging & Acceptance		X	

B. REQUIRED DOCUMENTATION	REQUIRED
1. Copy of Qualification test records for welders	X
2. Copy of Certificate of Authorization for fabrication to appropriate code	X
3. Certified material test reports	
4. Manufacturer's certifications acceptable	X
5. Liquid Penetrant Report	
6. Radiographic (if applicable) film negatives and reports	X
7. Record of repairs (per applicable code)	X
8. Hydrostatic/Pneumatic test report (per equipment specification)	X
9. Copy of Manufacturer's data report for pressure vessels	X
10. Certified performance test data and curves - Manufacturer's certifications acceptable, pumps, blower, motors, feeders (per equipment specification)	
11. Electrical - insulation resistance (per equipment specification)	
12. Electrical - dielectric strength (per equipment specification)	
13. Electrical - wattage rating verification, heaters (per equipment specification)	
14. Electrical - continuity (per equipment specification)	
15. DOP test report - HEPA filters (per equipment specification)	
16. Statement of Conformity	X

NOTES:

1) Manufacturer to notify AECC Quality Manager 56 hours prior to all inspection points.

2) Authorized Inspector check points must be inspected by Manufacturer's Inspector.

C. ACCEPTANCE

Acceptance of the subject equipment at the Manufacturer's plant shall be based on the following:

1. Evidence of acceptance of each of the applicable inspection points.
2. Completion and provision of applicable required documentation.

7.4.1 (cont.)

approval. Fabrication shall not commence until AECC has approved the fabrication drawings. Manufacturers of manufactured standard parts may submit a certified drawing in lieu of fabrication drawings.

7.4.2 Review of Material Certifications

When Manufacturer's Certificates of Conformance are required for the material, these documents shall be submitted to AECC in concurrence with the acceptance of the equipment.

7.4.3 Selected Weld Fitup

If required, subsequent to all weld joint preparation and tack welding of the major welds, the fitup shall be inspected by the manufacturer's inspector for conformance to the applicable drawing weld requirements, design joint efficiencies and provisions for inert gas backup.

7.4.4 Radiographs (if applicable), Film Negatives and Reports

Radiographs are read and interpreted by the supplier. The appropriate data report will be approved utilizing the drawing requirements for weld joints as his criteria for acceptability or rejection.

7.4.5 Weld Repairs

If a weld repair is required by Paragraph 7.3.3 Nonconforming Components, AECC reserves the right to inspect the surface preparation, weld fitup, welding and surface finishing.

7.4.6 Hydrostatic/Pneumatic Tests

If the equipment specification requires a hydrostatic or pneumatic test, AECC reserves the right to witness the test.

7.4.7 Electrical Tests

If the equipment specification requires electrical testing, AECC reserves the right to witness the test.

7.4.8 Final Inspection (Interface Dimension Check) and Review of Required Documentation

Interface and selected overall dimensions will be checked against the certified drawings for conformance. In addition, selected required documentation is reviewed for conformance to the system requirements. The attached data sheets spell out the specific data required for each equipment item as implemented by the Quality Assurance form.

Satisfaction of the above requirements constitute acceptance of the module with the exception of final packaging.

7.4.9 Packaging

The Packaging Procedures are surveyed to ensure conformance to the requirements of the contract and the applicable AECC design disclosure. In general, all requirements including shipping and storage requirements are per the equipment design disclosure.

7.4.10 Acceptance

AECC acceptance of the equipment and authorization to ship shall be based on the acceptance outlined in Paragraph 7.4.8 above, and the approval of the packaging.

7.4.11 Equipment Service

The Mobile Volume Reduction System has been analyzed by the service conditions during operation and placed in three sections:

Section 1. Equipment Processing Radioactive Fluid

Section 2. Equipment Which May Contact Radioactive Fluid

Section 3. Equipment Which Will Not Contact Radioactive Fluid

Sections 1 and 2 will be provided with a QAR and individual data sheet, but Section 3 will be provided only a QAR prior to release for procurement.

SECTION 1

EQUIPMENT PROCESSING RADIOACTIVE FLUID

Equipment		Design Code	Materials	Welding	Inspection & Testing
1.	Incinerator Off-Gas Quench System (A-1)	ANSI B31.1	ASTM	ASME Section IX	ANSI B31.1
2.	Gas Filter/Adsorber/ Filter Train (F-1/D-1/F-2)	ANSI N509	ASTM	AWS D1.1	ANSI N510
3.	Ash Transfer Conveyor (G-7)	Mfg Std	Mfg Std	Mfg Std	Mfg Std
4.	Densifier (G-8)	Mfg Std	Mfg Std	Mfg Std	Mfg Std
5.	Fill Hood (G-12)	Mfg Std	Mfg Std	Mfg Std	Mfg Std
6.	Ash Hopper (H-6)	Mfg Std	Mfg Std	Mfg Std	Mfg Std
7.	Scrubber Recirculation Pump (P-3)	Mfg Std	ASTM	Mfg Std	Hydraulic Institute
8.	Primary Combustor (R-5A)	Mfg Std	Mfg Std	Mfg Std	Mfg Std
9.	Secondary Combustor (R-5B)	Mfg Std	Mfg Std	Mfg Std	Mfg Std
10.	Trash Ram (G-4)	Mfg Std	Mfg Std	Mfg Std	Mfg Std
11.	Preconcentrator (S-9)	ASME Section VIII	ASTM	ASME Section IX	ASME Section VIII
12.	Venturi Scrubber (S-10)	ASME Section VIII	ASTM	ASME Section IX	ASME Section VIII
13.	Surge Tank (T-11)	Mfg Std	Mfg Std	Mfg Std	Mfg Std
14.	Valves	ANSI B31.1	ASTM	ASME Section IX	ANSI B31.1
15.	Piping*	ANSI B31.1	ASTM	ASME Section IX	ANSI B31.1
16.	Contaminated Oil Burner (B-3)	Mfg Std	Mfg Std	Mfg Std	Mfg Std
17.	Contaminated Oil Pump (P-11)	Mfg Std	ASTM	ASME Code Section IX (as required)	Hydraulic Institute
18.	Contaminated Oil Tank (T-12)	AWWA D-100	ASTM	ASME Section IX	AWWA D-100

*From incinerator exhaust flange through venturi scrubber and preconcentrator and contaminated oil lines.

SECTION 2

EQUIPMENT WHICH MAY CONTACT RADIOACTIVE FLUID

Equipment		Design Code	Materials	Welding	Inspection & Testing
1.	Piping*	Mfg Std	ASTM	Mfg Std	Mfg Std
2.	Induction Fan (C-4)	ANSI N509 Para 5.7	ASTM	AWS D.1.1	Mfg Std
3.	Emergency Blower (C-4A)	ANSI N509 Para 5.7	ASTM	AWS D.1.1	Mfg Std

*Exhaust piping downstream of scrubber-preconcentrator.

SECTION 3

EQUIPMENT WHICH WILL NOT CONTACT RADIOACTIVE FLUID

All This Equipment Will Be Manufacturer's Standard

Equipment

1. Auxiliary Burner (B-4)
2. Modulating Burners (B-1, 2)
3. Combustion Air Blower (C-5)
4. Process Air Compressor (C-7)
5. Emergency Air Compressor (C-9)
6. Main Control Panel (CP-100)
7. Incinerator Local Control Panel (CP-2)
8. Ash Handling Local Control Panel (CP-3)
9. Drum Handling and Capping Local Control Panel (CP-4A, B)
10. Monorail Crane (G-9A/B)
11. Trash Weigh Scale (G-10)
12. Container Capper (G-11A, B)
13. Standby Generator (K-1)
14. Motor Control Center (MCC-1)
15. Caustic Pump (P-6)
16. Caustic Tank (T-2)
17. Incinerator, Filter, Waste Preparation/Packaging Trailers
18. Process Piping*
19. Process Valves*
20. Field Installed Instruments
21. Propane Tank
22. Radiation Monitors
23. Exhaust Air Blower (C-8)
24. HVAC Filter (F-3)

*Air, water, hydraulic oil and caustic systems

8.0 COMPLIANCE WITH FEDERAL REGULATIONS

8.1 INTRODUCTION

The AECC MVRS has been designed and will be fabricated, operated, and maintained in a manner consistent with applicable U.S. Federal regulations and other regulatory literature. Conformance with the following regulatory literature is discussed below:

- o Title 10, Code of Federal Regulations (Atomic Energy)
- o Title 49, Code of Federal Regulations (Transportation)
- o Nuclear Regulatory Commission (NRC) Regulatory Guides
- o Nuclear Regulatory Commission (NRC) Licensing Criteria for Portable Radwaste Systems

8.2 TITLE 10, CODE OF FEDERAL REGULATIONS (ATOMIC ENERGY)

8.2.1 Part 20, Standards for Protection Against Radiation

The AECC MVRS operation will be consistent with the Nuclear Regulatory Commission regulations set forth in the following sections of Part 20:

8.2.1.1 10CFR 20.101 - Exposure of Individuals to Radiation in Restricted Areas

This section sets limits on the exposure of individuals to radiation in restricted areas. Dose per calendar quarter and accumulated doses received by occupational workers operating and maintaining the AECC MVRS are expected to be a small fraction of the limitations specified in this section. The bases for this expectation are as follows:

(1) The ash handling area will be shielded from the remainder of the trailer to reduce the does rate during normal operation to an acceptable level.

(2) The MVRS will be remotely operated from the main control panel where the expected dose rate is 0.1 mRem per hour.

(3) Only 2 or 3 drums of DAW will be stored in the trailer trash storage area to minimize dose exposure to the MVRS operator.

(4) The High Integrity Container, or other suitable container, is placed in a shielded cask (2 inches lead) during filling with incinerator ash.

8.2.1.1 (cont.)

(5) Prior to maintenance, components containing ash are decontaminated by transferring ash to another location remote from the component requiring maintenance. The residual ash is vacuumed.

(6) Portable radiation monitors will be used by the MVRS operator to determine the dose rate at the surface of each incoming drum of DAW, the dose rate in the ash handling area, and other areas around the trailers.

Table XI lists the total annual expected radiation dose for the MVRS operator.

8.2.1.2 10CFR 20.103 - Exposure of Individuals to Concentrations of Radioactive Material in Restricted Areas

This section sets limits on the exposure of individuals to concentrations of radioactive material in restricted areas. The maximum permissible concentrations for each isotope are listed in Appendix B, Table I, of this section. Compliance with these limits during normal operation and maintenance of the AECC MVRS is based on the following:

(1) The MVRS operates at negative pressure. Thus, any leakage is from the surrounding room air into the system.

(2) The MVRS is provided with an independent ventilation system which services the ash handling area and the complete incinerator trailer. The air is passed through a HEPA filter package prior to stack discharge.

(3) The MVRS process exhaust contains a very low level of activity since the exhaust gas has passed through a series of off-gas cleanup system components which, in combination, assure a very large decontamination factor.

(4) The two exhaust stacks on the MVRS, noted in Items (2) and (3) above, are provided with radiation monitoring equipment, as discussed in Section 6.0.

8.2.1.3 10CFR 20.105 - Permissible Levels of Radiation in Unrestricted Areas

This section sets limits on the exposure of individuals to radiation in unrestricted areas:

(1) 0.5 rem to the whole body in any calendar year.

8.2.1.3 (cont.)

(2) 2 millirem per hour.

(3) 100 millirem in any seven consecutive days.

The plant site boundary represents the closest unrestricted area to the MVRS. Since the dose rates near the MVRS hardware are only a few millirem per hour, the expected dose rate at the plant site boundary will be only a small fraction of one millirem due to normal attenuation.

8.2.1.4 10CFR 20.106 - Radioactivity in Effluents to Unrestricted Areas

This section sets limits on the exposure of individuals to concentrations of radioactive material in unrestricted areas. The maximum permissible concentrations for each isotope are listed in Appendix B, Table II of this section. Radioactivity in effluents to unrestricted areas due to operation and maintenance of the MVRS will be limited to concentrations that are "as low as is reasonably achievable" (ALARA). The concentrations at the plant site boundary will be far below those specified in Appendix B, Table II. Section 9.0 of this report provides an analysis of the concentration at the plant site boundary during normal operation of the MVRS. The results of this analysis confirms that the concentrations are well below the limits set in this section.

8.2.1.5 10 CFR 20.305 - Treatment or Disposal by Incineration

This section places restrictions on the treatment or disposal of waste material by incineration. The MVRS will incinerate dry active wastes and contaminated oil. This section specifically requires compliance with 10CFR 20.106, which is discussed above.

8.2.2 Part 50, Licensing of Production and Utilization Facilities

The MVRS will be located at a facility meeting the requirements of 10CFR 50 and will meet the applicable requirements of this part, as discussed below.

8.2.2.1 10CFR 50 Appendix A - General Design Criteria for Nuclear Power Plants

The design criteria listed in Appendix A that are applicable to the AECC MVRS are Criterion 60, 61 and 64. Compliance with each of these criteria is discussed below.

8.2.2.1 (cont.)

Criterion 60 - Control of Releases of Radioactive Materials to the Environment

The operation of the MVRS will result in controlled gaseous releases to the atmosphere of radioactive particulate matter. The estimated releases from the system during normal operation are presented in Section 9.0 of this report and are far below those allowed by federal regulations. There will be no liquid effluents from the MVRS. During normal operation the incinerator ash produced by the MVRS will be packaged in a HIC, or other container, for shipment to a commercial shallow-land burial site or storage onsite by the utility.

Criterion 61 - Fuel Storage and Handling and Radioactivity Control

The MVRS has been designed to assure adequate safety under normal and postulated accident conditions. The expected releases from the system during normal operation are presented in Section 9.0 of this report and are within the limits imposed by federal regulations.

In the event of an upset condition, either in the ash handling area or in any location on the Incinerator Trailer, that would result in a release of radioactive material to the air, the ventilation system that services these areas will pass the air through a HEPA filter for cleanup prior to discharge to the atmosphere.

Criterion 64 - Monitoring Radioactivity Releases

Expected releases from the MVRS during normal operation, anticipated operational occurrences, and postulated accidents are routed to the off-gas cleanup system for monitoring prior to release. An exhaust stack monitor is provided for each of the two stacks located on the MVRS.

8.2.2.2 10CFR 50 Appendix B - Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants

The AECC MVRS Quality Assurance Program is presented in Section 7.0 of this report and complies with U.S. NRC Regulatory Guide 1.143 requirements.

8.2.2.3 10CFR 50 Appendix I - Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criteria "As Low As Is Reasonably Achievable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents

The MVRS operation results in very low releases to the atmosphere. The expected

8.2.2.3 (cont.)

releases presented in Section 9.0 are well below the limits set in Appendix I. These releases are only a small fraction of the total plant dose. The dose attributable to the MVRS will have no significant effect upon the ability of the plant to satisfy the requirements of Appendix I.

8.2.3 Part 61, Licensing Requirements for Land Disposal of Radioactive Waste

The incinerator ash generated by the MVRS will be packaged in a High Integrity Container, or other container provided by the utility, and shipped to a commercial burial site for disposal or stored onsite. It is expected that the waste product will qualify as Class A waste.

8.3 TITLE 49, CODE OF FEDERAL REGULATIONS (TRANSPORTATION), PART 173

The MVRS operation will be consistent with the regulations set forth in the following sections of Part 173:

8.3.1 49CFR 173.390 - Transport Groups of Radionuclides

The radionuclides present in the solid product produced by the MVRS will be the same as those present in the dry active waste and contaminated oil that are processed in the incinerator. The Transport Groups of the isotopes contained in the ash will be mainly Groups III and IV.

8.3.2 49CFR 173.392 - Low Specific Activity Radioactive Material

It is expected that all ash material generated by the MVRS will qualify as Low Specific Activity material. The basis is as follows: A typical volume reduction factor for incineration of the dry active wastes is 40. Multiplication of the specific activity values presented in Section 4.0 by the corresponding volume reduction factor results in the expected specific activity of the ash material produced by the MVRS, approximately 1.3 μCi per gram of ash materal. This is well below the allowable specific activity for LSA material in Transport Group III, which is 300 μCi per gram. Thus, the waste package easily qualifies as LSA.

8.3.3 49CFR 173.397 - Contamination Control

The incinerator ash generated by the MVRS will be packaged in a High Integrity Container, or other appropriate container. The final waste package of LSA radioactive material will be decontaminated per the regulations defined in this section by the utility prior to shipment.

8.4 NUCLEAR REGULATORY COMMISSION (NRC) REGULATORY GUIDES

8.4.1 Regulatory Guide 1.143 - Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants

AECC has committed to the design guidance set forth in NRC Regulatory Guide 1.143. Specifically, this guide furnishes design guidance acceptable to the NRC staff relating to seismic and quality group classification and quality assurance provisions for radioactive waste management systems, structures, and components. The MVRS will process combustible wastes. Major guidelines in the regulatory guide to which the MVRS will conform are as follows:

(1) The MVRS will be designed and tested to the requirements set forth in the codes and standards listed in Table I, supplemented by the provisions in Section 1.1.2 and in regulatory position 4 of this guide. See also Section 7.4 of this report which contains the specific codes and standards applicable to each component of the MVRS.

(2) The MVRS will not be designed to the seismic criteria given in regulatory position 5 of this guide.

(3) The MVRS Quality Assurance Program will conform to the guidelines set forth in regulatory position 6 of this guide.

8.4.2 Regulatory Guide 8.8 - Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable

The MVRS design is consistent with the guidelines set forth in this regulatory guide so as to achieve "As Low As Is Reasonable Achievable" (ALARA) occupational exposure. Specifically, the general arrangement of the MVRS components

8.4.2 (cont.)

was developed to reduce the dose rates in areas that will be occupied by the MVRS operator either by shielding or limitation of radioactive material. Compliance with this Regulatory Guide is discussed in more detail in Section 5.3 of this report.

8.5 NRC LICENSING CRITERIA FOR PORTABLE RADWASTE SYSTEMS

This document contains Criteria for Portable Incinerators, and indicates that the incinerator design should meet the quality group and quality assurance criteria of Regulatory Guide 1.143. Normal effluents from the incinerator should not result in the total plant effluents exceeding the design objective doses of Appendix I to 10CFR Part 50 or the doses of 40CFR 190. Gaseous releases must meet 10CFR 20, Appendix B, Table II, Column 1. Furthermore, approval for incineration is required under 10CFR 20.305. The MVRS compliance with these regulations is discussed above and is assured.

9.0 ESTIMATED RELEASES FROM THE AECC MVRS

9.1 GENERAL

The AECC MVRS processes dry active wastes and contaminated oil. The products generated consist of an incinerator ash that is densified and metered into a High Integrity Container, or other suitable container, and a small amount of off-gas that is discharged to the atmosphere. Since the concentrated scrub solution is recycled back to the primary combustor for processing, there are no liquid wastes generated by the system. The Material Balance Flow Diagram for the AECC MVRS was previously presented as Figure 3. This diagram indicates the important pressures, temperatures, and flow rates of gases, liquids, and solids throughout the system during normal operation. The objective of this section is to present the basis for calculation of the expected releases from the AECC MVRS during normal operation. Releases of dry product and liquid wastes are not planned.

The releases from the AECC MVRS are calculated by applying the appropriate system particulate and iodine decontamination factors to the maximum activity feed rates expected. The maximum activity feed rates expected were discussed in Section 4.3 and are 5.2 Ci per year for a BWR and 4.9 Ci per year for a PWR. See Table IV. The system decontamination factors are discussed in Section 9.2 below.

9.2 DECONTAMINATION FACTORS

Decontamination factors across the major hardware components and across the total system are necessary to calculate the expected release of radioactive material from the AECC MVRS to the atmosphere during operation. The radioisotopes present in the dry active wastes processed in the MVRS are expected to remain with the incinerator ash, except for iodine. Iodine is not expected to be present in the combustible wastes processed (see Table VI). Radioactive iodine (I-131) is partially volatile at the temperatures of operation and would remain in the gas stream until it encounters the charcoal adsorber. Thus, it is necessary to assess the decontamination factors for particulate and iodine appropriate to the MVRS.

Consider the particulate decontamination factor. The individual components that provide off-gas cleanup capability, and, therefore, decontamination factor capability for particulate are: (1) Primary Combustor (R-5A), (2) Scrubber Preconcentrator (S-9), and (3)

9.2 (cont.)

HEPA Filter (F-1). The overall system decontamination factor (DF) is defined as:

$$\text{Decontamination Factor (DF)} = \frac{\text{Ash Generation Rate in Incinerator}}{\text{Particulate Release Rate to Atmosphere}}$$

In a similar fashion, decontamination factors can be defined for each component of the off-gas cleanup system as the ratio of the particulate input rate to the particulate output rate. The Material Balance Flow Diagram shown in Figure 3 can be used to calculate the expected DF values for the various components and the overall system. These expected DF values are summarized in Table XIII.

Table XIII

EXPECTED PARTICULATE DECONTAMINATION FACTORS FOR THE AECC MVRS

Component	Decontamination Factor
Primary Combustor (R-5A)	20
Scrubber Preconcentrator (S-9)	1000
HEPA Filter (F-1)	200
Total System DF	4×10^6

The basis for the values shown in Table XIII is as follows:

Primary Combustor (R-5A) - The design of this combustor is similar to the controlled air incinerator that has operated at the Los Alamos National Laboratory. A typical DF value for this unit is 20, i.e., about 95% of the ash generated in the primary combustor remains behind in the combustor, while the remaining 5% of the ash generated exits the secondary combustor with the off-gas.

9.2 (cont.)

Scrubber Preconcentrator (S-9) - The design of this highly-efficient scrubber is based on the proven and tested AECC venturi-scrubber preconcentrator that is an integral part of the off-gas cleanup system employed in the Aerojet Fluid Bed Dryer/Fluid Bed Incinerator Volume Reduction System. Testing of this component has yielded scrubbing efficiencies on the order of 99.9%, which is equivalent to a DF of 1000.

HEPA Filter (F-1) - The decontamination capabilities of the HEPA filter system were not specifically measured by AECC. However, values of 200 were measured at Idaho Falls on similar filter elements using trace radionuclide counting techniques. We have taken the measured DF of 200 to be valid for the HEPA filter assembly in the AECC MVRS.

For purposes of calculation of releases, the total system decontamination factor of 4×10^6 for particulate was utilized.

Consider the iodine decontamination factor. Although no iodine is expected in the combustible wastes to be processed (see Table VI), the AECC MVRS contains a charcoal adsorber for iodine removal in the unlikely event that iodine is present in the waste stream. The expected DF for the charcoal adsorber is 100.

9.3 RELEASE RATES DURING NORMAL OPERATION

Table XIV summarizes the expected release rates by isotope during normal operation of the AECC MVRS when processing wastes from a BWR. The isotope listing and % composition were taken from Table VI. The release rates were calculated for each isotope by dividing the activity feed rates shown in Table IV by the system decontamination factor (4×10^6). The total activity released is only 1.3 μCi per year per reactor unit.

Table XV summarizes the expected release rates by isotope during normal operation of the AECC MVRS when processing wastes from a PWR. The isotope listing and % were taken from Table VI. The release rates were calculated by dividing the activity feed rates shown in Table IV by the system decontamination factor (4×10^6). The total activity released is only 1.2 μCi per year per reactor unit.

9.3 (cont.)

Since iodine is not present in the wastes, there is no iodine present in the off-gas stream.

Table XIV

RELEASE RATES AND PLANT SITE BOUNDARY CONCENTRATIONS RESULTING FROM OPERATION OF THE AECC MVRS -- BWR WASTES

Annual Activity Feed Rate = 5.2 Curies per Year per Unit

Isotope	%	Feed Rate, Ci/Year	Decontamination Factor	Release Rate, μCi/Year	Boundary Concentration Limit, pCi/m^3	Boundary Concentration, pCi/m^3
Cr-51	5.4	0.281	4E6	0.070	80,000	2.8E-8
Mn-54	8.1	0.421	4E6	0.105	1,000	4.0E-8
Co-58	1.1	0.057	4E6	0.014	2,000	5.5E-9
Co-60	55.8	2.902	4E6	0.726	300	2.8E-7
Zn-65	4.6	0.239	4E6	0.060	2,000	2.3E-8
Sr-90	0.01	5.2E-4	4E6	1.3E-4	30	5.0E-11
Nb-95	0.1	5.2E-3	4E6	1.3E-3	3,000	5.0E-10
Zr-95	0.1	5.2E-3	4E6	1.3E-3	1,000	5.0E-10
Cs-134	8.4	0.437	4E6	0.109	400	4.3E-8
Cs-137	16.4	0.853	4E6	0.213	500	8.0E-8
	100.0	5.201 Ci/Yr		1.300 μCi/Yr		5.0E-7

9.3 (cont.)

Table XV

RELEASE RATES AND PLANT SITE BOUNDARY CONCENTRATIONS RESULTING FROM OPERATION OF THE AECC MVRS -- PWR WASTES

Annual Activity Feed Rate = 4.9 Curies per Year per Unit

Isotope	%	Feed Rate, Ci/Year	Decontamination Factor	Release Rate, μCi/Year	Boundary Concentration Limit, pCi/m^3	Boundary Concentration, pCi/m^3
Cr-51	1.5	0.074	4E6	0.019	80,000	7.0E-9
Mn-54	3.3	0.162	4E6	0.041	1,000	1.6E-8
Co-58	31.0	1.519	4E6	0.380	2,000	1.5E-7
Co-60	41.0	2.009	4E6	0.502	300	1.9E-7
Sr-90	0.05	2.5E-3	4E6	6.3E-4	30	2.4E-10
Zr-95	0.5	0.025	4E6	6.3E-3	1,000	2.4E-9
Ru-106	0.4	0.020	4E6	5.0E-3	200	1.9E-9
Sb-125	0.1	4.9E-3	4E6	1.2E-3	900	4.8E-10
Cs-134	6.1	0.299	4E6	0.075	400	2.8E-8
Cs-137	15.8	0.774	4E6	0.194	500	7.3E-8
	99.8	4.9 Ci/Yr		1.224 μCi/Yr		4.8E-7

9.4 PLANT SITE BOUNDARY CONCENTRATIONS RESULTING FROM NORMAL OPERATION

The plant site boundary was assumed to be 1,000 meters from the point of release which was assumed conservatively to be at ground-level. The atmospheric diffusion factor selected from Regulatory Guide 1.3 is the 4 to 30 day value for a ground-level release and is 1.2×10^{-5} sec/m^3 (see Figure 3(A) of Regulatory Guide 1.3). Plant site boundary concentrations were then calculated for a BWR based on the annual release rates shown in Table XIV and the selected atmospheric diffusion factor. The calculated plant site boundary concentrations are listed in Table XIV as a function of isotope. Table XV lists the corresponding plant site boundary concentrations for a PWR. For all nuclides, the concentrations calculated are several orders of magnitude below the limiting concentrations specified in 10CFR 20, Appendix B, Table II, Column I. The impact on the environment due to normal operation of the AECC MVRS is negligible.

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