4.2.1 Ventilation System

LA-SUB-94-156

An overview of the TA-55, Building PF-4 ventilation system is provided in the following sections. Included are descriptions of the zone configurations, equipment-performance criteria, ventilation support systems, and the ventilation-system evaluation criteria. Section 4.2.1.1 provides a brief discussion of the ventilation system function. Section 4.2.1.2 provides details on the overall system configuration. Details of system interfaces and support systems are provided in Section 4.2.1.3. Section 4.2.1.4 describes instrumentation and control needed to operate the ventilation system. Finally, Sections 4.2.1.5 and 4.2.1.6 describe system surveillance/maintenance and Technical Safety Requirements (TSR) Limitations, respectively. Note that the numerical parameters included in this description are considered nominal; set points and other specifications actually fall within operational bands.

General information sources used to prepare the ventilation system description include: the previous facility SARs (CMB-11, 1978) and (SAIC, 1991); the TA-55 Operations Center Manual (TA-55 Operations, 1992); Operational Safety Requirements for the Plutonium Facility (Oper. Safety, 1988); the Heating, Ventilating and Air Conditioning Operating Manual for Plutonium Building PF-4 (HVAC, 1981); and the (Revised) Design Criteria for the DP Site Plutonium Processing Facilities Tech Area-55, Plutonium Facilities Site (LASL Eng., 1972). In addition, relevant information was extracted from numerous facility engineering diagrams.

4.2.1.1 System Function. The function of the PF-4 ventilation system is to confine radioactive materials during normal process-line operations and specific design-basis accidents and to limit radioactive environmental discharges to the lowest practicable level. As briefly explained below, this function is achieved through the use of air-flow patterns that ensure air flow is from the lowest to the highest potentially-contaminated regions of the building.

Functional Design. As is shown in Figure 4.2.1-1, the PF-4 building is divided into 4 ventilation zones whose boundaries are determined according to the potential for radioactive materials contamination. The primary purpose of these 4 ventilation zones is to prevent contamination from migrating out of the 4 process areas (designated 100, 200, 300, and 400 Areas) on the main PF-4 Building floor. Some facility documentation refers to these 4 process areas as compartments; these terms are used interchangeably within this report.

As is displayed on Figures 4.2.1-2 and 4.2.1-3, the least likely building region to be contaminated by processing materials is the basement, defined as ventilation Zone 3. Much of the mechanical equipment used to the support ventilation system operation is located in this region. The next zone, in order of increasing potential for contamination, consists of the building mezzanine, stairwells, and the corridors connecting the main floor laboratories. This zone is designated as Zone 2A. A yet higher potential for contamination is represented by the areas in Zone 2, specifically the process laboratory rooms. Finally, areas in Zone 1 have the highest potential for contamination. The Zone 1 areas include the building glove boxes, where radionuclide operations are conducted, and their associated transfer-conveyor system.

Functional Requirements. The PF-4 ventilation system is designed to withstand a number of abnormal and accident conditions. Relevant functional requirements are summarized below.

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- **Explosion - Internal Pressurization.** Critical portions of the ventilation system and building structure are designed and constructed to continue to function together as a confinement structure following a design basis explosion and/or pressurization.
- **Design Basis Fire.** The ventilation system and associated protective features are designed for effective and continued operation during and following certain fires, even in the event that normal plant, utility, and fire protection systems fail.
- **Loss of Electrical Power.** In case of a loss of electrical power to PF-4, the ventilation system will automatically transfer to a "safe shutdown" configuration. This isolation condition is achieved via pneumatic closure of the building air intake valves and pneumatic alignment of the Zone 1 exhaust isolation valves in the open position. Safe shutdown is described in more detail in Section 4.2.1.2.
- **Seismic Events.** In general, ventilation system equipment is not seismically qualified to operate under the design basis earthquake (DBE) but critical portions are required to operate following an operating basis earthquake (OBE). An OBE is equivalent to approximately one-half the DBE in terms of ground acceleration.

Certain rooms containing critical ventilation hardware, such as the Zone 1 process exhaust plenum room(s) are reinforced for seismic protection for .38g horizontal acceleration and for .27g vertical acceleration.

Design Guidelines and Criteria. The design of the ventilation system generally follows AEC (Atomic Energy Commission) guidelines that were in place prior to the facility construction. Additionally, all PF-4 systems comply with National Fire Protection Association (NFPA) design criteria 90-A.

4.2.1.2 Overall Configuration. This section describes the ventilation system configuration. Following the brief introductory comments below, separate discussions are used to describe the four ventilation zones. Additional discussions are subsequently used to provide further details on the ventilation system, for example ventilation in special areas and the response of the ventilation system to selected challenges.

As previously mentioned, the ventilation system consists of an integrated set of four distinct zones. These zones were designed and are operated to establish building pressure gradients so that air flows from the outside to the progressively higher levels of potential contamination within the building. The pressure within any zone is individually pressure-controlled and maintained at a predetermined value by controlling flows through fans and exhaust dampers.

The building basement, designated as ventilation Zone 3, is considered the least likely area of the building to be contaminated from processing activities although contamination resulting from PU-238 storage is a potential hazard. The basement area, excluding the vault area, is served by an independent portion of the PF-4 ventilation system.

The primary function of Zone 2A, the next higher ventilation protection level, is to provide makeup air to the main-floor laboratories; this zone incorporates the corridors that connect the laboratory areas on the main floor, the mezzanine space and offices, stairwells, and airlocks. Recirculation within laboratory rooms and the vault storage rooms is provided by the Zone 2 system. Zone 2 vault rooms also receive makeup air as a result on infiltration from the basement. Finally, areas having the highest potential for the spread of contamination are ventilated by the Zone 1 system. Zone 1 areas include the conveyor system, glove boxes, and hood enclosures containing plutonium, uranium and americium.

Zone 1 areas are maintained at a differential pressure equivalent to about -0.8 in. water column measured with respect to the outside air. Lesser levels of protection are provided, in decreasing order, by Zones 2, 2A, and 3. These zones are maintained at differential pressures equivalent to approximately -0.2, -0.15, and -0.1 in. water column, respectively, referenced to outside air pressure at 0.0 in. water column.

As was previously shown on Figure 1, the main floor of building PF-4 is divided into 4 separate processing areas designated as the 100, 200, 300, and 400 Areas. Each of these areas have their own independent Zone 1 and Zone 2 recirculation systems. There are two Zone 2 bleed-off systems, one used to support the 100 and 200 laboratory areas, the other used to support the 300 and 400 areas. In addition, separate Zone 2A and Zone 3 systems service the north (100 and 200 Areas) and south (300 and 400 Areas) halves of the building.

The PF-4 ventilation system is designed to provide approximately 7 air changes per hour of fresh or recycled air to all occupied laboratory spaces and 0.66 air changes per hour to the basement. The ventilation system also utilizes heaters in order to provide temperature control for Zones 2 and 2A to provide for personnel comfort. Details of how normal operation functions are provided by various zone equipment are discussed below.

General Overview of Zone 3 Configuration. Both the north and south independent Zone 3 ventilation systems are comprised of 3 types of equipment units, an outside-air intake unit, several recirculation units, and an exhaust unit. These 3 types of units are operated so that the basement of PF-4 is maintained at a differential pressure of -0.1 in. water column in relation to the outside air. This negative pressure differential ensures that leakage flow into the basement is typically from the outside. Loss of PF-4 ventilation results in a rapid equalization of internal building pressure with outside pressure.

Zone 3 ventilation provides a source of input (non-leakage) air for the entire PF-4 building through several different paths. For example, basement air is provided into the Zone 1 supply units. Also, air for the north-side vault infiltrates into storage rooms from the north side of the basement. In addition, air is recirculated through the basement as well as through electrical equipment rooms prior to being exhausted out of the building. Because materials are being stored in and transferred in/out of PF-4 through basement areas, the basement may be a contamination path to the environment, even though it is considered the region least likely to be contaminated.

- **Zone 3 Air Supply.** During normal operating conditions, outside air is supplied to the basement at a constant and fixed flow rate sufficient to provide approximately 0.66 changes of air per hour. This input air is drawn through Outside Air Intake Stacks where hot-water preheat coils and dampers are used to adjust the air temperature before it enters the building.

Prior to entering the Basement Intake Units, input air passes through pneumatic butterfly damper valves located in the inlet plenum to the Zone 3 intake units. The temperature of the inlet air is measured at the inlet of the Basement Intake Units. If the inlet air temperature reaches 38 deg F, the FOC receives a warning alarm. If the temperature continues to drop to 35 deg F, the FOC receives a second alarm. The purpose of the second alarm is used to indicate a condition that requires immediate personnel action to prevent the freezing of water in the intake unit cooling coils. Note that no automatic actions will occur in response to either of the two alarms.

At any time, local adjustments can be made to the rate of outside air intake via the butterfly-control dampers. The Zone 3 exhaust unit variable-frequency drive fans are also used to compensate for these local air intake adjustments, as well as normal fluctuations in basement air pressure conditions.

Each Basement Intake Unit, which serves one-half of the basement, consists of a prefilter, a single-stage High-Efficiency Particulate Air (HEPA) filter, a cooling coil, and a fan.

- **Zone 3 Recirculation.** Each side of the PF-4 basement incorporates units that recirculate air through the basement open areas as well as through electrical equipment rooms. There are 3 Basement Air Recirculation Units, 1 Switchgear Room Recirculation Unit, and 2 Vault Recirculation Units in the north portion of PF-4, while there are 2 Basement Air Recirculation Units and 1 Switchgear Room Recirculation Unit in the south portion of PF-4. These Basement Air and Switchgear Room Recirculation Units are discussed below, while the Vault Recirculation Units are described in a later subsection.

The 5 Zone 3 Basement Air Recirculation Units are manually balanced prior to facility operation. These units are continuously operated unless locally de-energized or automatically shut down by the fire detection system.

Although the 5 Basement Air Recirculation Units are identical, their functions differ slightly for the 2 building halves. The 2 south side units maintain the required air-exchange rate for open areas, whereas the 3 north-side units must maintain exchange for open areas as well as for electrical equipment room 15. Each Basement Air Recirculating Unit consists of a series arrangement of a fiberglass replaceable media pre-filter, a heating coil, a cooling coil, and a fan. The heating and cooling coils are used to control basement temperature. Basement air flow is balanced between the Switchgear Room Recirculation Units and the Basement Air Recirculation Units.

The 2 Switchgear Recirculation Units, each of which serve one room in each basement half, consist of a fiberglass replaceable media pre-filter, a cooling coil, and fan. Because of the heat load generated by the electrical equipment in each switchgear room, heating coils are not required.

- **Zone 3 Exhaust.** The Zone 3 Exhaust Units are used to compensate for basement air intake over-adjustments as well as for normal fluctuations in basement air pressure conditions. Originally, the proper nominal differential pressure between the basement and the outside was maintained via automatic adjustment of variable inlet vanes on the 2 Zone 3 exhaust fans. However, these 2 exhaust fans, FA-828 and FA-829, are now controlled by variable-frequency drives. Because these variable-frequency drives are used to make necessary differential pressure adjustments, the exhaust fan variable inlet vanes have been disconnected from their control circuits and permanently left in the open position.

In addition to a set of two HEPA filter banks, the Basement Exhaust Unit for each basement side incorporates a prefilter, a moisture eliminator, a fire screen, and an exhaust fan. The prefilter-moisture eliminator and the first exhaust HEPA bank are protected by fire protection sprays.

Prior to entering each non-redundant Basement Exhaust Unit, the temperature of the basement exhaust air temperature is measured. If this temperature exceeds a nominal temperature of 140 deg F, the FOC receives an alarm. If the temperature subsequently

reaches 190 deg F, the fire sprinklers in the affected unit are automatically actuated. The Zone 3 exhaust air passes through two sets of HEPA filters prior to being released to the outside.

General Overview of Zone 2A Configuration. The purpose of the Zone 2A system is to provide a supply of air to the building corridors, the stairwell airlocks between the basement and laboratory floor, and mezzanine areas. In addition, the Zone 2A system provides most of the makeup air supply to the laboratory areas via open laboratory doors or by infiltration around laboratory doorways. The Zone 2A air is supplied at a differential pressure equivalent to approximately -0.15 in of water column with respect to the outside air. The Zone 2A pressure is less negative than the Zone 2 pressure but more negative than the Zone 3 pressure.

- **Zone 2A Air Supply.** The Zone 2A supply subsystem consists of a separate supply unit for each half of the building. As was previously noted, the ventilation zone supplies the corridor areas, mezzanine rooms, and stairwells with a constant flow of air. When the laboratory doors are closed, the Zone 2A subsystem maintains the corridors at a pressure differential of approximately +0.05 in of water column with respect to the laboratory areas. This pressure differential disappears locally as a laboratory door is opened.

The Zone 2A corridor dampers PDV-801A, B (north side) and PDV-851A, B (south side) are permanently closed with their air supplies disconnected. In addition, steel plates have been welded in the duct work to block all air flow in paths containing these dampers. Closure of these paths was necessary to establish proper facility ventilation flows and air balances.

Air for each supply unit is drawn from the outside air intakes where hot water preheat coils and dampers are used to adjust the air temperature as it enters the building. This air then passes through an air-actuated and a back draft damper prior to entering the Zone 2A supply units. Redundant low-temperature switches also measure supply-unit air temperatures. If the inlet air temperature reaches 38 deg F, the FOC receives a warning alarm. If the temperature continues to drop to 35 deg F, the FOC receives a second alarm. The purpose of the second alarm is used to indicate a condition that requires immediate personnel action to prevent the freezing of water in the intake unit cooling coils. Note that no automatic actions will occur in response to either of the two alarms

Each of the two Zone 2A Supply Units (intake corridor units) consists of an air actuated-dampere, a prefilter, a single bank of HEPA filters, a cooling coil, and two fans. The two fans in each unit are redundant; one operates while the second remains on standby. Reheating coils are installed in portions of the Zone 2A ductwork to maintain temperature control; this temperature adjustment capability is provided only for personnel comfort.

The butterfly damper valves located in the inlet plenum to the 2A intake units have emergency air tanks. These emergency air tanks will provide motive power to close the valves in the event of a loss of instrument air pressure.

- **Zone 2A Exhaust.** Air from the Zone 2A supply units is ducted into the service areas located above each corridor and into mezzanines, and stairwells. Continuous flow along the length of the corridors is achieved via the use of diffusers located along the hallways and mezzanines. Air provided by the Zone 2A intake corridor units ultimately passes into the Zone 2 ventilation system through leakage into the laboratory areas via

open doors or infiltration around doorways. The design of this once-through Zone 2A subsystem does not provide for direct return or exhaust of air from the corridor, stairwell, or mezzanine areas. Consequently, air flow from this subsystem is always directed into the laboratory areas.

General Overview of Zone 2 Configuration. The purpose of the Zone 2 subsystem is to provide recirculation for air inside the 100, 200, 300, and 400 Areas located on the main floor. A bleed-off portion of this subsystem is used to maintain a nominal pressure differential of approximately -0.20 in. of water column between the compartments and the outside air. While one bleed-off unit is provided for each half of the building, each of the four areas has its own dedicated set of two recirculation units. In addition, the vault area has its own recirculation units that are located in the north half of the building.

- **Zone 2 Air Supply.** As was previously discussed, Zone 2A air from the corridors passes into the Zone 2 ventilation system through leakage into the laboratory areas via open doors and infiltration around doorways. With all of the laboratory doors closed, the pressure difference between the laboratory and corridor areas is approximately -0.05 in. of water column. Though this pressure difference becomes much smaller as a door is opened, airflow is still maintained into the laboratory. This air flow from the Zone 2A system represents most of the Zone 2 air supply.

When the laboratory doors are closed, a relative pressure difference of .05 in water column exists between the corridors and laboratory areas. The zone 2 ventilation system is designed to allow for manual adjustments of air flow rates in the event a laboratory door is kept open for an extended interval of time. This adjustment is accomplished using a manually-operated damper located in the supply duct in each of the laboratories. A manual valve is used to adjust local air flow if necessary.

Finally, note that the Zone 2 basement vault rooms also receive makeup air from Zone 3 via infiltration from the basement.

- **Zone 2 Recirculation.** Each of the 4 areas (the 100, 200, 300, and 400 Areas) in Zone 2 has two Recirculating Units that are interconnected by ductwork. These units provide a flow through the main floor areas equivalent to approximately 7 air changes per hour. Both Recirculating Units dedicated to a given area normally operate in parallel at approximately 50% capacity each. If one of the operating Zone 2 Recirculating Units fail, the ventilation rate reduces, but can still be maintained at approximately 60% of the design rate. For these situations, ventilation recirculation is still maintained to all rooms of the building areas, even though the flow rate is reduced. Additionally, the relative pressure level of the area is still maintained. The supply systems are designed for continuity of operation, but manual dampers are installed in laboratory-room ductwork so that a room can be isolated in the event of accident or fire conditions.

Prior to operation, the Zone 2 Recirculating Units are manually balanced to provide approximately seven air changes per hour to their respective areas and to maintain proper negative pressure in the areas as discussed below. Bleed-off units remove air through the compartment supply duct via a modulating damper.

Each Recirculating Unit consists of a prefilter, a moisture eliminator, two stages of HEPA filters, a cooling coil that is positioned between the two HEPA filters, and a fan. The prefilter-moisture eliminator and the first exhaust HEPA bank are protected by fire protection sprays. Additionally, reheat coils in the room supply branches of the ventilation duct are used to maintain individual temperature controls in the laboratory rooms.

The Zone 2 recirculation system provides a flow through the building areas equivalent to approximately 7.5 air changes per hour. A portion of the Zone 2 air is removed from the discharge of the recirculation units to the Zone 2 bleed-off subsystem described below. Modulating dampers installed between the recirculation units and bleed-off units are used to maintain the appropriate compartment pressure conditions. The fan discharge paths on the Zone 2 Area recirculating units have parallel blade dampers that fail open upon the loss of instrument air pressure.

- **Zone 2 Bleed-Off Exhaust.** The Zone 2 bleed-off exhaust system provides a means to maintain desired pressure levels in the laboratory rooms. This pressure control is accomplished by removing air from the Zone 2 recirculation system as necessary out the facility exhaust stacks. There is one bleed-off system for each of the building halves.

The Zone 2 bleed-off system for each building half consists of 2 filter plenums that are connected to 3 fans. Each of the the 2 filter plenums consists of a prefilter, a moisture eliminator, two stages of HEPA filters, a fire screen, and a fan having a volume-control inlet vane. The prefilter-moisture eliminator and the first exhaust HEPA bank are protected by fire protection sprays. The third fan is cross-connected to the output of the two filter plenums.

There is an air-operated isolation damper upstream of each filter plenum. The downstream side of each plenum is cross-connected to its redundant unit via two air-operated dampers. This filter plenum cross-connection is subsequently connected to the three bleed-off fan units. The inlet to each fans has a series arrangement of a manual and air-operated isolation damper.

Dampers used in the Zone 2 Bleed-off Units are designed to fail in the open position in response to a loss of instrument air pressure. These dampers include the variable fan inlet dampers and the parallel blade dampers in the upstream side of each filter plenum.

Each of the three Zone 2 bleed-off unit fans has sufficient capacity to provide the required bleed-off flow so that proper pressure conditions are maintained in the laboratories.

The Zone 2 bleed-off fans utilize variable-volume inlet vanes to maintain the bleed-off duct at a nominal differential pressure of -0.6 in. of water column with respect to the outside air. A nominal pressure differential of -0.2 in of water column is maintained between the compartment air and the outside air by the use of modulating dampers located between the compartment air supplies and bleed-off units. Pairs of redundant bleed-off units are provided so that one unit can serve as a standby to the operating unit. Each bleed-off unit has a dedicated exhaust fan. Should the operating unit fail to maintain pressure at -0.6 in. of water column, an automatic signal will start the standby unit. Because these bleed-off units are critical to maintaining proper building pressure conditions, a third fan is available in case the two unit-dedicated fans become unavailable.

The following sources of air are input into the north side bleed-off system: vacuum pumps discharge, Zone 2 bleed-off fan room, laboratory fume exhaust hoods, battery exhaust (from electrical equipment room 15), PU-238 process exhaust filter room, and PU-239 process exhaust filter room.

The following sources of air are input into the south side bleed-off system: vacuum pumps discharge, Zone 2 bleed-off fan room (room no. 40), recycle exhaust filter room, special recovery/metal fabrication exhaust filter room, and laboratory fume exhaust hoods.

General Overview of Zone 1 Configuration. The purpose of the Zone 1 system is to provide a once-through ventilation of normally-contaminated areas, such as the process glove boxes and their material-feed conveyors and drop boxes. Separate Zone 1 subsystems are provided for each of the four Areas located on the main floor. Each of these four Zone 1 subsystems includes an air supply unit and two process exhaust units as described in the following sections.

- **Zone 1 Air Supply.** The purpose of the Zone 1 system is to provide once-through ventilation to the glove box and conveyor enclosures. Equipment in Zone 1 has the greatest potential for accidental release of radioactive material. Therefore, Zone 1 is maintained at the highest negative pressure differential with respect to the outside atmosphere. Air supplied to the Zone 1 system passes through HEPA filter banks before being discharged from the building via the exhaust stacks.

Input air for all 4 Zone 1 supply units is drawn directly from the basement. This air then passes through a single prefilter, a fan, a drier, an air-operated damper, and finally, two parallel single-stage HEPA filters prior to being discharged into conveyor tunnels. Note that the main tunnel as well as glove boxes in the 400 (wet chemistry) compartment do(es) not use dry air.

Supply air for the zone 1 conveyor enclosures is drawn from the basement. Each conveyor enclosure supply duct has a control damper that is manually fixed to provide the required nominal -0.6 inches of water column relative to the compartment. Should the conveyor pressure increase, a limit switch will shut off the conveyor tunnel air supply fan and sound an alarm.

The supply fan in a given unit automatically stops when a differential pressure between the conveyor and laboratory areas rises to approximately 0.0 in. of water column; the fan automatically restarts when the conveyor pressure drops to nominally -0.55 of water column less than the laboratory pressure. The 100, 200, and 300 Area air dryers, manufactured by Lectrodryer, use molecular sieve units to dry glove box supply air to a nominal -70 deg F dew point. At one time, dampers could be used to regulate air flow around the supply fans and dryers, but the pneumatic controls for these dampers have been disconnected.

After air passes through these two parallel single-stage HEPA filters, it is discharged from the Zone 1 supply units is introduced into conveyor tunnels that are used to route air into drop boxes that are then connected into associated glove box supply lines.

A damper separates each drop box from its air source conveyor tunnel. This normally-open damper automatically closes in response to manual actuation of a push button or as a result of a high temperature in an individual glove box.

Any time that a Zone 1 fan starts, the FOC control system sends an "open" signal to all four of the valves connected to the Outside Air (OSA) Intake. These valves are HCV-832 (north side Zone 2A intake), HCV-833 (north side Zone 3 intake), HCV-882 (south side Zone 2A intake), and HCV-883 (south side Zone 3 intake). Note that these valves cannot be closed by the facility control system. Rather, they fail closed upon loss of instrument air pressure as described later in this Section.

- **Zone 1 Exhaust.** After air passes through an individual glove box, it exits each glove box via an exhaust duct containing at least one, and sometimes two HEPA filters. A manually-positioned butterfly valve is also located in the exhaust duct from each glove box so that this pressure differential can be maintained and yet at the same time allow for the required glove box air flow rates. Groups of glove boxes used to perform operations involving liquids share a common vertically-mounted moisture eliminator to maintain dry conditions in the Zone 1 exhaust. Liquid levels in these moisture eliminators are monitored by visual inspections of a level-gauge. Glove box exhaust is subsequently routed to Zone 1 process exhaust units that ultimately discharge the air outside the building.

With the exception of the special recovery room, each Exhaust Unit consists of a cool down box that contains a series arrangement of a prefilter, a moisture eliminator, a set of HEPA filter banks, a fire screen, and an exhaust fan. Four HEPA filter banks are used for the 200 Area (compartment) operations, while three HEPA filter banks are used to filter exhaust from the other areas. Modulating dampers, located at the output of the exhaust units, maintain the exhaust systems at a nominal pressure differential of -2.0 in. of water column with respect to the associated compartment. Dampers located in the plenum inlet and fan discharge of the Zone 1 exhaust units have emergency air tanks. These emergency air tanks will provide motive power to open the valves in the event of a loss of instrument air pressure.

Glove Box, Transfer Box, and Chemical Hood Ventilation Details. The following paragraphs provide additional details related to the ventilation used in glove boxes, transfer boxes, and chemical hoods.

- **Glove Box Ventilation.** Four different types of atmospheres are provided in the various glove boxes, depending upon the specific process requirements. These four atmosphere types are: high-purity argon or helium, low-purity argon and nitrogen, dry air, and room air. High-purity argon or helium atmosphere is used in glove boxes where oxygen, nitrogen, and water vapor levels must be maintained at less than approximately 10 ppm. The high-purity atmosphere used in these glove boxes is recirculated. In contrast, other glove boxes can tolerate nominal oxygen levels as high as 5%. These glove boxes are provided with low-purity argon and nitrogen once-through flushing atmospheres. Operations in other glove boxes can utilize dry atmospheric oxygen that is drawn from the basement and then passed through the previously discussed Lector dryer units. Finally, note that operations in some glove boxes can be accomplished with ordinary ambient air.

Inlet air for glove boxes can be supplied by either the glove box line entrance trolley and/or by a separate HEPA-filtered inlet line originating from the Zone 1 air inlet ducting.

Even though portions of Zone 1 ventilation operate with recirculating atmospheres, Zone 1 ventilation is generally designed to be a once-through system. Sets of Zone 1 glove boxes, fed by either of the independent north or south conveyor tunnels, have 2 exhaust systems; one set is operational and the other remains in standby. The standby systems are automatically controlled and energized in the event of failure of the operating system, whereas the failed unit must be manually shut down. Zone 1 exhaust unit 100% redundancy is justified because continuity of operation is critical.

During normal operations, the glove boxes and conveyor enclosures are maintained at -0.6 in. of water column relative to the laboratory in which they are located. A 2 inch

manually-positioned butterfly valve, located in the exhaust duct from each glove box, maintains this pressure differential while simultaneously allowing for the required glove box air flow rates. Operations with the inerted high-purity argon or helium glove boxes are performed with the 2 inch manually-positioned butterfly exhaust valves in the fully open position.

An additional pressure control (relief) device is installed in the exhaust air line of each inerted glove box to maintain a static pressure seal. These pressure relief devices, called "bubblers," are glass containers that are partially filled with DUO Seal mechanical vacuum pump oil. Silicone-based oil was originally used in these bubblers, but this oil was replaced because radiation was causing the oil molecules to break up. Glove box-to-exhaust relative pressure is manually maintained by either changing input gas flow rate or by changing the bubbler plunger position. Relative pressure is indicated by Magna Helix needle-indicator pressure gauge mounted on the front of the boxes; no other annunciator alarms excessive glove box pressure.

- **Transfer Box and Chemical Hood Ventilation.** Inlet air for transfer boxes and hoods are provided by infiltration from laboratory rooms. In general, hood atmospheres are exhausted through a HEPA filter into the Zone 2 recirculation ducting and transfer box atmospheres are filtered and exhausted into either the Zone 1 exhaust ducting or into the Zone 2 recirculation ducting. However, to prevent the potential spread of fumes into laboratory rooms, exhausts for transfer boxes and hoods where chemicals are used or stored are passed through HEPA filters and subsequently discharged into the Zone 2 bleed-off system, rather than into the Zone 2 recirculation system.

Special Area Ventilation. The following discussion provides additional details on the ventilation to unique rooms, such as the Storage Vault, the Decontamination Room, the Special Recovery Room, and the PF-4 control room (the FOC).

- **Vault Storage Area Ventilation.** Zone 2 recirculating units are used to ventilate the vault storage area. In addition, basement air directly infiltrates into the vault. Also, a small quantity of basement air is drawn through a single-layer HEPA filter and into the input of the vault recirculation system. The vault recirculating units are described below.

As is shown in Figure 4.2.1-2, two dedicated, continuously running, nominal 100% capacity units located in the north half of the basement provide recirculation to the vault area. Each of these vault-recirculation units consists of prefilter-moisture eliminator, two stages of HEPA filters, a cooling coil located between the two HEPA filters, and an inlet-vane fan having a damper at its exit.

The supply duct that connects the vault-recirculating units to the vault contains a common reheat coil that is used to maintain desired temperature level. A portion of the air that exits this heating coil flows through a proportional diaphragm valve and then into the Zone 2 bleed-off system, while the remainder flows into the basement vault rooms.

The fan discharge paths on the Zone 2 vault recirculating units have parallel blade dampers that fail open in response to the loss of instrument air pressure.

With the exception of Rooms 26 and 31, vault room air is exhausted directly into the Zone 2 Vault Recirculating Units described above. Air exhausted from Vault Rooms 26 and 31 is filtered through single-stage HEPA filters before flowing into the Zone 2 bleed-off units because these two rooms contain plutonium solutions.

During operation, one of the vault recirculation units is running, while the other unit remains on automatic standby. The operating unit draws a constant amount of air from the basement. A pressure differential of -0.05 in. of water between the vault and basement is maintained by the automatic control of a bleed-off damper that routes a portion of the vault air to the north half Zone 2 bleed off system.

- **Decontamination Room.** Air is supplied from the 200 Area Zone 2 recirculation system into transfer boxes XB-219 and XB-220 located in Decontamination Room 212. A manual valve is located on the inlet to both of these transfer boxes. Air is exhausted from these transfer boxes through parallel paths containing a single-stage HEPA filter and a manual valve directly to the north half Zone 2 bleed-off system. Because only one transfer box may be used at a time, only one set of inlet/exhaust valves may be open at any time.
- **Special Recovery Room.** The special recovery exhaust system provides a separate filtering arrangement for the special recovery operations. As is shown on Figure 4.2.1-3, exhaust air from Zone 1 certain Zone 1 special recovery equipment items is filtered by two redundant units, called Special Recovery Room Exhaust Units. Each of these two units consists of a series arrangement of three HEPA filter banks and a fire screen. Zone 1 exhaust from this laboratory region is discharged to the South side facility exhaust stack via two redundant filter plenums.

When operation of a special recovery room exhaust system unit is initiated, its associated discharge control damper (PDV-890 or PDV-891) is opened. Should an operating unit be subsequently shut down, its associated control damper closes automatically and operation of the standby exhaust unit is initiated. Once the special recovery equipment exhaust has been filtered by this dedicated filter system, it is subsequently combined with exhaust from the 300 Area Zone 1 exhaust units and ultimately discharged outside the building.

- **Assembly Room.** Air is supplied to Assembly Room 317 from the 300 Area Zone 2 recirculation system. As is shown on Figure 4.2.1-3, this supply air passes through a fan, a drier, a air-operated damper, and finally, two parallel single-stage HEPA filters prior to being discharged into laboratory Room 317. Room 317 air then infiltrates directly with no additional filtration into Assembly Box, XB-309. Air from assembly box XB-309 air is discharged through a single HEPA filter before it is subsequently exhausted into the south half Zone 2 bleed-off system.
- **Facility Operations Center.** The FOC is provided with a separate air conditioning system that includes humidity control. This system, which is contained in a hardened enclosure, includes two nominally 100% capacity fans. In the event that the main refrigeration plant fails, the system can be switched to 100% outside air.

Details of Ventilation System Equipment. The following sections provide information concerning selected items of ventilation system equipment, specifically HEPA filters, building intakes and outlets, dampers, and valves.

- **HEPA Filters.** The Zone 2 recirculating ventilation systems utilize a series arrangement of two filter banks located in basement plenum units. Each of these filter banks consists of 21 standard, fire-retardant, 24"x24" HEPA filters mounted in plywood frames. When new and clean, these filters are nominally rated at 1,250 scfm with a pressure drop equivalent to 1 in. of water column.

- **Building Intakes and Outlets.** All the ventilation openings to the outside are protected against tornado conditions. Each of the building air intakes and outlets is separated from the outside air by HEPA filters. A single set of HEPA filters is included in the air intakes to protect against the possibility of an air back-flow condition. Two HEPA filters in series are used to filter the exhaust air from Zones 2 and 3, whereas 3 or 4 (depending on the Area) HEPAs filter Zone 1 exhaust air.

The two air intakes are located on the west side of the building. In addition, one of the two exhaust stacks are located on the north side of the building, while the other is located on the south side of the building. Concrete areaways are used to protect the air intake and exhaust openings from tornado borne missiles. Restriction orifices are used to protect the HEPA filters from tornado-induced pressure differentials. These orifices, which consist of manually set dampers, are adjusted for a pressure drop of 0.75 in. of water column during normal operating conditions. If it becomes necessary to completely isolate the building intake or exhaust paths, manual-operated doors to these paths can be closed.

- **Dampers/Valves.** Standard butterfly dampers and double panel louvers with opposed blades are the major types of dampers used in the ventilation systems. The butterfly dampers are used in round ducts, whereas the double panel louvers are used in rectangular ducts.

With regard to the double panel louvers, opposed blade types were selected because they have superior control characteristics compared with parallel blade types of louvers.

The dampers were designed to minimize the leakage around shafts. In addition, the dampers were also designed to minimize potential hysteresis effects to enhance ventilation system operation and control.

Dampers used in the Zone 2 bleed-off units are designed to fail in the open position in response to the loss of instrument air pressure. These dampers include the variable fan inlet dampers and the parallel blade dampers in the upstream side of each filter plenum.

The butterfly valves located in the inlet plenum to the Zone 3 and 2A intake units are designed to be forced closed with air stored in emergency air tanks in response to the loss of facility instrument air pressure.

Major butterfly valves located in the main Zone 1 exhaust units are designed to be forced open with air stored in emergency air tanks in response to the loss of facility instrument air pressure.

Ventilation System Response to Selected Challenges. This section details ventilation-system response to various challenges and hardware failures. Included are descriptions of equipment failure modes.

- **Loss of Facility Electrical Power (Safe Shutdown).** A discussion is given below that describes the sequence of events that occur in response to a prolonged loss of incoming AC electrical power to the facility. In response to this type of event, the ventilation system is designed to achieve a "safe shutdown" configuration. In the discussion that follows, it is assumed that the onsite auxiliary generator would not be used to provide backup power to the facility. This assumption is based on the fact that a number of time consuming manual actions would have to be accomplished before the diesel generator could be connected to necessary loads. In addition, it appears that there is no intent on the part of facility management to use this generator during power outages.

Immediately after power is lost to the facility, a number of major equipment items stop operating, including the ventilation fans and air compressors. At the same time, the SCADA system responds to the power loss by commanding the ventilation valves and dampers to close, except for outside air intake isolation valves HCV-832, HCV-833, HCV-882, and HCV-883. The control system can only open, but not close, these four air intake valves.

Approximately 20 minutes after power has been lost, the instrument air pressure will drop from the normal operating range of 110-100 psi to a value below 85 psi. As the air pressure reaches 85 psi air pressure, the FOC computer system initiates actions to achieve a safe shutdown configuration of the ventilation system. To achieve the desired safe shutdown configuration, the FOC sends commands to re-open air-operated butterfly valves on the Zone 1 exhaust paths. Specifically, the following butterfly exhaust valves (18 total) are re-opened: HCV-816A, B; HCV-822A, B; HCV-865A, B; HCV-866A, B; HCV-872A, B; PDV-815A, B; PDV-821A, B; PDV-871-A, B; PDV-890, and PDV-891.

Each of the above air-operated butterfly exhaust valves has its own individual emergency air receiver tank. Air stored in these tanks is required to re-position the valves during the prolonged loss of normal power condition considered here or during other situations that result in loss of sufficient air pressure in the PF-4 instrument air header. Figure 4.2.1-4 displays a simplified schematic of the actuation system for these valves, including connections to the instrument air supply system, the emergency air receiver tank, and associated pilot and switching valves. After the instrument air pressure has dropped sufficiently, the spring-loaded pilot valve transfers position so that air from the emergency air tank is directed behind the actuator piston. At the same time, the switching valve transfers its position so that air can be exhausted from the front portion of the actuator piston. Air stored in the emergency air tank subsequently pushes the piston forward, thereby causing the valve to open. Note that a check valve is installed between the emergency air receiver tank and instrument air supply to prevent the bleed-off of air from the emergency air tank following loss of instrument air pressure.

Four normally-open air inlet butterfly valves must also be closed before the safe shutdown configuration has been completely achieved. These butterfly valves, HCV-832, HCV-833, HCV-882, and HCV-883 are connected to the Zone 2A or Zone 3 outside air intakes. These four valves are designed to fail closed on loss of instrument pressure. As was the case with the Zone 1 exhaust valves described above, emergency air tanks are used to provide a means to operate the air inlet valves following a loss of instrument air pressure. As is indicated in Figure 4.2.1-5, loss of instrument air pressure will cause the spring-loaded pilot valve to transfer position so that air from the emergency air tank is directed in the front of the actuator piston. The switching valve transfers its position so that air can be exhausted via the back of the piston. Subsequently, air from the emergency air tank pushes the piston backward, thereby causing the attached valve to close. Based on tests that have been performed at the facility, the two valves located on the North side of PF-4 (HCV-832 and HCV-833) will close when the instrument air pressure falls to approximately 60 psi. In contrast, the two valves located on the South side of PF-4 (HCV-882 and HCV-883) will close when the instrument air pressure reaches a much lower value, somewhere around 15-20 psi.

A facility safe shutdown test is performed once per year. During this test, it is possible to evaluate the failure response of the exhaust and intake valves identified above. Note

that it possible to remotely monitor the position of each of the inlet and exhaust valves via instrumentation that determines the positions of their associated valve shafts.

During the past 10 years, there have been approximately 20 safe shutdown events at PF-4. In the future, any loss of normal power initiator will lead to an administratively-required safe shutdown condition, even if power is recovered in time to prevent significant drops in the instrument air pressure. During this type of administrative safe shutdown, personnel from HS Division will automatically assume control of the facility. The HS Division personnel will work with NMT personnel to ensure that a formal and orderly process is followed to restore facility operation once power is restored. Note that current procedures require facility evacuation any time that power is lost.

- Outside Air Intake Coil Freeze-up. Instrumentation is used to monitor the temperature of the outside air that passes into the Zone 3 and 2A intake units. As previously noted, if the inlet air temperature reaches 38 deg F, the FOC receives a warning alarm. If the temperature continues to drop to 35 deg F, the FOC receives a second alarm. The purpose of the second alarm is used to indicate a condition that requires immediate personnel action to prevent the freezing of water in the affected intake unit cooling coils. Note that no automatic actions will occur in response to either of the two alarms.
- Fire Scenarios. Details of the maximum credible fires postulated fire accidents are discussed in Appendix VI of the original facility SAR (CMB-11, 1978).

In the event of a fire in the basement, an automatic action will occur to shut off the Zone 3 recirculation unit located within the affected area. This automatic action helps to ensure that the spread of smoke will be minimized. Should a fire threaten the HEPA filters or otherwise have the potential for loss of effluent control, local actions can be taken to close the basement intake and exhaust paths.

In the event of a fire in a laboratory room, an automatic sprinkler system will be actuated in the affected room. Air will drawn from the affected room into the Zone 2 recirculation subsystem. As this air passes through the recirculation units, quenching of the air will be accomplished if necessary by a water spray. The air will ultimately be recirculated back into the affected compartment, with automatic venting by the bleed-off system so that proper pressures are maintained in the compartment. Note that fire dampers are not used.

In case of glove box fire, a damper between the line drop box and the conveyor tunnel can be closed to prevent smoke or heat spread. Damper closure occurs when dc power is applied to a frangible link. Dc power can be manually applied to the link as a result of depressing a manual push button mounted to the drop box.

For fire protection purposes, the Zone 3 exhaust units, the Zone 2 recirculation units, the Zone 2 bleed-off units, and the Zone 1 exhaust units have automatically-actuated water sprays that for cooling the prefilters. Backup protection for the automatically-actuated prefilter sprays is provided by manually-controlled sprays that serve the first stage of HEPA filters.

The arrangement for fire water spray protection of the Zone 1 exhaust units is identical to the arrangement used for the Zone 2 exhaust units previously described. A FOC alarm is generated if the exhaust air reaches approximately 140 deg F. In addition, actuation of the automatically-controlled spray is initiated when the exhaust air reaches approximately 190 deg F.

- **Glove Failures.** A 2-man work rule is recommended, but not mandatory, for glove box operations so that contamination may be limited if a glove tears. In concept, if a glove tears, the operator should keep his hands inside the glove while his co-worker contacts a Radiation Control Technician (RCT). Subsequently, the RCT is responsible for monitoring and limiting contamination spread while the worker disengages from the torn glove.

4.2.1.3 System Interfaces/Support Systems. Several systems are required to support operation of the ventilation system. These support systems include electrical power, instrument air, heating/ventilation hot water, the central circulating chilled cooling water, and a variety of instrumentation and control equipment. In addition, the ventilation system has numerous interfaces with the fire detection and suppression system.

Electrical power is used to operate a number of ventilation equipment items, for example fans, air dryers, and miscellaneous control devices. The facility electrical power supply system is described in more detail in Section 4.2.2.

Instrument air is used to operate numerous ventilation dampers and valves. An overview of this system is provided in Section 4.2.8. Details on the emergency air supply tanks used to force butterfly valves to desired failure positions were previously provided in Section 4.2.1.2.

The heating/ventilation hot water and central circulating chilled cooling water systems are used to control the temperature of air provided in zones 2, 2A, and 3.

Information on the ventilation instrumentation and control system is described below in Section 4.2.1.4.

Finally, a brief discussion was previously provided in Section 4.2.1.2 regarding the ventilation system interface with the fire detection and suppression system. Additional details on the fire detection and suppression system are provided in section 4.2.4.

4.2.1.4 Instrumentation and Control. The following paragraphs provide information related to the instrumentation and control systems that are used to operate the ventilation system. Included are descriptions of pressure transmitters, damper control, fan modulation, local heating and ventilation panels, and air flow monitors.

- **Pressure Transmitters.** Differential pressure type transmitters are used to sense pressures. One side of each pressure transmitter is connected to one of three reference pressure headers. One of the reference pressure headers averages outside pressure. One of the two other reference headers averages pressures in the north laboratory compartments, while the other averages pressures in the south laboratory compartments. Note that both the Zone 2 and Zone 3 pressures are referenced to the outside air, while Zone 1 pressures are referenced to the associated laboratory area.

The differential transmitters utilize a 2-wire design, with electrical power provided via a central power supply into the appropriate control panel. The design criteria require that these transmitters remain operational following a design basis earthquake. To minimize the amplification of earthquake motion, the transmitters are mounted on rigid structural elements, for example pedestals, walls, and columns.

- **Damper Control.** Pneumatic operators are used to control the dampers that are modulated. These dampers receive positioning commands via pneumatic operators.

Because of the relatively small pressure drops across these dampers, only limited forces are required to move them. Local heating and ventilation panels, contain current-to-pressure converters that transform the 4-20 ma controller signals into corresponding 3-15 psig air pressure signals.

- **Fan Modulation.** Modulation of the Zone 3 basement exhaust units is accomplished by the use of variable frequency drive units that control the fan motors. These variable frequency drive units are controlled by differential pressure measurements between the basement and outside air as discussed above.

The Zone 2 bleed-off fans have variable vortex-inlet dampers that are modulated as necessary to maintain the desired level of differential pressure between the entrance to the bleed-off plenum and the outside air.

Modulation of the Zone 1 exhaust is accomplished by the use of fan bypass paths. These paths return air from the fan discharge outlets to the fan intakes. Control valves installed in these bypass paths are modulated to maintain the desired differential pressure between the fan intake paths and the outside air.

- **Local Heating and Ventilation Panels.** Fifteen local heating and ventilation panels are located in the basement so that the distribution of necessary wiring and tubing between panels and controlled equipment would be minimized. The panel enclosures protect various electrical instrument components from potential damage from potential wetting from firewater sprays or wash hoses.

Each of the local heating and ventilation panels is a free-standing Hoffman box mounted on a 6 in concrete pad. The gauges and indicators are installed on the rear portion of each box. Consequently, the rear portion of each box represents the front of the panel.

- **Air-Flow Monitoring.** PF-4 has 2 sets of exhaust-flow monitors that measure the exhaust flows from the three zones and the total exhaust flows from the two stacks. One set of monitor elements consist of averaging Pitot tubes. Electronic signals from these air monitors were originally intended to transmit flow indicator signals to local control panels and for control room display. However, positioning of these Pitot tubes resulted in questionable flow readings, so the first set of flow monitors are not used.

The second set of approximately 30 flow monitors is used only for monitoring; no alarms or annunciators are associated with their operation.

4.2.1.5 Surveillance/Maintenance. This section describes the surveillance, maintenance, testing, calibration, and inspection of various items of ventilation-related equipment.

Surveillance, Testing, Inspection, and Calibration Requirements. The following paragraphs describe surveillance, testing, and calibration requirements for various items of ventilation system equipment. Note that test procedures and design features allow operations to continue during testing and maintenance.

- **Overall Ventilation System Performance.** The ventilation system performance is monitored in the FOC via the data acquisition and control system. The ventilation system status is known at all times and changes are automatically recorded. The FOC is manned by operating personnel on a continuous basis (24 hours per day, 7 days per week).

- **Exhaust Filtration Surveillance.** Exhaust plenum differential pressure readings are monitored on a continuous basis by the FOC. Plenum flows, pressures, and temperatures are also continuously monitored. Differential pressure readings for individual filter banks in the exhaust plenums are taken on a bimonthly schedule.
- **Safe Shutdown Test.** As previously noted in Section 4.2.1.2, a ventilation system safe shutdown test is conducted annually. A checklist of dampers and valves used in conjunction with this type of test is given in (TA-55 Operations, 1992).
- **HEPA Filter and Pre-Filter Testing.** With the exception of the glove box exhaust filters, all HEPA filters have been quality assurance tested to a nominal design efficiency of 99.97% using an aerosol with particles having a mean size of 0.3 micrometer. In addition, these HEPA filters have been subjected to in-place testing with polydispersed aerosol droplets having mean diameters of 0.25 micrometer.

The HEPA filters are annually tested by introducing challenge aerosols into an injection port. Filter efficiency is determined by using a spectrometer to analyze air sampled from pertinent locations. A challenge test is also performed any time that a HEPA filter is replaced. Additional details of the testing procedure are provided in (SAIC, 1991).

Based on historical operating experience, most of the filter changes have involved replacement of the first stage banks only. Trending of flow resistance through filter banks to predict future filter failures has not been found to be useful. Actual filter failures experienced at the facility have involved sudden plugging of filters caused by the inadvertent introduction of chemical processing materials into the ventilation system. Instances of inadvertent plugging due to chemical contamination occur on a random basis.

- **Open-Front Box and Hood Testing.** An annual check is made of the face velocities of the open-front boxes and hoods by the Industrial Hygiene Group.
- **Calibration of Sensors and Transmitters.** Flow, pressure temperature, and delta-P sensors and transmitters are calibrated when installed or repaired.
- **Glove Inspection.** Facility process box gloves are inspected visually by the process operator. If the operator believes a glove may be close to the end of its useful life, he will label the glove as "worm" adding his initials and the date.
- **Daily Basement Equipment Inspections.** All HEPA filter cooling coils are inspected daily for leaks.

Maintenance. The following paragraphs describe maintenance activities associated with ventilation equipment:

- **Glove Box and Transfer Box Maintenance.** Even though glove box metallic interior surfaces are polished using buffers and wiped cleaned, the most common glove box maintenance is the replacement of gloves. Leaking or suspected glove boxes are routinely changed out every 18 to 24 months. After a glove has been replaced, a RCT visually inspects and measures a glove for radiation leakage.

Glove box window removal and replacement occurs primarily when boxes are being decommissioned and decontaminated, when new equipment is being installed, or when

seals are being replaced. Personnel are fully suited during these potentially hazardous processes.

- **Glove Box Bubbler Maintenance.** Bubbler oil has been replaced only for those bubblers that have lost oil volume because of either a leak or because of blow-out caused by an excessively pressurized glove box. In general, bubbler oil has darkened with use.
- **HEPA Filter Replacement.** HEPA filters are not replaced in accordance to a schedule, rather they are usually replaced when measured operational parameters, such as flow or pressure-drop, indicate the need for replacement. For normal situations where replacement is necessary due to particulate build-up, only the first of a series of HEPA filters is usually replaced. There are situations caused by water or oil saturation requires a series of filters to be replaced. For these situations, replacement order should correspond to the level of contamination, beginning with the least-contaminated filter and proceeding to the most contaminated filter.

4.2.1.6 Technical Safety Requirements Limitations. A set of limiting conditions for operation that pertain to the ventilation system and exhaust filtration are provided in (Oper. Safety, 1988). The limiting conditions given in this document are listed below, along with their corresponding bases.

Ventilation. This specification applies to PF-4 ventilation systems and ensures adequate ventilation for contamination control.

- **Specification for Zone 1.** At least one Zone 1 exhaust unit must be operational in each of the four areas (100, 200, 300, 400 Areas). If Zone 1 exhaust negative pressure is not maintained at a minimum of -1" water column then PF-4 automatically moves to "safe shutdown condition" and normal operations are terminated.
- **Specification for Zone 2/3.** At least one Zone 2 recirculation fan unit must be operational in each area within each section of PF-4 (north section includes 100, 200 areas; south section includes 300, 400 areas). If one fan cannot be kept operational in a given area, then normal operations are terminated in that section of PF-4.
- **Specification for box and hood face velocities.** Face velocities for open-front boxes and hoods are maintained at 125 linear feet per minute (lf pm) for radioactive operations and 100 lf pm for non radioactive operations. If the minimum face velocities are not met, then normal operations in the hood/open-front are terminated.
- **Basis for Above Specifications.** The ventilation system provides directional flow in operating areas, differential pressure between operating areas and glove boxes, and air flow of sufficient linear velocity in hoods and introductory boxes for contamination control. The above limiting conditions assure minimum safe operating conditions exist in PF-4.

Exhaust Filtration. This specification applies to the ventilation system exhaust filters installed to minimize radioactive material releases from PF-4. This specification ensures that adequate filtration is provided to reduce releases from PF-4 during routine operations and design bases accident conditions.

- **Specification.** Table 4.2.1-1 lists the minimum filtration installed:

Table 4.2.1-1

Location	Installed Filtration
100 Area/Zone 1	1 ss demister, 3 stages HEPA filter
200 Area/Zone 1	1 ss demister, 4 stages HEPA filter
300 Area/ Zone1	1 ss demister, 3 stages HEPA filter
400 Area/Zone 1	1 ss demister, 3 stages HEPA filter
North Zone 2 Bleedoff	1 ss demister, 2 stages HEPA filter
South Zone 2 Bleedoff	1 ss demister, 2 stages HEPA filter
North basement exhaust	1 prefilter, 2 stages HEPA filter
South basement exhaust	1 prefilter, 2 stages HEPA filter

If the above filtration cannot be maintained then normal operations are terminated and PF-4 is placed in a "safe shutdown condition."

A water column pressure of -2.0 in is maintained in the Zone 1 exhaust header ahead of the filtration listed above. If this pressure goes above the -2.0 in differential pressure level, the filters are replaced.

- Basis. The FSAR for PF-4 shows that this filtration is adequate to reduce releases from postulated accidental sources to levels less than the limits of (ALO, 1988).

4.2.2 Electrical System

An overview of the TA-55 electrical system is provided in the following sections. Included are a discussion of the system function and descriptions of the normal electrical service, the auxiliary diesel generator system, the PF-4 Uninterruptible Power Source (UPS), and the 125 Vdc switch gear control power system. Instrumentation and control, surveillance and maintenance, and operability requirements for the TA-55 electrical system are also discussed. Note that the numerical parameters discussed in this document are considered nominal; set points and other specifications actually fall within operational bands. A one-line electrical schematic diagram for TA-55 is shown in Figure 4.2.2-1, the TA-55 Electrical Distribution Overview Diagram.

4.2.2.1 Electrical System Function. The function of the TA-55 electrical system is to supply normal and emergency power at proper voltage levels to meet the electrical needs of the facility. Appropriate ac and dc power must be provided with suitable reliability to promote safe and reliable operation of the facility. Under abnormal or adverse conditions, the electrical system is configured to preferentially supply the high-priority (or critical) safety loads.

4.2.2.2 Overall Configuration. The TA-55 electrical system receives 13.2 kV power from two underground lines entering the basement of Building PF-4. The two switching stations in PF-4 power two secondary unit substations. These substations include appropriate transformers and switch gear sections to provide 480 Vac and 208/120 Vac power to most of the facility equipment and lighting. UPS EE617 provides continuous emergency power for critical loads. A 750 kVA auxiliary diesel generator is also available

in the event of normal power failure. The switch gear operate with 125 Vdc power provided by two battery banks located in the secondary unit substations in PF-4. These power distribution systems are described in detail in the following sections.

115 kV Power Distribution. The Los Alamos 115-kV system forms a three-node ring bus with nodes at the Eastern Technical Area (ETA), Technical Area -3 (switching station SM-23), and at Technical Area (TA)-53. The SM-23 switching station, located in TA-3, has both a 115-kV ring bus and a 13.2 kV ring bus that can be supplied power from either the ETA station (via the MP and LA lines) or from the TA-3, SM-22 power plant.

The 115-kV supply to the ETA switching station, which is constructed as a ring bus, comes over two separate lines: the RL line, owned by Public Service Company of New Mexico (PNM), and the NL line, owned by the DOE. The RL line feeds from the BA substation northeast of Bernalillo, and the NL line feeds from the Norton substation northwest of Santa Fe. 13.2 kV ac power for TA-55 is supplied via 115/13.2 kV step-down transformers and 13.2 kV feeder lines that originate from the TA-3 and the ETA switching stations.

13.2 kV Power Distribution. Two 13.2 kV feeders, designated EA-9 and S-10, are available to provide power for the entire TA-55 site including all items that require electrical power other than battery-operated systems. Power is routed through one of these 2 feeders while the other feeder remains in ready stand-by for use in the event of the failure of the active feeder.

The S-10 feeder connects directly from the TA-3 substation switch gear and travels 1.75 miles underground to a manhole at the southwest corner of PF-4, whereas the EA-9 feeder connects to the ETA substation switch gear and travels 1.5 miles underground to a manhole at the southwest corner of TA-55. Both feeders are routed through separate underground ducts to cable vaults located under the north and south switching stations in the basement of PF-4 and to the Utility Building, PF-6.

The PF-4 and the PF-6 switching stations consist of sections of metal-clad switch gear containing three 15 kV 1200A circuit breakers: an active feeder breaker, a stand-by feeder breaker, and a bus tie breaker and some 1200A bus ducting. Relaying and power instrumentation for these stations are located at the TA-3 and ETA switching stations. Because the stand-by line breaker is normally open and the tie breaker is normally closed, the active line circuit breaker feeds both 1200A switching-station buses. Each of these buses in turn provide power to two transformers located in both the north and the south secondary unit substations.

The status of the primary 13.2 kV electrical system is monitored in the FOC, but the 13.2 kV substation breakers cannot be operated using the Facility Control System (FCS). Breaker operation usually involves automatic relay switching as described below.

If low voltage conditions occur on the incoming active 13.2 kV source feeder so that voltage decreases below the setting of its under voltage relay, the source breaker opens. If the alternate (stand-by) line voltage is normal and in synchronization with the lost source voltage, an automatic closure of the alternate line breaker occurs. This sequence, called a high speed power transfer, should occur in approximately 12 cycles (0.2 seconds). The high speed transfer system is not controlled by the site computer system, rather it is hardwired within the switch gear system. The TA-55 site loses normal ac power an average of 2.6 times per year [Ref. Gordon Memo].

The transfer of the load from one power source to the other can also be performed by manually closing onto the alternate power source, opening the original power source, and then changing the preferred feeder switch. This parallel and disconnect operation, which is approved by NMT-8 but accomplished by ENG-5 personnel, is performed so that no load-power variation occurs. FOC personnel responses to any power outage or high speed power transfer is detailed in (TA-55 Operations, 1992).

480 V Power Distribution. This section describes the configuration of the TA-55 480 Vac system, excluding PF-8, the auxiliary generator building. A diagram of this system is given in Figure 4.2.2-2.

- Building PF-4. As discussed previously, power from the PF-4 north and south switching stations is delivered to the north and south secondary unit substations, EE-607 and EE-608, respectively. Each secondary unit substation consists of two 1500 kVA, 13.2 kV/277-480 V transformers with their disconnect switches and switch gear sections. This switch gear includes three (2 mains and a tie) 3000 A frame electrically operated low-voltage power circuit breakers and a combination of 600 A and 1600 A frame manually-operated 480Vac power active and spare circuit breakers.

Each PF-4 secondary unit substation transformer supplies one of 2 main buses, either Bus A or Bus B, that are separated by a normally-open tie breaker. Buses A and B supply power at 480V ac to the loads discussed below. In addition, feeders from the auxiliary generator connect to each Bus B in PF-4.

The PF-4 B buses supply power to six motor control centers: MCC EE-611, MCC EE-612, MCC EE-698A, MCC EE-698B, MCC EE-699A, and MCC EE-699B that in turn power the building high-priority loads. The North and South Emergency Motor Control Centers, MCC EE-611 and MCC EE-612, respectively, provide power to nearly all of the building's ventilation systems, the plant compressed air system, the fire protection system jockey pumps, UPS EE617, and other miscellaneous high priority loads. The other motor control centers are designated North Miscellaneous Equipment Motor Control Centers MCC EE-698A and MCC EE-698B and South Miscellaneous Equipment Motor Control Centers MCC EE-699A and MCC EE-699B. These motor control centers supply the remaining ventilation systems, the fire protection system electric pumps, building general lighting and convenience power systems, and general laboratory services, including the house vacuum, air sampling, and positive and negative pressure chilled water.

As shown in Figure 4.2.2-2, the PF-4 A buses provide power to various bus ducts. The bus ducts supply power to loads within individual laboratories to support process functions.

The secondary unit substation in the PF-6 Utility Building consists of two 1000 kVA 13.2 kV/277-480V transformers with their disconnect switches and switch gear sections. This switch gear includes three (2 mains and a tie) 3000 A frame electrically operated low-voltage power circuit breakers and a combination of 600 A and 1600 A frame manually-operated 480 Vac power active and spare circuit breakers. In addition, recent modifications included the addition of two 13.2 kV/277-480 V transformers and one 13.2 kV/120-208 V transformer off breaker 152-31.

The Utility Building switch gear serves the building heating and cooling equipment, motor control centers, and the east electric fire pump. Two Utility Building motor control centers, MCC EE-603C and MCC EE-603D provide power to the heating system boilers and pumps, the process steam system boiler, the chilled water system

pump, the Calcium Grinding Building, the east fire pump house, and the Utility Building's general lighting and convenience power.

208/120 V Power Distribution. The secondary power system for the site is three-phase 480 Vac provided by the A and B transformers in the PF-4 and PF-6 substations. As seen in Figure 4.2.2-2, 208/120 Vac power is provided primarily for control and power panel bus ducts by additional step-down transformers.

125 Vdc Power Distribution. The 125 Vdc power distribution system, which is used for breaker operation and auxiliary generator start up is discussed in this section.

- **Switch Gear Control Power.** 125 Vdc power is required for manual electrical operation of the 13.2kV breakers and for relay operation of the 13.2kV and 480 Vac switching and secondary unit station switch gear in PF-4, PF-6, and in PF-8.

Circuit-breaker switching power is provided to the PF-4 EE-604 and EE-607 substations by a dedicated station battery bank located in the north switching substation. Similarly, dc breaker control power for EE-605 and EE-608 are provided by a similar battery bank in the south switching substation. The south station also has one backup maintenance battery bank in case one of the primary banks fails or is out for maintenance. Each switching substation has a switch to change over to the maintenance battery bank.

The north station battery charger (EE-635) is powered off Lighting Panel B (EE-648), which in turn is powered from the North Miscellaneous Equipment MCC (MCC 698A). The south battery charger (EE-637) is powered from Power Panel PP (EE-641) connected to the South Emergency MCC (MCC 612). The maintenance battery charger is powered from Power Panel PD (EE-633), which is connected to the South Miscellaneous Equipment MCC (MCC EE-699A).

The PF-6 Utility Building 125 Vdc switchgear control power is provided by two battery banks. The primary battery bank is designated 5561; the backup battery bank is designated 5562. They consist of 20 three-cell lead acid batteries in series. Battery specific gravity, voltage, and temperature are monitored and logged monthly. The battery banks are also load tested. In addition, the local panel monitor lights indicate when these parameters fall out of range. Finally, the FOC receives a low input ac power and a low output dc voltage alarm if these fall below a pre-determined set point. The battery chargers for banks 5561 and 5562, designated CB-1 and CB-2, respectively, are both powered from Panel A, which is powered by MCC EE-603D.

The 3 PF-8 auxiliary generator electrically-operated breakers are switched by a station battery bank located in the Generator Building, EE-660 station. This station also has one backup battery bank in case the primary banks fails or is out for maintenance. In contrast to the other TA-55 breakers, the 2 generator bus duct normally open (NO) breakers can be cycled by the FOC.

- **Auxiliary Generator Starting Power.** The auxiliary generator has both a primary and backup starting battery located in the Generator Building PF-8 EE-660 station. Each bank provides the capacity for successive starting attempts without recharge. The auxiliary generator is also equipped with an air starter which receives compressed air off the main air header in PF-8. Backup compressed air is provided by pressurized cylinders.

Uninterruptible Power Supply. The PF-4 UPS (EE617) is designed to supply a continuous source of ac power to high-priority loads when normal power is lost or unstable. The following systems are connected to this UPS.

- The Facility Control System (FCS),
- the criticality alarm system,
- the emergency and local public address system,
- the Entry Control System (ECS) operating personnel accountability system,
- the complete heating and ventilation instrumentation system for PF-4,
- the air compressor system standby logic power source, and
- the standby PF-4 exhaust stack HSE sample pumps and Continuous Air Monitors (CAMs).

Details of the UPS system is shown in Figure 4.2.2-3. This UPS system consists of seven main sections: two battery chargers, two inverters, a three-position static semiconductor switch, an AC bypass switch, and a sixty-cell 1800 A-hr battery common to both 37.5 kVA rectifiers/chargers and inverter units (connected for redundant operation). The AT-3 bypass switch allows normal ac power to be supplied to external loads in case of maintenance or malfunction of the UPS. If the UPS output power is lost because of failure of the normally used semiconductor switch, the switch position changes first to the maintenance source and then to the third static semiconductor. After maintenance or loss of the normal static-switch semiconductor, the UPS has to be manually aligned with MCC EE611.

When normal or alternate ac power is available, the UPS battery chargers constantly float charge the battery bank while providing power to the inverters. On the loss of ac power, the inverter continues to provide ac power to the external load by automatically drawing energy from the battery bank. When normal ac power is restored, the battery chargers automatically resume providing power to the inverters. No switch-over time is required because the battery is constantly in the inverter power input circuit. Finally, the UPS battery bank is placed in a fenced enclosure that has natural circulation so that hydrogen buildup resulting from battery chemistry is avoided.

Normal ac power to the UPS is provided from the North Emergency Motor Control Center MCC EE-611. After a 3 minute timed delay, alternate UPS AC power is provided via Automatic Transfer Switch (ATS) AT-1 from the South Emergency Motor Control Center MCC EE-612. ATS re-positioning will continue with a 3 minute delay per transfer until power is provided to the UPS. If the B bus does not fail, power may be supplied by the auxiliary generator.

If both the south and north B Buses fail, UPS EE617 alternate ac power (20kW required) may be supplied from a trailer-mounted generator external to PF-4 via ATS AT-2. A trailer-mounted generator is presently not located at TA-55, but if necessary one could be made available.

Operation of the UPS on battery-supplied power alone will proceed until the dc bus drops below 105 Vdc, at which point the UPS automatically shuts down. Sustained operational time, without recharging, exceeds seven hours. If the UPS fails or shuts down so that ac power is lost to critical loads, building PF-4 must be evacuated. When the normal ac power is restored, the battery chargers automatically resume powering the inverters and recharge the battery.

Emergency Lighting. Emergency lighting is provided by individual battery pack halogen units that are distributed in laboratories, corridors, stairwells, and throughout the basement

in PF-4. These lighting units are designed to operate from a self-contained battery pack for more than 90 minutes in the event of a power loss, in accordance with NFPA 101. A monthly operability inspection is performed on each light. In addition, a standing work order is in place to annually test each light's duration of illumination. Units failing to meet the 90 minute requirement are replaced under the same work order.

Special Design Considerations. Because of the location and altitude of the TA-55 site, special design considerations are necessary both for lightning protection and for electrical equipment ratings. First, because of the high incidence of lightning in the Los Alamos area, all structures and exposed equipment are provided with industry standard lightning protection. Lightning arrestors that meet or exceed Underwriter's Laboratory and Lightning Protection Institute standards are also provided at line terminations and equipment to prevent damage due to voltage surges.

Furthermore, because the site altitude of approximately 7200 ft. exceeds the usual service conditions for most electrical equipment, the operational ratings of equipment that rely on air for insulation and heat dissipation must be decreased because of the reduction in the air dielectric strength and density. The rating of electrical equipment at Los Alamos has been suitably adjusted to compensate for operation at the site altitude.

4.2.2.3 System Interfaces/Support System. The TA-55 electrical system provides support to nearly every other major facility system. The details of electrical power support provided to other facility systems is included in the appropriate system descriptions and will not be repeated here.

The electrical power system depends on several of its own subsystems for support, as described below.

4.2.2.4 Instrumentation and Control. The following sections describe the control sequence for loss and recovery of normal power and the role of the FOC.

- **Loss and Recovery of Normal Electrical Power.** Loss of utility power results in a ventilation system outage initiated by a low-pressure alarm. Loss of normal power does not result in an automatic re-configuration of the ventilation system. Rather, after approximately 20 minutes, instrument air pressure drops low enough to initiate safe shutdown. This scenario is discussed in the ventilation system description. The following paragraphs discuss restoration of normal power following the loss of 13.2 kV power to PF-4.

As discussed previously, portions of or all of the PF-4 480 Vac bus loads may be powered from either of the A or B secondary unit transformers. As discussed in earlier sections, these loads may also be powered from the auxiliary generator, or from the PF-4 UPS. In contrast, the PF-6 Utility Building buses cannot be powered by the auxiliary generator.

Whenever normal power is restored, the PF-6 substation is restored first to assure that required chilled and hot water services are available. Because the 480 Vac bus breakers do not trip on under voltage, all loads are restored when the 13.2kV station breakers are closed. After PF-6 power is successfully restored, PF-4 power is restored as discussed below.

Whenever power is restored to PF-4 unit substations, the North Emergency MCC bus (bus B) is restored first since the PF-4 UPS and two instrument air compressors are

powered from this bus. Next, the South Emergency MCC bus (Bus B) is restored because it powers the last instrument air compressor. Again, because the 480 bus breakers do not trip on under voltage, all loads are restored when the 13.2kV station breakers are closed. After normal power is restored and after the instrument-air pressure reaches approximately 85 psig, the FCS automatically sequences the ventilation fans motors and dampers back to normal operating conditions and positions.

If site power can be restored but at least one of the Facility Control Computers cannot be restored, NMT-8 Facilities section personnel coordinate all PF-4 power restoration activities.

- Role of the FCS. The FCS is used to log facility data; to monitor the status of various equipment and systems; and to monitor fire, criticality, CAM, and hazardous gas alarms. This system is also used to cycle the two generator bus duct normally open (NO) breakers, to cycle failed and redundant ventilation-system equipment, to maintain interlock control, and to sequence ventilation fan motors and dampers.

Normal operations within PF-4 cannot be performed if the FCS is not functional. However, brief FCS outage periods are allowable based upon reliance on other systems such as ventilation, independent fire alarm [hardwired] to the Central Alarm Station, and the hardwired criticality system.

Any lost bus, tripped breaker, or computer-system malfunction which inhibits FCS status reporting must be promptly restored to normal. Both NMT-8 Facilities Section personnel and ENG-5 Area Coordinators are available to correct general electrical system and loss-of-system monitoring malfunctions. If the FCS is inoperative for more than one hour for any reason, including maintenance or testing, normal PF-4 operations are terminated and personnel must evacuate the building.

4.2.2.5 Surveillance/Maintenance. UPS routine maintenance is performed once per year.

The auxiliary generator is tested once per month as per the Monthly Generator Test procedure listed on pages 31 through 33 of the Facility Safety, Service, and Utility Systems section (MISC-91-067) of (Pred. Doc.).

4.2.2.6 Technical Safety Requirements Limitations. The following specification and basis is from (Oper. Safety, 1988). The specification applies to PF-4 UPS and ensures proper power supply to PF-4 critical systems.

Specification: The UPS provides power to critical systems and must be operable. Failure of the UPS results in loss of critical systems and the facility shall move to a safe shutdown condition and normal operations will be terminated.

Basis: UPS is essential for operation of the following systems:

- the complete facility control system (FCS),
- the complete criticality system,
- the complete emergency and local paging systems,
- the complete operating personnel accountability system,
- the control room telephones,
- the complete heating and ventilation instrumentation system for PF-4
- the air compressor system standby logic power source,
- the standby PF-4 exhaust stack HSE sample pumps, and

- the emergency generator system.

4.2.3 Glove Box Confinement Systems

The glove box confinement system at PF-4 is provided by the entire external structure of PF-4 and the ventilation system. Portions of the ventilation considered part of confinement system include portions of the Zone 1, 2, 2A, and 3 ventilation damper system that can isolate the building from the outside environment during emergency conditions.

4.2.3.1 System Function. The confinement system isolates Building PF-4 from the environment during emergency situations. PF-4 is designed to withstand the forces of a Design Basis Earthquake and all postulated facility fires without building failure or significant cracking. The ventilation system is designed to continue to operate through all maximum credible events including the DBE and hypothetical two-hour fire, and still release less than the allowable levels of contamination to the atmosphere.

Codes and Standards. The following list includes the referenced applicable codes and standards for the confinement system.

4.2.3.2 Overall Configuration. Operations involving SNM are carried out within glove boxes, while all areas outside of the glove boxes are normally free of contamination. Therefore, the glove box system and associated ventilation system represent the primary confinement for hazardous materials. As is described in more detail in Section 4.2.1, air flow to and from the glove boxes is provided by the Zone 1 portion of the ventilation system. The Zone 1 exhaust is also continuously monitored for contamination. A shutdown of the facility and Zone 1 will occur if a high radiation count is experienced with the Zone 1 exhaust. In addition, an immediate facility shutdown will occur if Zone 1 flow or negative pressure is lost.

Ventilation System. The ventilation system is described in detail in Section 4.2.1 of this report.

Glove Boxes . Wherever possible, standardized glove boxes are used in PF-4. The standardized glove boxes are constructed in single or multiple sections that are approximately 32 in wide and 30 deep at each glove port station. Single glove boxes have the glove and windows on only one side, whereas the double boxes have these items on both sides. Each end of the glove boxes has a standard connector ring that allows changing of glove box trains.

All glove boxes are constructed of stainless steel. To facilitate the cleanup of contamination that normally occurs in the glove boxes, all interior glove box welds are ground smooth to eliminate cracks or crevices that could trap contaminated material. In addition, protuberances inside the glove boxes are minimized, and all interior parts are readily accessible. The glove boxes are mounted on mild steel supports that are designed to meet Class 1 seismic criteria.

The glove boxes are lighted with fluorescent fixtures that hang above safety glass windows located on the top of each box. Leakage through the glove box seals associated with the windows, glove box penetrations, and air lock closures is limited to levels consistent with process requirements. Flexibility in operations is facilitated by the use of standardized connections for utilities, instrumentation, electrical, and service lines.

A 1/4 in thick layer of lead is encased in the walls of some glove boxes to provide gamma shielding. If additional x-ray or gamma shielding becomes necessary, neutron shielding panels and high-density lead glass panels can be positioned on the exterior of the glove boxes. The glove box windows are constructed from laminated safety plate glass. The size of the glove box windows is minimized. Metal fire shields located on the interior of the glove boxes are used to shield window seal gaskets so that burnout is retarded and windows retained in case gaskets lose their function.

Gravity-operated fire dampers separate glove box trains from each other. In addition, this type of dampers is used to separate glove box trains from associated drop boxes and conveyors. During normal operation, the dampers installed between the glove box lines and conveyors are open. In the event that a fire occurs, a frangible link is broken by a signal from the fire alarm system and automatically closes the affected damper(s).

The glove ports are welded to the metal structure of each glove box. The gloves are constructed of materials especially selected for their usage, often a lead-laminated rubber composite.

Depending on the specific process requirements, one of following types of atmosphere is used in the glove boxes:

- High-purity argon, hydrogen, or helium (a recirculating system),
- Low-purity argon (flush system),
- Dry air (flush system), and
- Room air (flush system).

Additional details on glove box ventilation are given in Section 4.2.1.2.

4.2.3.3 System Interfaces/Support Systems. The glove box confinement system interfaces with the ventilation system, and therefore requires support from the same systems as the ventilation system. These support systems include the instrument air, electrical, heating and ventilation hot water, central circulating chilled water, and the air sampling system.

4.2.3.4 Instrumentation and Control. The instrumentation and control for the ventilation system is described in Section 4.2.1.

4.2.3.5 Surveillance/Maintenance. An Annual Safe Shutdown Test which exercises many of the ventilation system components is described in (TA-55 Operations, 1992).

4.2.4 Fire Detection and Suppression System

The TA-55 fire detection and suppression system includes subsystems and components designed to prevent, suppress, and contain the SAR bounding accident fire. Portions of the fire service water system meet the seismic design criteria where such equipment is available. A centrally supervised alarm system is provided in the building, glove boxes, and ventilation systems. Sixteen firewater flow alarms are provided. Fire hose racks are located in the PF-4 corridor, and fire extinguisher stations are located in the PF-4 corridor and throughout the facility as required.

The following subsections provide information regarding the PF-4 fire detection and suppression system, including system function, overall configuration, support systems, instrumentation and control, surveillance and maintenance, and TSR limitations.

4.2.4.1 System Function. The function of the fire detection and suppression system is to automatically prevent, suppress, or contain a fire, whether internal or external, in compliance with the appropriate requirements of National Fire Protection Association (NFPA), Uniform Building Code (UBC), and Factory Mutual (FM). The minimum fire protection required for most areas in the facility is an ordinary hazard wet pipe automatic sprinkler system. The storage vault contains a dry pipe system. Special protection systems are provided where special hazards or high loss potential exists. The following sections discuss the functional requirements and the applicable codes and standards for the fire detection and suppression system.

Functional Requirements. The PF-4 fire detection and suppression system was designed to meet a number of functional requirements. These requirements are listed below.

- **General.** The facility is a low fire hazard facility. The contents of the facility have an inherently low fire loading, and the building is constructed of fire resistant materials. In addition, the facility has the capability to automatically prevent, suppress or contain either an internal or external fire in accordance with the requirements of NFPA, UBC, and FM. Wet pipe automatic sprinklers represent the minimum protection required for most areas in the facility; the storage vault uses a preactive dry pipe system. Special protection systems are provided for areas that contain special hazards or where a high loss potential may exist.
- **Fire Service Water.** A supply loop consisting of two separate sources of water is used to provide fire protection water. The fire protection system has the appropriate degree of reliability pertinent to risk and in accordance with the minimum requirements of FM and NFPA.

The position of all fire service water post indicator valves is indicated on a tag on each valve and can be checked by visual inspection.

- **Fire Suppression System.** Type 3 standpipe outlets and hose racks are mounted in cabinets with gasketed doors. The cabinets are flush mounted in corridors that have a width less than 6' 0" or in locations where they could interfere with equipment movements. Otherwise, the cabinets are surface mounted. The hose racks are equipped with a minimum of 75 feet of synthetic jacketed lined 1 1/2" fire hose having light weight plastic adjustable nozzles. The hoses are rated for 100 psig.

The fire sprinklers were installed on the basis of a hydraulic analysis of the sprinkler system. This installation was performed by a qualified fire protection engineer that normally performs this type of work.

In plutonium handling and storage areas, the ventilation system is designed to operate continuously during and after a design basis fire. Water sprays are provided in the ventilation exhaust systems so that heated exhaust gases can be cooled prior to passing through the HEPA filters. To prevent a single fault of the water supply from rendering this function inoperable, two separated sources of water are provided. In addition, a complete automatic wet pipe sprinkler system is provided for all HEPA filter rooms that enclose filter plenums.

Special Halon 1301 systems are used in the two PF-4 switchgear rooms, the switchgear room in PF-6, the FOC, and the computer room (room 181 of PF-3). The halon systems are actuated by smoke and thermal detectors.

- **Thermal Detectors.** Thermal detectors used in the facility are of the fixed temperature type with a rate of rise feature. Each glove box has one thermal detector installed in the top of the box.

One thermal detector is installed in each ventilation system duct. The detectors are mounted through the top of the duct wall with a coupling. In addition, one thermal detector is installed near the center of each filter plenum upstream of the demister/roughing filter. One detector is also installed upstream of the filter bank in each filter plenum.

Area thermal detectors are mounted in the vault, switchgear rooms, and FOC only.

Codes and Standards. The following standards apply to the fire detection and suppression system: NFPA 13, 101, 70, 71, and 39.

4.2.4.2 Overall Configuration. The following subsections provide descriptions of the major features of the PF-4 fire detection and suppression system, specifically the system design, subsystems, and equipment/component items.

Design Description. The fire detection and suppression system consists of numerous smoke and thermal detectors along with several subsystems that provide fire suppression. The fire suppression subsystems include a water supply and storage system, a fire water pumping and distribution system, automatic sprinklers, a maintenance fire system, Halon gas systems, manual hose rack systems, and hand-held fire extinguishers. In addition, special suppression systems are used as appropriate in selected glove boxes. The special suppression systems include magnesium oxide, graphite powder, or argon for extinguishing plutonium fires.

Finally, note that certain of the building design and construction features are also considered an integral part of the suppression system, for example the use of fire-resistant barriers, fire doors, and dampers.

Subsystem Description. As noted above, the fire detection and suppression system consists of a number of different subsystems. To facilitate the further description of this system, individual subsystems are separately described below. These individual subsystems are defined to be fire detection, water supply and storage, fire water pumping, fire suppression, and fire service water collection.

- **Fire Detection.** Automatic detection of fires is accomplished with thermal detectors and smoke detectors. In addition, manual pull stations installed inside and outside various areas of PF-4 provide a means for facility personnel to generate a fire alarm. Also, PF-4 is equipped with push-button permanent fire alarm stations at each drop box.

Thermal detectors are installed in a number of areas within PF-4, including each of the glove boxes, switchgear rooms, vault, FOC, and in the ventilation system filter plenums. Ceiling mountings are used to place thermal detectors located in vaults, elevators, and switchgear rooms. Most of the thermal detectors used in the facility are preset to alarm at a nonadjustable nominal temperature of 140 deg F. Thermal detectors located in glove boxes with furnaces or in other locations with high temperatures are set to alarm nominally at 190 deg F.

Ionization type smoke detectors are installed in the vault areas, switchgear rooms, and the FOC. The smoke detectors are surface-mounted and are provided with indicating lamps. The smoke detectors are continuously supervised.

The manual pull stations are non-coded, double-pole double-throw design and contain a breakable glass rod. As necessary, pull stations are housed inside weatherproof enclosures.

- **Water Supply and Storage.** Two separate sources of water are used to supply water to the TA-55 site. Both of these sources run parallel to Pajarito Road. One of these sources consists of a 10-inch feeder line connected to a 16-inch concrete water main located south of the road. This feeder line is used to supply water to a 150,000 gal. holding tank that is located on the southwestern corner of the site. The second source of water consists of a 10-inch feeder line connected to a 12-inch cast iron water main located north of the road. This feeder line is used to supply a 150,000 gal storage tank located on the northeastern corner of the site. A schematic diagram of the fire service water system is shown in Figure 4.2.4-1.

An altitude valve and air-gapping are used in each of the 10-inch feeder lines to protect against the flow of contamination into the water supply mains.

The two 150,000 tanks described above are used to provide holding water for fire service uses. To prevent freezing conditions each tank is equipped with a temperature transmitter and relay which control a recirculating pump, allowing the water to be recirculated through two natural gas-fired boilers when the temperature is nominally 37 degrees Fahrenheit or lower. The boilers are shown in Figure 4.2.4-1 and are designated H-701A and B for the east tank, and H-704A and B for the west tank. As shown on Figure 4.2.4-1, water is pumped out of each tank to its respective fire service water pumps. When the temperature drops to 37 degrees F, the recirculating "antifreezing" pump SP/147 pumps the water through the boiler loop before returning to the tank. The two storage tanks are connected to the fire service water pumps that provide fire service water to the 10-inch fire water main that loops the site.

- **Fire Water Pumping.** Located near each of the fire water holding tanks is a seismically-qualified fire water pump house. The two pump houses are constructed of concrete block/steel rebar with both horizontal and vertical structural reinforcements. Each of the pump houses contains three fire service water pumps. Water is supplied to the pump houses from their respective holding tanks through 12-inch piping headers. These headers consist of welded and flanged carbon steel with flexible couplings.

The three fire pumps located in each pump house consist of a primary pump, a secondary pump, and a jockey pump. The primary and secondary pumps are large demand pumps rated at 1,000 gal/min at 110 psig, while the jockey pump is rated for much smaller flows, specifically 100 gal/min at 125 psig. The function of the jockey pumps is to maintain adequate line pressure during system standby. To accomplish this function, the jockey pumps cycle on and off as necessary during periods when the system is in a standby mode. The fire water pumps are set up for automatic start at the nominal pressures shown in Table 4.2.4-1.

Table 4.2.4-1
Automatic Start Pressures for Fire Service Water Pumps

Pump No.	On (psig)	Off (psig)
West Jockey P-706	110	137
West Electric P-704	100	125
West Diesel P-705	90	135
East Jockey P-703	105	137
East Electric P-702	95	125
East Diesel P-701	86	135

The primary and jockey pumps are electrically-driven, while the secondary pump is diesel engine-driven. The three pumps in each building discharge flow into a common 8-inch carbon steel welded and flanged header that is coupled into the 10-in site fire main loop.

The diesel engines that are used to power the secondary pumps receive fuel supplies from day tanks that can be replenished from underground storage tanks. The day tank inventories are sufficiently large to sustain diesel pump operation beyond the point at which the water storage tank inventories are depleted.

To provide protection against freezing conditions, the site fire main loop is buried underground. In addition, this loop is divided into sections with post indicator valve assemblies so that subsystem isolation can be accomplished without interruption of fire protection. Ten fire hydrants are spaced around the fire main loop at intervals of approximately 250 feet.

The fire main loop is used to provide water flow to TA-55 buildings via individual headers that are protected with post indicator isolation valves and flow alarm check valves.

- **Fire Suppression.** As previously noted, the facility utilizes several methods for accomplishing fire suppression. These methods involve the use of automatic sprinklers, Halon gas, manual hose rack systems, and hand-held fire extinguishers.

Automatic sprinkler systems are installed throughout the facility, with the exception of certain rooms in the calcium grinding building. (Use of water spray in the calcium grinding building is precluded due to potential reactions of the materials used in this building to water.) By design, the automatic sprinklers are capable of spraying a minimum of 0.19 gal/min/sq ft over the most remote 1,500 sq ft of the facility. Flow sensor check valves are used to alarm the system. System isolation can be remotely accomplished with manual post indicator valves that are located outside the building.

Halon systems are installed to protect areas of the facility that have the potential for fires involving vital electrical equipment. These areas include the control room and portions of the facility that house electrical switchgear and computers. Two detectors in the same room are required to actuate the halon system. One detector will set off an alarm.

The PF-4 corridors contain fire hose stations that utilize either 2-1/2 in or 1-1/2 in outlets with 100 ft of hose. Located throughout the remainder of the facility are other hose stations that are supplied from the sprinkler headers and equipped with 2-1/2 in valves. Portable dry chemical and water extinguishers are also provided to supplement fire protection from the hose stations.

As appropriate, special suppression agents are used within glove boxes to extinguish plutonium fires. The special agents used are magnesium oxide (MgO) powder, graphite powder, and argon. Because of its abrasive nature, MgO powder is not used in the vicinity of operating equipment and machinery. On the other hand, graphite powder is used to extinguish plutonium fires, especially if machinery is present in the affected glove box or adjacent glove boxes. To extinguish plutonium fires with these powders, the burning plutonium metal is covered with the chosen powder, or placed in a pan of power and subsequently covered with additional powder. As appropriate, powders are stored in selected glove boxes. Bell jars utilizing argon purging are also used to extinguish plutonium metal fires. Finally, note that especially hazardous operations are carried out in glove boxes that have an inerted atmosphere.

Fire suppression systems have also been provided for the ventilation system in the plutonium handling and storage areas. These fire suppression systems are designed to allow the ventilation system to operate for 2 hours during a fire. The fire suppression system for the Zone 1 HEPA filters consists of an automatic spray in the cool-down box, actuated at a nominal 190 deg F, and a manually actuated spray immediately upstream of the first set of HEPA filters.

Automatic actuation of the Zone 1, Zone 2, Zone 2 Recirculation, and Zone 3 exhaust cool-down spray occurs when an entry duct sensor registers an air temperature of 190 deg F. The cool-down spray for the first stage HEPA filters can only be manually actuated from the local control box in the Zone 1 exhaust plenum room. Manual actions from the local control box are required to turn off the cool-down spray.

The manually-actuated spray immediately upstream of the HEPA filters can be controlled on or off only from the local control box.

- **Fire Service Water Collection.** Special facility design features and equipment have been provided to collect fire service water discharged during a Design Basis Fire. Specifically, water collected on compartment floors will first overflow to adjacent compartments once the floor water level exceeds 2.0 in. Once the compartments are at their maximum capacity, the water will flow to the basement where pumps are aligned to transfer the water to the TA-50 Industrial Waste Stream. Contamination levels will be taken into account in determining the required disposition and treatment of the water.

4.2.4.3 System Interfaces/Support Systems. The fire detection equipment is powered by multiple, dedicated, FM-approved UPS systems that are powered from normal building ac power. Five UPS units provide a 24-hour source of power for the following: fire alarm computer, frangible links, magnetic doors, and transponders used in circuits that detect closure of detector contacts.

The fire service water system receives utility water from two separate utility water mains, as shown on the fire service water schematic diagram, Figure 4.2.4-1.

4.2.4.4 Instrumentation and Control. All fire points are supervised and communicate with a transponder. The transponders have data links to FMUs to the FCS

computer and to the autocall panel. The autocall panel communicates via a data concentrator to the central alarm station, and can also transmit fire alarms and transponder malfunction alarms to the FCS computer via an FMU.

The fire alarm computer is not required to send a fire alarm signal. Also, FOC personnel monitor the fire alarm signal frequency on their radio units. Finally, an eight-second delay occurs following a detected fire condition before an alarm is initiated.

4.2.4.5 Surveillance/Maintenance. The minimum test requirements for some of the components of the fire detection and suppression system are summarized in Table 4.2.4-2. In addition, all fire detection and suppression points are monitored continuously by the facility control system and alarms are reported to the Central Alarm Station.

Table 4.2.4-2
Maintenance/Surveillance Requirements for Major Components of the
Fire Detection and Suppression System

Equipment	Function Tested	Frequency	Reference
Smoke Detectors	Operability	Annually	OCM-9-91
Sprinkler Flow	Operability	Bi-monthly	OCM-9-91
Halon System	Operability	Annually	OCM-9-91
Fire Pump Test	Operability	Weekly	OCM-9-91
Fire Pump Flow	Operability	Annually	OCM-9-91
Thermal Detectors	Operability	Bi-annually	OCM-9-91

A key out switch on the drop box allows welding and other smoke- and heat-producing maintenance activities to proceed without activating the drop box zone fire alarms. Only fire protection personnel are authorized to key out a zone of fire alarms.

4.2.4.6 Technical Safety Requirements (TSR) Limitations. The following specifications are taken from (Oper. Safety, 1988).

Fire Detection. This specification applies to fire detection systems for PF-4.

- **Specification.** Normal operations in PF-4 will be terminated if the fire detection system is not operative. Limited operation may be continued with a fire watch in effect if the fire detection system is inoperable. Test procedures and design features allow operations to continue during test and maintenance.
- **Basis.** Although PF-4 will remain a confinement structure during and after a design basis fire, even if all normal fire suppression systems fail, it is still desirable to limit the consequences of fire to the building.

Fire Suppression. This specification applies to fire suppression systems, fire water storage, and redundant pump systems for PF-4.

- **Specification.** Normal operations in PF-4 will be terminated if the minimum fire suppression systems are not operative. One water storage tank and associated diesel fire pump on line constitute minimum fire suppression capability.

- Basis. Although PF-4 will remain a confinement structure during and after a design basis fire, even if all normal fire suppression systems fail, it is still desirable to limit the consequences of fire to the building.

4.2.5 Facility Monitoring System

The facility monitoring system consists of a stack monitoring system using two continuous air monitor (CAM) units, 250 room CAM units, 1300 fixed-head units, and 25 in-line duct sensors. The in-line monitors also consist of continuous air monitors. Within the PF-4 building, the CAM and fixed head units are about equally distributed between the north and south halves of PF-4 with each half having a separate vacuum header serving the three sensor types within its respective side. Each north and south side has a separate vacuum header drawing 1 actual cubic feet per minute (acfm) per CAM and in-line unit and 2 acfm per fixed-head unit. Each side also has redundant pairs of vacuum-blowers (vacuum pump) attached to its respective headers. Any one blower is capable of drawing nominal flow required for CAMs, in-line, and fixed-head air monitor operation associated with each side.

4.2.5.1 System Function. The function of the stack monitoring system at the TA-55 facility is to monitor for radioactive particulate emissions from the TA-55 facility and to ensure that such emissions do not exceed state or federal standards.

The function of the PF-4 facility airborne monitoring system is to detect on-site spills, transportation container and glove box leaks, and gross contamination buildup in the air exhaust headers during normal facility operation. Essentially two types of detection systems are installed, the CAMs and the fixed-head monitors. The CAMs monitor large scale accidents, the exhaust stacks, and contamination buildup in the ventilation headers, while the fixed head monitors check for a chronic, low level release. Because the highest vacuum is maintained within the glove boxes, a small leak in any glove box is unlikely to result in a significant, detectable release for either type of detector provided the ventilation system remains operational. Upon loss or partial loss of the ventilation system, however, small, previously undetectable leaks in glove boxes or other interim transfer systems may become significant.

4.2.5.2 Overall Configuration. The facility air monitoring system uses two different types of sensors employed in different modes. This section describes the configuration of the stack monitoring system, the PF-4 CAMs, the fixed-head units, and the in-line duct sensors.

Stack Monitoring System. Information on the stack monitoring system was obtained from (TA-55 CAM, 1991) and (TA-55 Tech. Man.). The stack monitoring system at TA-55 consists of a total of two CAM units. One unit samples the north facility exhaust stack, while the other unit samples the south exhaust stack. In addition, there are some fixed head air sampling units that sample approximately 16 separate locations on each exhaust stack in order to monitor for compliance with federal and state air quality standards. It is also anticipated that tritium monitoring of each stack exhaust will be added in the future. Note, however that in its current configuration, real-time monitoring is carried out by the individual CAM units sampling a single location on each exhaust stack. As a result, only the CAM units will be discussed in the following paragraphs.

The stack monitoring system employed at TA-55 consists of an Eberline TA-55 CAMS type detector. This detector provides real time, solid state detection of Plutonium-239 (Pu-239) alpha decay using a single channel pulse height analyzer. The analyzer is

calibrated to detect alpha particles of a specific energy while rejecting other energies. By calibrating the detector to a specific energy range and rejecting others, the sensitivity of detection of Pu-239 is greatly enhanced by the rejection of radon-thoron daughter background. A block diagram of the stack monitoring system is given in Figure 4.2.5-1.

A single TA-55 unit samples the north and another samples the south stack exhaust continuously during operation. Both are normally in the pulse height analyzing (PHA) with background subtraction mode of operation. Other modes include gross count and PHA without background subtraction. The background subtraction circuit uses a separate adjustable window to provide a more stable background reading during changing radon concentrations.

The count rate is recorded on a 4 decade logarithmic rate meter located on the front of the unit. The meter registers counts from 1 to 10^4 counts per minute. A high level alarm is set to trip at 30 counts per minute and may be verified by pressing the alarm setpoint button located on the front of the CAMS unit. Should the alarm be actuated during operation, visual FOC alarms will occur.

The unit has a self monitoring failure warning circuit that checks for the loss of signal (no counts within 30 seconds) from the detector. Should the signal be lost, the FAIL light is illuminated and the COUNTING light is turned off. Both lights are located on the front panel of the CAM unit. The units are also monitored for proper operation by the FOC computers; the computer checks for absence of an input pulse over a 4 hour period. Should either stack monitoring CAM unit fail to provide an input pulse during any 4 hour period, an alarm is signaled in the FOC.

Operation of the stack CAM units consists of a connection to the main "Roots Blower" vacuum header within TA-55 in order to provide air flow through the monitors. In addition, individual UPS powered, dedicated vacuum units provide a backup vacuum source upon loss of site power. These units are automatically started should vacuum pressure reach a preset level. Stack exhaust air is drawn through a 1/2 inch (I.D.), heavy walled tubing at a rate of about 20 liters per minute into the CAM unit and passes through a 1-inch diameter filter (Millipore SM or equivalent). Airflow indication is provided by a front panel mounted flowmeter. The 1-inch filter is located in close proximity to the 2p alpha detector (within 0.1 inch) which records alpha decay from filter entrained Pu-239 and other alpha decays such as the radon-thoron daughter decays. The internal circuitry then analyzes the counts according to the precalibrated PHA window and outputs a signal based upon the operational mode selected (gross, PHA with background subtraction, or PHA without background subtraction). Since normal operation consists of operating with the PHA and the background subtraction circuit mode, other energy alphas are excluded from the CAM output and the counts recorded are those that may be attributed to Pu-239 decay.

PF-4 Room Continuous Air Monitor (CAM) Units. The units involve continuous air monitoring within the individual rooms of the 100, 200, 300, 400, and basement areas. In PF-4, this task is performed by Eberline Alpha 5-A CAMs. These units consist of an external vacuum source (separate from the unit and discussed above) which pulls room air across a stationary filter media that is in close proximity to the detector window. Periodically, the filter media must be changed and the detector window cleaned in order to sustain efficient, and accurate operation. This is due to the presence of dust in room air which eventually clogs the filter and deposits on the detector and detector window thus reducing detection efficiency. Also on the unit are a visible, variable radiation level (logarithmic) meter; alarm set point indication button; airflow indicator and adjustment; and visible (red light) and audible (alarm bell) alarm indications.

Radiation from naturally occurring radon-thoron decay presents a background problem due to the overlap in energy spectrum between these and plutonium decay products. As a result, a background discriminator is incorporated into the design and operation of all CAM units within PF-4. One final requirement/installed feature is that the CAM system will supply a switch closure indication when an alarm condition is present, as well as a pulse count in each of two energy windows. These energy windows correspond to the background and the actual plus background counts in order to allow the data collection computer to independently integrate its own counts per minute and determine an independent background subtraction.

The CAMs serve as a local area accident release warning. In addition, the instrument must have a capability of detecting 4 MPC hours of plutonium-239 with an average radon-thoron background. In the event of an accident, the CAMs have an important role in the radiation protection plan for facility workers, allowing evacuation of affected areas to minimize the time of exposure.

The CAM units do not have any effect on the facility ventilation system. The facility ventilation fans and dampers normally maintain increasing levels of vacuum according to the potential for an accidental release in conjunction with preferential flow paths. The highest level of vacuum is maintained in the glove boxes where the plutonium and other special nuclear materials are handled and processed. As a result, the CAM system is primarily designed to detect spills or breached handling containers external to the glove boxes and not minor leaks within the glove boxes. The latter would result in air flow from the less contaminated into the more contaminated area (room to glove box) and would most likely be detected by abnormal ventilation system flows within the affected area(s). The room CAMs are tested for proper operation by the Chemistry and Health Protection Group weekly using a Pu-239 alpha source check. The source is varied every other week alternating between a high intensity and a low intensity source.

In-Line Duct Sensors. The in-line duct sensors also employ CAMs, but monitor the ventilation exhaust air ducts for alpha entrained contamination rather than the individual rooms. Otherwise, the operation is essentially identical to that discussed previously. These units serve as a second check on room air contamination. For example, if the individual room CAMs fail to alarm during an accident, the ventilation exhaust duct which serves the affected room should detect an abnormal level of alpha emitting contaminants and eventually cause an alarm, depending upon the location of the accident in conjunction with individual room air flow patterns and total ventilation air flow. In addition, the system may be used to help identify the source of an accident and plutonium buildup in the exhaust ducts. The filters from these units are changed weekly by health physics personnel and counted for total gross alpha contamination.

Fixed-Head Monitors. The fixed head monitors sample for prolonged low level exposure. This is accomplished by placing a filter paper on a vacuum inlet at about the 6.5 foot level of (approximately) every other glove box throughout the facility. The filter papers are collected and replaced, with the old ones being measured by health physics personnel for alpha contamination either daily or weekly, depending on the contamination potential. The vacuum source for this sampling method is the same as for the CAM systems.

4.2.5.3 System Interfaces/Support Systems. The facility monitoring system provides input to the facility control and data acquisition system and the alarm system. The electrical system and vacuum system provide essential support for the operation of the facility monitoring system.

4.2.5.4 Instrumentation and Control. All CAMs are capable of detecting the presence of numerous radionuclides, including Pu-238, Pu-239, Pu-240, Pu-242, and Am-242. Upon indication of an alarm, evacuation of the affected room(s) is carried out. In addition, all CAMs are connected to the FOC computers through the two multiplexers. The on-line "monitor" computer scans the signals of all CAMs and generates a computerized alarm at the FOC if signal minus background exceeds a preset number of counts. Both the local CAMs generated alarm and the computer generated alarms are capable of being visually displayed within one of three FOC computer displays. The computer generates a square and a diamond to correspond to each CAMs location within the PF-4 building. During non alarm operation, both are designated solid green. However, during a computer generated alarm, the square changes to flashing red, and similarly for a CAMs generated alarm, the diamond flashes red. If both indicate alarm, both shapes flash red. The data update rate is once per minute in the normal mode and every 15 seconds if either alarm is received. Upon receipt of a computer or CAMs generated alarm, the FOC operator announces the alarm and its location over the PF-4 PA system. The operators and all personnel located within the affected area are required to evacuate and will re-enter only after the room air is verified to be within acceptable airborne levels or if proper respiratory protection is worn.

4.2.5.5 Surveillance/Maintenance. The stack monitoring CAM units are calibrated yearly or upon failure. In their current configuration, any CAM unit may function in the role of a stack monitor CAM. Hence, calibration normally consists of replacing the stack monitoring CAM unit with a spare, previously calibrated CAM unit. However, at sometime in the future, dedicated stack monitoring CAM units will be employed for facility stack monitoring. In addition to the above calibration, weekly calibrated source checks are performed on each stack monitor in order to verify proper operation of each monitor.

The surveillance/maintenance requirements for the facility monitoring system are summarized in Table 4.2.5-1 below.

Table 4.2.5-1
Surveillance/Maintenance Requirements for the Facility Monitoring System

Equipment	Function Tested	Frequency
Room CAMs	Operability	Weekly
Room CAMs Filters	Change/Count Alpha	Weekly
In-Line Duct Sensors	Change Filters/Count Alpha	Weekly
Fixed-Head Filters	Change Filter/Count Alpha	Daily or Weekly

4.2.6 Alarm Systems

The alarm system consists of audible safety alarms to warn facility personnel of fire, radiation, ventilation, and hazardous gas problems. Alarms can be reported locally, centrally to the FOC, or both. The following section describes the elements of the TA-55 alarm system.

4.2.6.1 System Function. The function of the alarm system is to warn facility personnel of fire, radiation, ventilation, and hazardous gas problems.

4.2.6.2 Overall Configuration. The major emergency alarms include radiation alarms, ventilation alarms, fire alarms, and hazardous gas alarms. This section describes the primary components of each system in the above categories.

Radiation Alarms. The radiation alarm system consists of CAMs, stack monitors, criticality alarms, and tritium alarms. A description of each system follows.

- **Continuous Air Monitor Alarms.** Alpha CAMs are located at exhaust registers in the Zone 2 ventilation areas, and at various locations in the duct work and stacks associated with the ventilation systems. The CAMs draw air through a Millipore filter with 5.0 E-06 m porosity and are monitored continuously by a surface barrier detector. The processor logic circuit compares the output of two single channel pulse height analyzers to the background signal to identify the presence of radionuclides, including Pu-238, Pu-239, Pu-240, Pu-242, and Am-241. Under normal operating conditions, the CAMs have a lower detection sensitivity of 15 DAC hours for these radionuclides. When this value is exceeded, both audible and visual alarms are activated locally to signal room evacuation.

The CAMs are monitored by the FOC computers for instrument alarm conditions. The computer scans the signals from the pulse height analyzers in each CAM and independently calculates the background-corrected disintegrations per minute. The computer uses this information to generate a computerized alarm status.

The computer display distinguishes between a computer generated alarm and a local alarm at the CAM itself. Both types of alarms would be indicated during a real airborne release. When a CAM alarm is indicated in the FOC, the operators announce the PF-4 location over the PF-4 public address system.

- **Stack Monitors.** Each of the PF-4 exhaust stacks has a 16-point isokinetic sampling probe connected to in-line samplers. The in-line samplers are collected on a weekly basis for analysis for particulate airborne radioactivity. Each stack also has a CAM unit that is connected to the FOC computer.
- **Criticality Alarms.** The criticality accident alarm system consists of 20 gamma detectors placed throughout PF-4 such that any criticality would occur no more than 100 ft from three detectors. Activation of at least two detectors simultaneously is required to produce a criticality alarm. A criticality alarm produces a pulsating midrange tone throughout TA-55, indicating the immediate evacuation of PF-4 is required. A remote audible and visual alarm in the FOC is also generated. The system is powered by the UPS.
- **Tritium Alarms.** Two types of tritium monitors are in use at TA-55. One type is used for room air and cleanup system monitoring and the other type is used for stack emissions monitoring. Both are auto-ranging instruments.

The room air tritium monitors provide signals to the building central computer through a multiplex system. The alarm limits are set at a level slightly above background. In the event of a local alarm, a switch closure is actuated at the instrument and a signal is relayed to the computer which transmits an audible alarm. Adjustable audible and visual alarms are incorporated into each instrument for evacuation of personnel during a high airborne release of tritium gas.

A new tritium stack monitoring system is planned for PF-4 exhaust stacks. Output signals to the computer allow continuous integration of tritium gas released through the

stack to the atmosphere. The monitor will alarm to the FOC when a high level is detected.

Ventilation Alarms. Differential pressure sensing devices in the Zone 1 ventilation system activate audible alarms to indicate ventilation problems in that area. The Zone 1 alarm point is 1 in. of water column. A ventilation alarm is also activated when Zone 2 is not operating properly. Depending on the nature of the ventilation problem, personnel will exit to either the corridor or PF-3, as announced by the FOC operator.

Fire Alarms. The fire alarm system at TA-55 consists of several independent systems. The Brass 3225 system covers the original TA-55 buildings, including PF-1 - PF-11 and PF-20. Its audible alarm system is part of the supervised alarm system described later. Independent alarm systems are in place at PF-28, PF-41, PF-42, PF-39, PF-114, PF-47 and PF-48 (one system for both buildings), and the drum storage building. These systems are independent of each other, with their own audible alarm systems independent of the Brass 3225 system. Each system has an output to the FOC computer system indicating an alarm condition to the operator.

The supervised fire alarm system consists of smoke and thermal detectors, manual pull stations, flow and pressure switches, and other hardware monitored by the Autocall Fire Alarm System within the site.

The status of the fire alarm system is transmitted to the FOC computer via a multiplex system, which provides a date log, cathode ray tube display, and activation of audible fire alarms. All fire alarms are automatically transmitted to the Los Alamos Central Alarm Station.

In addition, glove boxes are equipped with local audible fire alarms. When the glove box thermal detectors sense a rise in glove box temperature, the Autocall System activates the fusible links on the drop boxes in addition to generating an audible fire alarm. A button on the "Red Boxes" outside the glove box provides the operator a means to manually activate a fire alarm.

Hazardous Gas Alarms. Gas detectors are installed in the storage areas and laboratories where toxic gases are used. These gases include chlorine, fluorine, and hydrogen fluoride. The detectors are set to alarm at the Threshold Limit Value for the given gas. The alarms are a high beeping tone that is easily recognized. Rooms are to be evacuated when the alarms sound.

4.2.6.3 System Interfaces/Support Systems. The TA-55 alarm system interfaces with the facility monitoring system, fire suppression and detection system, and the FCS. The alarm system does not provide direct support to any safety related system. The facility electrical system provides instrument power to support the alarm system's operation.

4.2.6.4 Instrumentation and Control. The alarm system is an instrumentation system. It provides information to facility personnel and the FOC operator.

4.2.6.5 Surveillance/Maintenance. The TA-55 FOC provides continuous surveillance of the alarm system. The alarms are tested with the tests of their associated detectors. Table 4.2.6-1 below summarizes required surveillance/maintenance activities for the alarm system.

Table 4.2.6-1
Surveillance/Maintenance Requirements for Alarm System

Equipment	Function Tested	Frequency
Manual Pull Fire Alarms	Operability	Annually
Smoke Detectors	Operability	Annually
Site Audible Alarms	Operability	Monthly
Thermal Detectors	Operability	Bi-Annually
Criticality Alarms	Operability	Quarterly

4.2.6.6 Technical Safety Requirements Limitations. The following specification is taken from (Oper. Safety, 1988), and applies to the emergency alarms in PF-4. It ensures that unsafe conditions are detected and audible alarms are transmitted to allow personnel to respond according to site procedure.

Specification. Operations in PF-4 are affected by emergency alarms in the following manner:

CAMs (pulsating sonar) must be operable to warn personnel of airborne contamination. Normal operations in a laboratory area will be discontinued if continuous air monitoring is not available in the vicinity of an operation having airborne contamination potential. Due to multiple CAMs being present in each laboratory, maintenance and testing can be performed on individual units during normal operations.

Criticality alarms (pulsating mid-range tone) must be operable to warn personnel of a criticality incident. Response is immediate evacuation. If the criticality system were inoperative, normal operation would be terminated. If any two detectors within a section of PF-4 are inoperative, operations with fissile materials in that section will be terminated.

Fire alarms (double slow whoop) must be operable to warn personnel of a fire in the affected zone. Personnel first check their areas/operations for fire, suppress if possible, or evacuate to the corridor.

Ventilation alarms (chimes) must be operable to warn personnel in the affected area of a Zone 1 failure. Personnel evacuate to the corridor.

The TA-55 site-wide paging system must be operative since several alarms are transmitted on this system (criticality, fire, ventilation). Normal operations in PF-4 will be terminated if the emergency paging system is down for any reason, including maintenance and testing.

Basis. The ability to evacuate work areas is ensured if alarms and the emergency paging system are operable. Rapid detection of spills or leaks of radioactive materials within the laboratories prevents the spread of contamination.

4.2.7 Facility Control and Data Acquisition System

The facility control and data acquisition system is used to monitor, provide control and interface, and store data for various operating parameters within the PF-4 complex. The

majority of equipment is located in the FOC which is manned by operations center specialists (OCS). Within the FOC, approximately 3200 parameters are monitored 24 hours a day every day of the year. Building systems monitored include heating and ventilation, fire detection and suppression, radiation detection, and electrical power. Control, monitoring, and data storage are performed within the FOC, where all facility parameters are under a 24 hour watch by the on duty OCS. Visual and audible alarms alert the FOC operator, the facility health physics office, and the remote emergency coordination office of abnormal system conditions associated with the above parameters. In addition, in the event of a computer system fault which would render either or both CPUs inoperable, audible and visual alarms are provided within the facility operations center, facility health physics office, and the remote emergency coordination office. Finally, each monitoring location is equipped with individual local alarms for criticality and fire.

4.2.7.1 System Function. The function of the PF-4 facility control and data acquisition system is facility monitoring, data storage, and independent/remote notification of on-site accidents which may impact onsite worker or offsite public safety and health during normal facility operation. The system is limited to detection and notification of conditions related to the parameters discussed previously. Without the data acquisition system, sustained performance and operation of the PF-4 facility cannot be achieved. There are provisions for operation for less than 1 hour without the system in an operational status, providing the heating and ventilation system is fully functional, and the hardwired criticality alarm system and the independent fire alarm to the Central Alarm Station (CAS) are fully operational. One final function performed by the system is on a loss of site power, the system provides a remote manual start signal to the onsite auxiliary diesel generator.

4.2.7.2 Overall Configuration. The system consists consists of two redundant computers (CPUs); nineteen field multiplexer units (FMUs); two remote, dual path, central control unit multiplexers (CCUs); two moving head disc memory units (DMUs); two linewriter data terminals with integral cassettes; consoles with I/O terminals/printers; and a number of other peripherals and various types of sensors located within the PF-4 complex. Discussion of the major components follows.

Central Processing Units (CPUs). The CPUs within each computer are designed to operate simultaneously and independently, with each receiving the same information from the remote multiplex system (RMS). One runs as the primary, or "monitor" computer/CPU; the other is the secondary, or "backup", computer/CPU. Both computers may operate in either mode, hence, dual redundancy exists within the computer portion of the system. Upon loss of the primary computer, the secondary computer assumes the role of primary computer with no backup until the failed computer is repaired and restored to use. If the secondary computer is lost during operation, the primary computer continues to operate in the primary role without a backup. In the event that a computer fault jeopardizes the safe operation of the PF-4 complex, including the differential pressure zones (1, 2, 2A, 3, 4, and outside), an operator initiated, hardwired shutdown of zones 2 and 3 may be initiated from the FOC.

Each computer contains a multiplex interface buffer controller. The interface controller controls signals to and from the CCUs, core memory, disc memory, and display terminals and the central processor. It also controls priority levels to and from the computers.

The monitor computer has the following capabilities and features:

- Acquires directly from its core memory all data input directly from the CCU. Such data is transferred to memory at the time it is processed by the CCU.
- Acquires data from the RMS through its interface controller.

- Monitors its interface controller for proper operation.
- Acquires input from any point in the multiplex system, asynchronous to the sequential scan.
- Provides an output to the multiplex system, asynchronous to the normal multiplexer sequential scan.
- Supplies data to any output point processed by the CCU directly from core memory.

The secondary or "backup" computer has simultaneous capabilities as outlined in the first three requirements above.

Central Control Unit Multiplexers (CCUs). The CCUs communicate as simultaneous, but independent input/output devices from the computers to the FMUs. The data are communicated in digital format, with the CCUs initiating polling of all process, criticality, and fire alarm systems. In addition, the CCUs transmit all control signals initiated by the computers, or by the Control Room via the control room multiplexers (CRMs), to affect alarm and control.

Field Multiplex Multiplex Units (FMUs). The nineteen field multiplex units act as information headers and are distributed throughout various locations throughout PF-4. Like the CCUs they are multiplexing units but act as information relays, providing or receiving a multiplexed signal consisting of the individual unit's inputs or outputs and receiving/sending this information to/from the CCUs. Information is passed in a "dual bus", serial data mode, with each bus feeding one CCU. Bus isolators are used at each individual FMU to provide bus protection in case an individual FMU modem shorts out during normal operation. The FMUs are not redundant, and failure of a single unit results in loss of all information which is processed by the unit. An alarm signals loss of the affected unit to the FOC, and the FMUs are configured in such a fashion that failure of a single unit may be tolerated without requiring termination of operations within PF-4. This is partially due to the FMU having no effect on local alarms (criticality, fire, etc.).

Disk Memory Units (DMUs). Disc memory units are used to store data for later analysis or retrieval. As hard copies are made of important data, old data are archived and removed from disc memory. Old facility operational data are discarded unless of interest for other data base analysis (e.g., incident reports, etc.).

4.2.7.3 System Interfaces/Support System. The facility control and data acquisition system interfaces with the facility monitoring system, the alarm system, and the monitored parameter's systems. The facility electrical system provides instrument power to support the facility control and data acquisition system's operation.

4.2.7.4 Instrumentation and Control. The facility control and data acquisition system is an instrumentation system. It provides information to the OCS and stores data on numerous facility parameters as previously discussed.

4.2.7.5 Surveillance/Maintenance. The FCS has redundant computers and switches over automatically to the backup computer if the main computer fails. The system is self-monitoring and error conditions are recorded on the CRTs and line printers. Test procedures and design features allow operations to continue during testing and maintenance.

Flow, pressure, temperature, and delta-P sensors/transmitters are calibrated when installed or repaired. Calibration may also be performed when anomalies in facility operations are detected by the FCS. An FCS database dump is performed daily to generate reports and backup the database.

4.2.7.6 Technical Safety Requirements (TSR) Limitations. The FCS is essential for the operation of all plant critical systems. Without the FCS, critical systems cannot be monitored. Monitoring capability is necessary to take appropriate control action if a critical system failure occurs.

The following specification is stated in (Oper. Safety, 1988).

Specification: If the FCS is inoperative for more than one hour for any reason, including maintenance and testing, normal operations will be terminated.

Basis: The critical systems are highly reliable, stand-alone systems, and can operate without the FCS. However, the FCS monitors these systems and if a transient or failure occurs, the FCS invokes certain control actions, such as switching to a standby fan unit.

4.2.8 Instrument Air System

The following sections describe the instrument air system. The function of this system is described in Section 4.2.8.1, followed by a discussion of the overall system configuration in Section 4.2.8.2. Section 4.2.8.3 provides information on system interfaces/support systems, while Section 4.8.2.4 discusses instrumentation and control. Finally, Sections 4.8.2.5 and 4.8.2.6 discuss surveillance/maintenance and Technical Safety Requirements Limitations, respectively.

4.2.8.1 System Function. The function of the instrument air system is to provide a supply of clean and dry compressed air to the PF-4 facility. The system nominally provides 100 psig compressed air to operate a various ventilation system components. The ventilation system in turn maintains special negative pressure zones as a means of preventing the release of radioactive materials. The ventilation system is further described in Section 4.2.1.

The instrument air system receiver is required to meet ASME pressure vessel code standards.

4.2.8.2 Overall Configuration. The first section below provides an overview of the PF-4 compressed air systems, while the second section provides an overview of the instrument air system. Finally, the third and fourth sections discuss instrument air equipment/components and instrument air system operation, respectively.

Overview of Compressed Air Systems Used in PF-4. There are essentially two air systems used within the PF-4 complex; the instrument air system which is discussed in detail in the following sections, and the process air system which does not support any vital or significant loads, and will not be discussed here. There is also a breathing air system, however, it is only used to support respirators, hoods, and air suits as required within the facility. It is also not discussed in detail. As previously noted, the instrument air system is used to provide 100 psig operating air for ventilation system damper positioning, as well as operating and control power for other ventilation and containment system components. The process air system is used primarily for all other facility functions involving the use of

compressed air except breathing air. Originally, the two systems functioned as a single "compressed air system," but were separated into the two systems to provide an independent, redundant, and reliable source of compressed air for facility ventilation/containment equipment control and operation; and a second, process air system for all other facility compressed air needs. The instrument and process air systems are currently cross-connected only to the extent that the process air system can and normally does provide compressed air to the instrument air system through a check valve that prevents flow in the reverse direction (instrument to compressed air). This is facilitated by the operating band of the process air compressor being "within" the LEAD instrument air compressor operating band during normal operation.

Instrument Air System Overview. An overview of the instrument air system is shown in Figure 4.2.8-1. This system consists of three reciprocating, non-lubricated air compressors located within the PF-8 building which is a separate, detached building on the north side of the PF-4 building. Each compressor can deliver a maximum of 208 acfm at 114 psig at the TA-55 site altitude. However, they are not designed for continuous operation and are operated at a 40% duty loading. The compressors are cooled by a self contained glycol system and the aftercoolers are cooled by water provided by the onsite central circulating chilled water (CCCW) system. The aftercoolers provide cooling (to less than 90°F) to the compressed air prior to its delivery to the dryers. The moisture separators are no longer used and are retired in place. In addition, the aftercoolers may use industrial cooling water to provide cooling through automatic valving/pressure switches if the CCCW system is lost or non-operational. Industrial cooling water is supplied from the 25,000 gallon site water tank which in turn is fed from the 10 inch site water main. It is a once through water system which is fed by a four inch line from the 25,000 gallon tank. The four inch main feed line from the tank divides into domestic water and industrial cooling water in the utility building. Air drying and filtering are accomplished by dual-tower desiccant dryers which dry the air to a -40°F dew point followed by an in-line filter to remove any entrained desiccant or other solids. Just before the dryer and filters, air from the three compressor paths merge into a single 1533 gallon receiver.

From the receiver, a single 4 inch schedule 40 black steel pipe delivers air from the PF-8 building into the PF-4 complex. Once inside the PF-4 building, the schedule 40 pipe feeds a 2 inch copper main air header through a 2 inch manually operated main header ball isolation valve. This 2 inch copper main header in turn supplies instrument air to various loads via the piping network further discussed below.

Equipment and Component Descriptions. Equipment and components used in the instrument air system are described below, followed immediately by a description of the instrument air distribution network.

- **Compressors and Associated Equipment.** The three instrument air system compressors are reciprocating, non-lubricated, self contained radiative (convective loop) cooled air compressors capable of delivering 80 acfm at 114 psig (208 acfm at ~40% duty) at the TA-55 site altitude. Each compressor draws air from within the PF-8 room and discharges compressed air to a dedicated aftercooler. Cooling to each aftercooler is provided by the CCCW system. Upon passing through the aftercooler, the air is passes through a non-operational moisture separator and then to the 1533 gallon main receiver. From the receiver, air passes through one of two dryers, followed by a single in-line filter. The air dryers are dedicated dual-tower desiccant type dryers which dry the air to a -40°F dew point. The after-filter is a HEPA type paper filter that removes any entrained desiccant or other solids from the air upon exiting from the dryers. The 1533 gallon American Society of Mechanical Engineers (ASME) code vessel acts as a

receiver and stores the compressed air for delivery to loads and components located within PF-4. All of the above components are located in PF-8.

- **Instrument Air Distribution Network.** The main header extending from the receiver in PF-8 into the PF-4 north half of the building consists of a single schedule 40, 4 inch black steel pipe. This pipe connects to the main instrument air header running north to south within PF-4. This header is a 2 inch copper pipe and has a 2 inch ball isolation valve at the junction with the 4 inch black steel pipe. The copper pipe main header, two branch headers, and all subheaders and loads are located within the PF-4 north and south building areas. With the exception of some of the loads, the majority of this equipment is actually located in the basement of the north and south building areas.

The main 2 inch copper header supplies two subsystems that in turn feed most of the loads in the north and south portions of the PF-4 building. The two halves of the PF-4 building share the 2 inch main header, but differ in the sizing of the branch headers that feed some of the loads within the two areas. The south branch header consists of a 2 inch copper pipe, while the north branch header consists of a 1-1/2 inch header. Within each half of the building, loads are fed from both the 2 inch main and 1-1/2 or 2 inch branch headers using either 1/2 or 3/4 inch copper subheaders. Manual isolation valves are located in-line at most of the junctions between the main or branch header and the 1/2 or 3/4 inch subheader to provide isolation upstream of the connected devices. The control panel sub-headers do not have an isolation valve at the junctions between the main and branch headers.

The instrument air distribution network, including the 4 inch main supply, the 2 and 1-1/2 inch main and branch headers, and the 3/4 and 1/2 inch sub-header network and associated loads are also shown in Figure 4.2.8-1.

Virtually all of the instrument air main, branch, sub-headers and associated loads and components are located in the basement. The main exceptions to this are the 4 inch schedule 40 pipe that originates in PF-8 and the compressors, aftercoolers, dryers, and the receiver that are also located in PF-8.

System Operation. The ventilation system components served by instrument air are vital to maintaining the differential zone pressures and hence the second level of containment associated with the PF-4 complex. The system is normally fed from the process instrument air compressor and has one instrument air compressor available to provide makeup air should the process air compressor fail. This compressor is designated as the LEAD compressor. The LEAD compressor cycles on and off with its operating band being inside that of the process air compressor, and therefore, it is not normally running. Should it be demanded, the LEAD compressor runs at 40% loading capacity. The other two compressors operate in 1st and 2nd STANDBY mode where if the LEAD compressor should fail to maintain receiver pressure above the lower band setpoint, and the receiver pressure drops below the LEAD compressor start setpoint, the 1st STANDBY compressor is started, and assumes the load/unload operating role associated within its operating band. Similarly, should the 1st STANDBY compressor fail to perform properly and with the third compressor in the 2nd STANDBY mode, if the 1st STANDBY compressor should fail to maintain receiver pressure above its lower band setpoint, and the receiver pressure drops below the 1st STANDBY compressor start setpoint, the 2nd STANDBY compressor is started, and assumes the load/unload operating role associated within its operating band. An alarm also indicates failure of the normal online compressor, in addition to the automatic shifts discussed above. If the process air compressor is operational, two instrument air compressors may be down for maintenance during normal material processing operations.

Similarly, at least one instrument air compressor is required to be operational in order for materials processing to be performed at PF-4.

- **Description of Modes of Operation.** There are essentially five modes of operation of the instrument air system within the PF-4 facility, instrument air "normal", process air "normal" or "emergency", industrial air "emergency", and "nitrogen emergency". The normal mode consists of the process air compressor cycling to provide instrument air loads (process air "normal") with the LEAD instrument air compressor and none, one, or two remaining instrument air compressors operating in an "on demand" mode. The instrument air "normal" consists of the LEAD instrument air compressor providing operating air to the instrument air loads. In this mode, the compressor delivers air to its aftercooler, the 1533 gallon receiver, and then to one of two manually aligned dryers. The backup dryer must be manually valved into service should the online dryer fail or require changeout. In the "process air emergency" mode, the process air compressor provides instrument operating air through the one-way cross-connect to the instrument air system should all instrument air compressors become unavailable. This mode of operation differs from the normal mode of operation only by the unavailability of all instrument air compressors. Should all three instrument air compressors and the process air compressor become inoperable, the industrial air compressor, rated at 206 acfm, may provide an emergency source of instrument air through its one-way cross-connect line. This mode corresponds to the industrial air "emergency". As a last resort, the instrument air system may be manually connected to the nitrogen tube trailer (135 psig) located external to both the PF-8 and PF-4 buildings. This source would be sufficient to run the facility for approximately one day.
- **Failure Response.** Instrument air is required for normal operation of the PF-4 complex. However, upon failure of the instrument air system, settings of dampers and valves may be manually adjusted to allow full operation of the facility without instrument air, provided that both off-site electrical power and the computer control and monitoring system (in the FOC) are fully operational. Only under an extreme emergency is it likely that this mode of operation would be permitted though (need to verify).

If pressure within the instrument air system should fall below 85 psig, a visual and audible alarm is triggered in the FOC and the PF-4 HVAC system is automatically shut down and material processing operations are secured. If the automatic response should fail, procedures direct the operator shut down the HVAC system and secure material processing operations. These actions are based upon the requirement for a minimum of 80 psig for operation of pneumatic dampers within PF-4. It is notable, that under emergency conditions with a loss of both the computer control and monitoring system and the instrument air system, a negative differential pressure may be maintained in all four (Zone 1, 2, 2A, and 3) areas by operating the Zone 1 exhaust fans only (electrical power must be available), and manually positioning the Zone 1 makeup and exhaust dampers.

4.2.8.3 System Interfaces/Support Systems. A discussion of the systems that receive support from the instrument air system follows in the first section below. This discussion is followed by a description identifying the support systems that are needed to maintain operation of the instrument air system. Finally, the last section describes the systems that can provide backup sources of air in the event that the instrument air system supply fails.

Systems Receiving Support. The loads shown in the schematic include: Proportional Diaphragm Valves (PDVs), Control Panels (CPs), Pressure Switches (PSs), Level Controllers (LCs), Zone 2A and 3 Intake Valve Actuators (HCVs), miscellaneous

Ventilation System Dampers (HVs), Temperature Transmitters (TTs), Flow Transmitters (FTs), Pneumatic Pressure Transmitters (PTs), and the north and south OSA intake temperature control boards. Note also that there are 22 emergency air receivers used for emergency positioning of critical air dampers within PF-4 should normal instrument air become unavailable. These dampers include HCV-832, 833, 882, 883, HV-816A&B, 822A&B, 865A&B, 866A&B, 872A&B, and PDV-815A&B, 821A&B, 871A&B, 890, 891.

Systems Providing Support. There are essentially a total of three systems that provide direct support to the instrument air system, specifically the AC electrical power system, the DC electrical power system, the process air system, and the CCCW system. These support systems are briefly described below.

The first is the AC electrical power system that provides 3 phase, 480 V power to the three instrument air compressors. This power is provided to two of the compressors from the PF-4 north Emergency Motor Control Center (EMCC), with the third compressor being powered from the PF-4 south EMCC. Both the north and south EMCC may be provided back-up power from the on-site auxiliary diesel generator.

The second is the DC instrument control power that provides power to control signal instrumentation to maintain instrument air pressure within its normal operating band. The control logic unit for the instrument air system is powered from the Uninterruptible Power Supply (UPS).

The third is the CCCW system that provides cooling to the three instrument air compressor aftercoolers

Backup Systems. In addition to the three direct support systems discussed previously, there are three additional systems which may provide temporary direct support. First, in the event CCCW cooling is lost to the instrument air aftercoolers, industrial service water may be valved in to provide aftercooler cooling. Second, process air may be used in an emergency to provide makeup air to the instrument air receiver should all instrument air compressors be unavailable. Similarly, if both process air and instrument air are lost, the industrial air system may be used to supply instrument air loads. In this case, the industrial air system (Atlas Copco) compressor or the process air (Ingersol Rand) compressors, may provide an emergency source of instrument air through a one-way cross-connect line. Third, and last, in the event that air pressure is lost and all three compressors are inoperable, the nitrogen tube trailer may be manually connected (using a spoolpiece located inside PF-4) to the instrument air system of PF-4. The trailer may be manually connected to the instrument air system by hooking up a spoolpiece located inside of PF-4 in order to provide 135 psig nitrogen gas for temporary operation of the components supplied by the system. This source would be sufficient to run the facility for approximately one day. In order to provide 135 psig nitrogen gas for temporary, short term operation of the system.

4.2.8.4 Instrumentation and Control. Air pressure, compressor status, dryer status, and compressor power sources are monitored by the FCS continuously during normal operations (materials processing). Visual and audible alarms are triggered in the FOC; the PF-4 HVAC system is automatically shut down; and material processing operations are secured upon receipt of a low pressure (85 psig) alarm. The 1st STANDBY compressor is automatically shifted to the online compressor upon failure of the LEAD compressor to load on demand and upon reaching the loading pressure of the 1st STANDBY compressor. Upon assuming the instrument air loads, the "1st STANDBY compressor becomes the LEAD compressor. The alarm associated with the failed compressor is subsequently investigated by an operator and corrections made in order to

return it to an operating status. Upon receipt of a standby compressor alarm, (either of 2 compressors are in the 1st and/or 2nd STANDBY mode and not currently operating) an operator is dispatched to investigate and correct the problem.

4.2.8.5 Surveillance/Maintenance. Due to the redundancy in compressors, material processing operations are permitted during the performance of testing, inspection and maintenance procedures. Compressors are inspected on a monthly basis and maintenance is performed on 2000 hour service intervals. Routine calibration of flow, temperature, and pressure transmitters is not performed. Air pressure and compressor status is monitored continuously by the FCS.

4.2.8.6 Technical Safety Requirements (TSR) Limitations. In order for material processing to occur at PF-4, at least one instrument air compressor must be operational in the LEAD mode.

The following specification for compressed air is provided in (Oper. Safety, 1988).

This specification applies to the compressed air system used for pneumatic controls within PF-4. Multiple redundant air compressors are located in PF-8. This specification ensures adequate air pressure to operate PF-4 ventilation.

Specification: If compressed air pressure drops below 85 psig, the facility moves to safe shutdown condition and normal operations are terminated.

Basis: The compressed air system is essential for operation of PF-4 ventilation because pneumatically operated dampers will not operate below 80 psig.

4.2.9 Chemical Feed Systems

Both solid and liquid chemicals are used within PF-4, however, the solid chemicals are stored in either the cold support building or in chemical cabinets located throughout the recovery area. Solid and liquid chemicals are stored in separate locations in order to avoid accidents which could lead to mixing of the two phases (and types) of chemicals. The liquid chemical feed systems consist of various means of storing liquid chemicals that are used in the many processes within the PF-4 facility. In some cases the chemicals are stored remotely, and physically transferred to the use site when needed. In others, chemicals are mixed and/or stored in pressurized tanks located in room 119 of PF-3. If they are stored within PF-3, dedicated lines deliver the liquid reagents to individual use locations within PF-4. If they are only mixed in room 119, they are transferred to holding tanks which then further distribute the solutions to individual locations. In still other cases, the liquid chemicals are stored in vessels located outside PF-4; from there the liquid reagents are transferred to the locations where they are used.

4.2.9.1 System Function. The function of the PF-4 liquid chemical feed system is to provide safe storage and dispensing of liquid chemical reagents to support the many and varied processes that occur within PF-4. In addition, it serves to isolate caustic, acidic, and reactive liquid reagents, thus minimizing the possibility of accidents and spills outside of controlled areas.

4.2.9.2 Overall Configuration. The system consists of storage and/or delivery systems for liquid hydroxylamine, hydrogen peroxide, nitric acid, sodium hydroxide, potassium hydroxide, aluminum nitrate, and sodium hydroxide/sodium citrate solutions. In all cases, pipes that are used to dispense or transfer the solutions are located in visible,

readily accessible locations to enhance leak detection and facilitate repair. In addition, all final and interim dispensing points are equipped with drip/catch basins to collect overflow, drops of solution from leaky shutoff valves, small spills at the dispensing location, and drops of solution after shutoff valve isolation. Discussions of the details of each solution follows.

4.2.9.3 Chemical Feeds. This section discusses the components of the major chemical feeds for Building PF-4.

Hydroxylamine. Liquid hydroxylamine is stored in small, 13 gallon containers located in room 422 of PF-4. Room 422 is a small room used only to store hydroxylamine in order to preclude the possibility of interaction with either hydrogen peroxide or nitric acid which could lead to an explosion. When called for in the process, a container is moved to a rack located near the actual use site and upon completion, it is returned to room 422 until needed again.

Hydrogen Peroxide. Liquid hydrogen peroxide, 30% concentration is stored in an insulated vessel located outside the PF-4 building. Permanent stainless steel piping is used to deliver the liquid solution to individual processes where the reagent is used.

Nitric Acid. Concentrated nitric acid is stored in a 6100 gallon tank which is located outside the PF-4 building. The tank acts as a secondary containment in the event of a leak or spill. It is routed to bulk acid dispensers located inside PF-4 through permanent, underground stainless steel piping. Vacuum transport is used to assist in the transfer of the acid from the 6100 gallon tank to the bulk acid storage dispensers.

Sodium Hydroxide. A 9.9 Molar solution of sodium hydroxide is prepared in a 100 gallon tank located in room 119 of building PF-3. The tank is equipped with a high velocity ventilation system to remove caustic vapors during the mixing process. Upon completion of mixing, the solution is transferred using vacuum assistance to stainless steel holding tanks. These holding tanks are then pressurized to 20 psig to enable delivery of the solution through individual stainless steel lines to select areas within PF-4.

Potassium Hydroxide. A 11.0 Molar solution of potassium hydroxide is prepared in a 150 gallon tank located in room 119 of building PF-3. The tank is also equipped with a high velocity ventilation system to remove caustic vapors during the mixing process. Upon completion of mixing, the solution is transferred using vacuum assistance to stainless steel holding tanks. These holding tanks are then pressurized to 20 psig to enable delivery of the solution through individual stainless steel lines to select areas within PF-4.

Aluminum Nitrate. A 4.3 Molar solution of sodium hydroxide is prepared in a 20 gallon tank located in room 119 of building PF-3. Upon completion of mixing, the solution is transferred using vacuum assistance to stainless steel holding tanks. These holding tanks are then pressurized to 20 psig to enable delivery of the solution through individual stainless steel lines to select areas within PF-4.

Sodium Hydroxide/Sodium Citrate. A low concentration solution of sodium hydroxide with sodium citrate is prepared in a 60 gallon tank located in room 119 of building PF-3. Upon completion of mixing, the solution is transferred using vacuum assistance to stainless steel holding tanks for storage and further distribution to individual glove boxes. These holding tanks are then pressurized to 20 psig to enable delivery of the solution through individual stainless steel lines to select areas within PF-4.

4.2.9.4 System Interfaces/Support Systems. The chemical feed system depends on the vacuum system for transporting the liquid reagents to the appropriate process area.

4.2.10 Gas Feed Systems

There are a number of gases used for various processes within the PF-4 facility. Some of the gases are flammable, some are inert, some are corrosive/toxic, and some are nonflammable/nonexplosive or inert-flammable mixtures. The latter mixtures remain nonflammable/nonexplosive, and henceforth will be grouped into the nonflammable/nonexplosive category. The flammable gases used within the PF-4 facility include: hydrogen, fluorine, ethane, methane, and acetylene. The inert gases include argon and helium. The corrosive/toxic gases include chlorine and hydrogen fluoride. Finally, the nonflammable gases include: oxygen, carbon dioxide, nitrogen, and, argon-hydrogen and argon-methane mixtures. Flammable, nonflammable, inert, and corrosive gas cylinders are stored within physically separated areas outside the PF-4 building. The following sections discuss the four types of gases used including the individual delivery system descriptions, and the process areas in which each type of gas is used.

4.2.10.1 System Function. The function of the PF-4 gas feed system is to provide safe storage and dispensing of gaseous reagents to support the many and varied processes that occur within the PF-4 100, 200, 300, and 400 areas.

4.2.10.2 Flammable Gases. Flammable gases used for processes within the PF-4 building are stored in H-size cylinders outside of the building. The flammable gases are stored outside of PF-4. Although they are located outside the building, the storage cylinders are located as close to the actual process locations as possible in order to minimize the delivery pipe length. In addition, excess flow valves have been incorporated into the main supply lines outside the PF-4 building for all flammable gases used within PF-4 in order to provide immediate isolation in the event a large leak (and associated high main header flow) is detected.

Hydrogen. Hydrogen is used only in Room 114, and is stored in a steel gas cabinet in that room. Hydrogen is used for various process functions within PF-4. Hydrogen leak detection is provided within PF-4.

Fluorine. Fluorine is provided to six gloveboxes within PF-4. Fluorine is stored outside the PF-4 facility in H-sized cylinders and is piped to the necessary process locations via short length lines primarily located in the basement of PF-4. Figure 4.2.10-1 displays the routing of fluorine piping in the PF-4 basement. A schematic diagram of the fluorine gas supply system is given in Figure 4.2.10-2.

Methane. Methane is used for processes as well as for direct measurement radiac devices within PF-4. As with hydrogen and fluorine, the majority of it is stored in H-size cylinders outside of PF-4. Small methane cylinders are located inside PF-4 to support the radiacs previously mentioned.

Ethane. Ethane is used in very small quantities within PF-4. Therefore, it is stored in 60 pound cylinders within the rooms in which it is to be used.

Acetylene. Acetylene is used for welding only within PF-4. It is stored in 60 pound cylinders within the rooms in which it is to be used. The cylinders are stored on welding carts and are transported to various locations as needed.

4.2.10.3 Inert Gases. Inert gases are used in various inert atmosphere processes within PF-4. The two gases used in appreciable quantities within PF-4 are argon and helium. Both gases are stored outside of PF-4 in tube trailers outside of PF-4. In addition, a 5000 gallon argon dewar is located outside the west wall of PF-4. The argon dewar provides the majority of argon for daily usage during normal operations. Small quantities of other inert gases, such as xenon, are stored in small cylinders and are located outside PF-4 near the process areas in which they are used. The gases are piped through approved building wall penetrations except in some cases small cylinders are stored within the process area where the gas is used. In all cases small inert gas leaks would be rapidly dissipated by the ventilation system which exchanges the atmosphere seven times per hour.

Argon. Argon is used in numerous processes in PF-4. In addition, it is used to purge other toxic/corrosive gas lines from the outside to the inside of PF-4 upon completion of use of the toxic/corrosive gas. This minimizes the corrosion of the handling pipe, as well as eliminating the risk of a toxic/corrosive gas leak within PF-4 during non-duty hours. The majority of argon used within PF-4 is stored onsite outside of PF-4 in the argon dewar on the west wall of PF-4. A tube trailer provides backup and emergency supply of argon. Switchover to the tube trailer is effected from the dewar if argon gas pressure from the dewar reaches 25-30 psig. However, small quantities of argon are stored in small cylinders in a few rooms. In all cases, the cylinders do not exceed 60 pounds total capacity.

Helium. Helium is used in processes in PF-4. The majority of helium used within PF-4 is stored outside of PF-4 in tube trailers. Small cylinders are stored inside PF-4 for use.

4.2.10.4 Corrosive/Toxic Gases. Corrosive and toxic gases are stored external to PF-4 in room 116 of PF-3 in cylinders ranging in size from Matheson 2P to Matheson 1V. Room 116 temperature is maintained at 75 deg F by a steam radiator. In addition, automatic fans are provided and are switched on manually or upon opening the door into the room. These fans ensure that any leaks are uniformly dispersed, and may be used to circulate room air in order to maintain a uniform temperature throughout the room. The toxic/corrosive gases used within the processes in PF-4 include chlorine and hydrogen fluoride. The gases are piped into PF-4 using small diameter piping which is mounted so as to prevent any physical damage to piping which may be due to earthquakes or other shock loadings. Room 116 and the locations where the corrosive/toxic gases are used are monitored for gas leaks using TLD-1 detectors manufactured by MDA Scientific Inc. Local and remote FOC alarms sound if the threshold limit values (TLV) are exceeded for the monitored gas.

Chlorine. Chlorine is used in Rooms 116 and 209 to support processes within PF-4. All of the chlorine is stored within room 116 of building PF-3 in two Matheson 1V (150 lb) size cylinders. A schematic of the Chlorine gas supply system is provided in Figure 4.2.10-3.

Hydrogen Fluoride. Hydrogen fluoride is used in processes within PF-4. The majority of the hydrogen fluoride is stored within room 116 of building PF-3 in 14 cylinders (60 lbs each). On some occasions, small cylinders are brought into the PF-4 building for various process reagent uses inside fume hoods.

4.2.10.5 Nonflammable and Nonexplosive Gases. The nonflammable and nonexplosive gases used inside the PF-4 building include oxygen, carbon dioxide, nitrogen, and argon-hydrogen and argon-methane mixtures. These gases are stored in either H-size cylinders or tube trailers (if the amount used justifies the larger amount stored) outside the PF-4 building.

Oxygen. Oxygen is used in processes within PF-4. All of the oxygen is stored outside of building PF-4 in a single H-size cylinder. Transport consists of a distribution header and piping network entering PF-4.

Carbon Dioxide. Carbon dioxide is used in processes within PF-4. All of the carbon dioxide is stored outside of building PF-4 in a single H-size cylinder.

Nitrogen. Nitrogen is used in processes within PF-4. All of the nitrogen is stored outside of building PF-4 in a single H-size cylinder. Nitrogen gas could be (it is presently not in use) supplied from the 5000 gallon liquid nitrogen dewar located outside the PF-4 building. Should the dewar be employed, a vaporizer is used to convert the liquid nitrogen to gas at a regulated pressure of 50 psig. If the dewar is used, it is the primary source of nitrogen gas with the tube trailers providing a backup source should pressure fall below 40 psig. The current configuration has 50 psig nitrogen being supplied directly from the nitrogen tube trailer.

Argon-Hydrogen Mixtures. Argon-hydrogen mixtures are used in processes within PF-4. All of the mixtures are stored outside of building PF-4 in individual H-size cylinders.

Argon-Methane Mixtures. Argon-methane mixtures are used in processes within PF-4. All of the mixtures are stored outside of building PF-4 in individual H-size cylinders.

4.2.10.6 Instrumentation and Control. Instrumentation for these systems consists mostly of local gauges only. Low pressure mercury switches are installed on all tube trailers. These switches activate remote audible and visual alarms in the FOC when individually preset low limits are reached.

4.2.10.7 Technical Specifications Requirements Limitations. Original facility design specifications and information given in (Matheson Gas Data) are used for technical specifications requirements.

4.2.11 Waste Treatment System

The waste treatment system consists of equipment and facilities for receiving and treating sanitary waste, industrial waste, utility waste, and liquid process waste.

Sanitary waste includes material from one of the following categories:

- showers, urinals, water closets, and lavatories outside of PF-4
- sinks in chemical laboratories where no radioisotopes are handled, and,
- sink drainage and floor washings from the cafeteria.

Industrial waste includes the following types of waste generated in PF-4:

- janitor's sinks,
- decontamination shower drains,
- overflow from the Positive Pressure Circulating Chilled Water System,
- laboratory sinks,
- basement sumps, and
- process heating and cooling condensates.

Utility waste includes material generated from the following:

- overflow from negative process chilled water systems,
- decontamination activities, and
- seal water from vacuum systems.

Liquid process waste includes acid and caustic materials that are generated in various processing operations.

4.2.11.1 System Function. The function of the waste treatment system is to collect and process the various categories of waste described above. The processing of the waste is done to render the materials in forms suitable for release to the environment or for long term storage.

4.2.11.2 Overall Configuration. The major elements of the waste treatment system are described below.

Sanitary Waste. Sanitary waste is collected into a lagoon/sand filter sewage treatment facility located east of TA-55. The releases of material from this treatment facility meet all applicable local, state, and federal standards.

Industrial Waste. Industrial waste material is discharged from PF-4 by gravity flow in double encased lines to the Radioactive Liquid Waste Treatment plant at TA-50. The waste is continually monitored for gamma radiation prior to leaving PF-4. In addition, waste flow rate and radiochemistry data are gathered at the entry point to the Radioactive Liquid Waste Treatment plant. A sampling device at the treatment plant entry point takes grab samples every 15 minutes. The liquid is also monitored for alpha activity every 2 weeks.

Utility Waste. Utility waste is transported via double-encased acid and caustic lines to the Radioactive Liquid Waste Treatment plant at TA-50.

Liquid Process Waste. Liquid process waste is discharged from PF-4 in double encased lines to the Radioactive Liquid Waste Treatment plant at TA-50. The acid process waste is routed in stainless steel inner carrier lines, while the caustic process waste is routed in a monel inner carrier line. The outer lines that surround both types of inner carrier lines are constructed from polyvinyl chloride (PVC). Radioactivity levels in the annular pipe spaces are continuously monitored.

The acid and caustic lines are connected to separate stainless steel storage tanks located at TA-50. These two storage tanks are stirred and sampled for americium, Pu-238, and Pu-239 at two week intervals.

4.2.12 Vacuum Systems

There are four types of vacuum systems employed within the PF-4 facility, a wet vacuum, a dry vacuum, an ultra-high vacuum, and a fixed head and CAM vacuum system. The first three are discussed in this section while the fixed head and CAM vacuum system is discussed in the section on facility monitoring. All three of the systems described below are used in various process applications.

4.2.12.1 System Function. The function of the PF-4 vacuum systems vary according to the three types of systems, wet, dry, and ultra-high. The wet vacuum systems are used primarily to transfer corrosive or toxic liquid solutions from larger mixing tanks into smaller, localized stainless steel holding tanks. The dry vacuum systems are used to

provide a moderate negative pressure environment for various individual processes (glove boxes) in PF-4. The ultra-high vacuum systems are used to provide high negative pressure environments at specific glove boxes throughout the PF-4 facility.

4.2.12.2 Overall Configuration. The three types of vacuum systems consist of various components as outlined by each type of vacuum system below.

Wet Vacuum. The wet vacuum system provides a vacuum source for transfer of caustic/toxic liquid chemicals that are used within the individual glove boxes. The system consists of a number of distinct systems providing vacuum services to various glove boxes in the 100, 200, and 400 areas. There are essentially two sizes of wet vacuum systems: 1) a large system capable of approximately 170 cfm at 19 in Hg, and 2) a small system capable of approximately 50 cfm at 19 in Hg. Small systems containing a single vacuum pump are used in rooms 111, 205, 212, 401, and 415. Rooms 407 and 427 utilize large vacuum systems.

The wet vacuum systems are virtually all identical in terms of equipment design and performance, a single vacuum pump (small or large) draws vacuum on an overflow flask which is in turn connected to a basement or main floor level header (usually a 3 inch pipe located at basement or main floor ceiling level). Seal water is provided to each pump from a seal water storage tank located within each pump room. Seal water is manually refilled and checked daily for each pump room. In room 427, the header is run in the basement between 427 where the pump is located, and 429 where the glove box wet vacuum loads exist. Wet vacuum systems are located in the 100, 200, and 400 areas. There is no wet vacuum system in the 300 area. In all of the wet vacuum areas, the main header runs lengthwise across the individual area it is dedicated to serve. At locations where wet vacuum is needed for use in the glove box(es), a tap is made into the header (sometimes through a floor penetration) with an isolation valve present at the tap/header junction. In addition, a normally closed pneumatic main header split out valve is present in the 400 area providing capability of splitting out loads within rooms 401, and 409/420. All systems operate in the range of 12 to 20 inches of mercury vacuum, and are potentially contaminated with radioactive elements from the various processes that the systems support. The wet vacuum system in room 111 runs in a demand mode. The wet vacuum system in room 205 is occasionally run in a demand mode if the loads are expected to be small, but it and all other wet vacuum pumps are normally run continuously. One final note, the wet vacuum pumps and tanks are normally located in a separate room or enclosure which is typically isolated from the main glove box rooms in order to minimize the potential for spread of contamination.

The small and large pumps are constructed entirely of stainless steel, manufactured by Nash Engineering. The small pumps are Model MD673 and are being replaced by MHF50 pumps as they reach the end of life. Similarly, the large pumps are Model CL202 which are also being replaced by Model SC2 pumps as required.

Except as previously noted, the pumps run 24 hours per day, every day, and only when pump problems are detected requiring pump replacement are they secured. In order to detect trends in pump performance and maintain seal water within normal levels, daily logs are kept on pump vacuum and seal water level. Because individual pump vacuum gauges are not calibrated, only trends in vacuum pump performance may be detected.

Dry Vacuum. The dry vacuum system typically consists of a single mechanical vacuum pump located underneath the compartment (and associated glove box) to which it provides vacuum service. The piping passes from the basement into the compartment/room in which it serves through floor penetrations.

Ultra-High Vacuum. This system consists of a mechanical fore (roughing) pump and a diffusion pump to achieve and maintain high vacuum conditions. The roughing and diffusion pumps, and all piping are generally located beneath the single glove box serviced by the system.

4.2.12.3 System Interfaces/Support Systems. The wet vacuum system provides support to the chemical feed system. The dry vacuum system discharges into the Zone 2 bleed-off of the ventilation system. Some vacuum pumps require positive pressure chilled cooling water, and all pumps rely on electrical power for operation.

4.2.12.4 Surveillance/Maintenance. The wet vacuum pumps are checked a minimum of once per day. The vacuum readings are taken of the vacuum with no load. A daily data log is kept for readings of pump vacuum and seal water level.

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