WASTE EXPERIMENTAL REDUCTION FACILITY

DESCRIPTION AND PROGRESS REPORT

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ABSTRACT

This paper traces the establishment of and describes the current characteristics of the Waste Experimental Reduction Facility, now processing low level beta/gamma contaminated waste at the Idaho National Engineering Laboratory. It outlines principal findings and facility and procedural changes that occurred during the facility startup period (September 1982 to July 1983) while sizing (cutting) and melting uncontaminated metal in preparation for processing contaminated metal, which commenced in July 1983. It also describes processing experiences thus far with contaminated metal.

INTRODUCTION

The Waste Experimental Reduction Facility (WERF) is a waste processing facility established at the Idaho National Engineering Laboratory (INEL) to reduce the volume of low level beta/gamma contaminated waste being disposed of at our radioactive waste disposal site and thereby prolong the disposal site's useful life; and develop waste processing technology by providing a facility where full size processes and equipment can be tried, modified as necessary and proven for contaminated waste processing applications.

At WERF, capabilities are being developed to:

- Size reduce contaminated metal at a rate of several hundred tons per year
- Melt contaminated metal at a rate of several hundred tons per year and cast it into ingots for disposition
- Incinerate contaminated combustible waste at a rate of 400 pounds per hour

This paper provides a report on actions involved in getting the facility operational and on findings and facility changes made during activities thus far.

BACKGROUND

Few incentives existed in the past to reduce the volume of low-level beta/gamma contaminated waste generated, because disposal of such waste was relatively inexpensive. However, in recent years costs have increased considerably and the trend is continuing toward still higher cost.

Simultaneously with this trend, the remaining space within our radioactive waste disposal site steadily decreased as about 5000 m^3 to 6000 m^3 of β/γ waste was disposed of there annually, and projections indicated that without corrective actions this site's space would be entirely filled in another two or three decades.

The above trends caused volume reduction to become more attractive. Prompted by this, and because analyses of the waste being placed in the disposal site indicate that about one third of the volume was occupied by metal objects and another third was occupied by combustible materials, it was decided that by melting most of the incoming metallics and incinerating most of the incoming combustibles, the overall volume of the waste could be halved and the remaining useful life of the disposal site could be doubled.

This led to consideration of the characteristics required for a facility that could accomplish this; to consideration of the time required to establish such a facility; and the economics involved.

Our objectives included creating a facility as inexpensively and rapidly as practical. Since analysis of the waste being placed at the disposal site indicated that more than 80% of its volume is occupied by lightly contaminated waste (below 10 mrem/hr at near contact), the approach taken was to base the design on contact handling of the waste, but to lay the facility out so that shielding could be added later and remotization could also be added when and if desired.

Off-the-shelf equipment or equipment already proven by others was to be used where possible. A building formerly occupied by a test reactor (the SPERT III reactor) was selected as the location, since it provided space that would be adequate for much of the facility's equipment.

The decision to proceed with design for metal sizing and melting capabilities was made and Title I design commenced in January 1981. Construction was completed in the summer of 1982 and the first trial metal melting operation was conducted in September 1982. Trial melting activities continued till July 1983, accompanied by miscellaneous equipment and procedural modifications. The first contaminated metal operation was conducted in July 1983, by commencing to cut up and melt the piping and components of the SPERT III reactor (which had been left at the site for this purpose). Contaminated metal processing operations have continued since that time. Thus far, approximately 150,000 lbs have been processed.

The total cost for design and construction to establish sizing and melting capabilities was about $2-1/2 million.

The decision to proceed with design for incineration capabilities was made and Title I design commenced in January 1982. Construction sufficient to permit commencing trial burns was completed in September 1983. After system testing and procedure finalization, trial burns with uncontaminated waste are scheduled to commence near the end of this month. The first contaminated waste burn is scheduled to occur by September 1984.

The estimated total cost for design and construction to establish incineration capability is about $3 million, at completion.

FACILITY DESCRIPTION

Building Description

The original SPERT III reactor building was modified to adapt it to WERF. A basement room extension was constructed along the north side to house two furnace power supply units. The second extension consists of both a basement and above-ground extensions and was constructed along the east side to house the incinerator, provide for incinerator auxiliary equipment, and provide separate areas in the basement for ingot cooling, ash collection, and waste processing. The third extension is the emergency generator room, attached to the northwest corner of the original building (see Fig. 1).

The first floor area (see Fig. 2) includes: a receiving area; high-bay process and off-gas treatment area; incinerator room and auxiliary equipment room; emergency generator room; HP office and instrument room; a switchgear room; a restroom; a lunch room; a storeroom and an office.

The lower floor (see Fig. 3), with the exception of the control room and the furnace power supply room, is intended for handling low-level beta-gamma contamination in operational amounts. Therefore it is specifically equipped and ventilated to provide positive containment. All surfaces are finished to reduce the difficulty of decontaminating them. The lower floor includes the control room, furnace equipment room, 2 furnace rooms, a transfer room, an ingot cooling room, a cleaning room, and rooms for incinerator ash handling.

During the SPERT III decommissioning a concrete pad was built to store the contaminated piping, components, and reactor vessel removed from the building, for future processing in WERF. This pad also now serves as a receiving area for waste sent to WERF by the generators. On a portion of this pad a 40 ft by 60 ft metal building was built to house equipment and some waste.

Waste generators are now required to segregate their ferrous metallic waste (and later also their combustible waste) and place it into reusable metal shipping containers which will be sent to WERF and stored on the pad.

SIZING ACTIVITY AREA DESCRIPTION

This Activity is located within the abovementioned metal building and consists of a Herculite entrance chamber and a 20 ft by 24 ft sizing room (see Fig. 4).

Containers with metallic waste are moved from their stored locations on the interim storage pad via forklift and placed inside the sizing room entrance. The containers are opened, the metallic objects are sorted, and small amounts of residual thermal insulation and other undesirable materials are removed from objects to be sized. Due to the nature of the operations being conducted, it is required that full-time respiratory protection be worn while dust or fume producing work is in progress.

Metallic wastes received are reduced in size as necessary for later loading into an induction furnace crucible. This sizing can be accomplished using several techniques, though plasma arc torch cutting has generally been found most efficient and is used in most cases.

Once the objects are size reduced they are placed in a sealable metal transfer container that is interfaced with a lidded opening in the wall of the sizing room, and then the transfer container is sealed shut and transported to the hatch in the WERF building main floor leading to the basement. Once the hatch is opened the container is placed on a scissors lift and lowered into the transfer room of the basement. The scissors lift is fully enclosed and serves as an airlock between the basement and the main floor.

A ventilation system exhausts the sizing room, combining with the main facility exhaust and passing through the baghouse and HEPA filter bank. Point of operation exhaust is used to the maximum extent practical for all cutting operations. This serves to minimize fugitive emissions and resultant airborne radioactivity, surface contamination, and personnel exposure to toxic fumes.

MELTING ACTIVITY AREA DESCRIPTION

This Activity is located in the basement and is comprised of a control room, furnace equipment room, two furnace rooms, a transfer room and ingot cooling room.

The control room is used as the main entrance for personnel access to the basement, provides a place for viewing the basement activities and serves as a central point for controlling melting and incineration operations. Windows and closed circuit television have been installed, enabling the operators and visitors to monitor melting and sizing operations. Hydraulic controls and remote furnace controls have been installed, allowing direct control of melting and pouring from this room.

The furnace equipment room is located on the north end of the building adjacent to the control and furnace rooms. This room houses the two furnace power supplies.

Two furnace rooms have been constructed, each to house a coreless induction furnace. In Furnace Room #1 a 1500 lb furnace has been installed. In Furnace Room #2 a furnace can be installed for future developmental work and as a backup to the main furnace.

The furnaces have been fitted with close-capture fume hoods for the removal of metal fumes and smoke. The hoods are mounted to the tops of the furnaces and connected to the main exhaust duct via telescopic ducts and swivel joints to allow for movement while pouring.

When a sealed transfer container containing sized metal reaches the basement, it is picked up by a forklift, carried across the transfer room, and inserted into a lidded opening in the furnace room wall. The lids are opened from within the furnace room by a technician in forced-air respiratory equipment and anti-contamination and heat protective clothing and the sized metal is lifted from the transfer container and charged into the furnace crucible. The metal is then melted, slagged, and poured into a reusable metal mold sized to hold the entire contents of the furnace. The mold and ingot are then removed from the furnace room to the ingot cooling room. When adequately cooled the ingot is removed from the mold, packaged, and shipped to the waste disposal site.

INCINERATION ACTIVITY AREA DESCRIPTION

The major portion of this activity is located in the new east wing of the building, with some support equipment located in the high bay.

The principal equipment for this activity is a dual-chambered controlled air incinerator manufactured by Environmental Control Products. As mentioned previously, this equipment is not yet operational, but is undergoing startup testing.

Combustible low-level radioactive waste as received from the generators is to be prepackaged in 2 ft x 2 ft x 2 ft corrugated cardboard boxes with internal sealed polyethylene liners. These cardboard boxes containing waste are placed on a conveyor. The primary function of the feed conveying and inspection system is to transport the combustible material from the feed staging area to the incinerator feed mechanism, while monitoring for specific conditions enroute.

For informational and control purposes, each box will be weighed by a conveyor mounted scale. This data provides the operator with a guide to either slow down or increase the feed rate. The incinerator is designed to handle 400 lb/hr of 12,000 Btu/lb waste. This equates to about seven to ten boxes of waste per hour, using a waste density of 5 to 7.5 lb/ft^3. This data will be recorded and periodically used in evaluating the incinerator's performance.

Radiation intensity from each box will be measured and recorded. Only those boxes reading 10 mR/hr or less will be initially processed. Boxes exceeding this level will be flagged and rejected by the system for subsequent sorting or alternate disposal.

Although some noncombustibles are acceptable to the incinerator, large pieces may interfere with the ash removal process and subsequent treatment methods for ash disposal (i.e., solidification). For this reason and to preclude explosive liquids, conveyed waste is also monitored for non-combustibles and liquids through x-ray inspection, using a standard airport-type x-ray unit, in-line with the conveyor. A video monitor is provided in the control room along with controls to allow remote operation of the x-ray unit.

Waste feed material is admitted to the primary combustion chamber through a gravity drop chute. Initial energy for combustion is provided by burners using #2 fuel oil. In the primary chamber burning takes place in a slightly oxygen deficient environment. As the gases pass into the secondary chamber, they are burned in the presence of 100% excess air. Incineration in this manner allows for complete combustion with minimal disturbance of the ash, thus minimizing the amount of particulate carried over into the exhaust system. Both chambers of the incinerator have been extended four feet in length to assure complete combustion through increased residence time (2 sec at 1100°C).

A ram is provided in the bottom chamber that periodically pushes the ash into a hopper for storage and cooling. When cooled sufficiently, a slide gate will be opened allowing the ash to drop into drums located in the ash collection room in the east wing basement.

OFFGAS TREATMENT SYSTEM DESCRIPTION

Exhaust gases from the sizing room, incinerator, furnaces, and exhaust from other basement activities are collected for treatment and filtration in a common system prior to discharge from the facility. The integrated system, however, can be divided into several subsystems.

Incinerator Offgas Treatment

Combustion gases leave the incinerator at about 2000°F and are immediately cooled to 1400°F using dilution air from outside the facility. Further cooling of the combustion gases is accomplished using a tube-and-shell air-to-gas heat exchanger, with gases leaving the heat exchanger at about 750°F. This two-step cooling process was selected to minimize thermal stress problems across the heat exchanger caused by the large difference in temperatures and reduce high temperature corrosion problems. Excess process heat is removed from the heat exchanger and incinerator room using independent exhaust systems and exhausted through a separate stack (south of the facility).

Furnace Offgas System

The induction furnaces have been fitted with close-capture fume hoods for the removal of smoke and fumes generated during the melting process. These are designed to operate at 2500 cfm and capture all of the smoke and fumes generated during melting. Further downstream, the ducting provides a drop-out point for larger particulate through a reduction in velocity and cyclonic action. The air from the furnaces, along with the cleaning room exhaust, joins directly with the main exhaust stream, reducing the incinerator offgas temperature to about 350°F.

Sizing Room Ventilation

Air, smoke and fumes are drawn from the sizing room via a duct that connects into the main exhaust system upstream of the baghouse filter in the WERF high-bay.

Baghouse Filter

A large capacity (16,000 cfm) baghouse filter is installed in the main exhaust stream upstream of the HEPA filters. This filter eliminates much of the dust and particulate (99%) that would otherwise be deposited on the HEPA filters, resulting in longer filter life and less frequent changeout.

Air and gases introduced into the baghouse are filtered by fabric bags and the particulate matter is deposited on the outside of these bags, forming a cake. Up to a point, the buildup of this cake results in an increase in filter efficiency. At a predetermined differential pressure as sensed by a photohelic gauge, a cleaning cycle is initiated that pulses a reverse flow of compressed air through the bags, row by row, until the pressure drop is reduced to an acceptable level. In this manner, the baghouse is self-cleaning, with the resultant particulate material dropping to the hopper for subsequent removal.

The bag filters are fabricated of Huyckglas, a fire resistant material which can withstand temperatures up to 500°F. To provide fire protection for the baghouse, spark arrestors have been installed upstream of the bag filters, and a Halon fire suppression system has been installed in the baghouse housing.

HEPA Filter Unit

A high-efficiency particulate (HEPA) absolute filter is installed downstream of the baghouse to act as a final filter for the facility exhaust. The efficiency of the filter is 99.97% for removal of particles of 0.3 microns. The filters are designed to operate at temperatures up to 500°F.

Stack Effluent Monitoring

A continuous air monitor is installed to constantly sample the air released from the facility through the main stack (the stack north of the facility). Indication of the airborne radioactivity of the main stack effluent is displayed on the front panel of the unit, and a remote alarm is provided in the control room. In addition, the filter is routinely removed, replaced by a new filter, and analyzed for gross radioactivity using a simultaneous alpha and beta-gamma smear counter.

DEVELOPMENTS DURING SIZING & MELTING STARTUP

The staff for the facility consists of the WERF Manager, who has overall responsibility to see that the facility and its personnel, procedures and equipment are satisfactory and perform well in executing the approved work program; an Operations Support Engineer who provides supporting services; the Operations Supervisor, who directly supervises the operations technicians in their work activities; four operations technicians; and two health physics technicians.

Mechanical cutting devices have generally been found too slow for production work and too limited in applicability so a plasma torch is used for most cutting operations. Initial metal cutting operations with the plasma arc torch, using nitrogen in the plasma and blanket gases, produced much heavy smoke which would have excessively loaded the offgas filtration system. This situation was improved by changing to a 65% argon 35% hydrogen mixture for plasma gas and to argon for the blanket gas, which greatly decreased smoke generation. However, the baghouse still experiences self-cleaning difficulties, and further changes are planned. One of these will be to install a local self-cleaning cartridge type plasma arc torch offgas filtration unit (manufactured by Torit) to filter this offgas before it reaches the main baghouse.

A decision to physically separate the sizing room location (now in the metal building on the concrete slab north of the main building) from the furnace rooms (in the basement of the main building) required devising an efficient and radiologically satisfactory method of transferring sized metal from the sizing location to the furnace room through areas that are maintained radiologically clean. This was accomplished by designing and constructing relatively inexpensive sealable transfer containers that could be inserted into lidded receptacles in the walls of the sizing room and furnace room.

Special heat protective clothing using aluminized Pereox material (a carbon base synthetic replacement for asbestos), was procured and modified for compatibility with anti-contamination clothing and special intercom headsets. It has performed satisfactorily. The smooth aluminized surface decontaminates more easily, and the carbon base Pereox fabric can repel molten ferrous metal splashes.

Ordinary intercom equipment was found unusable for communications between personnel in the furnace rooms and the control room because of the electromagnetic interference induced by the coreless induction furnace. This problem was solved by changing to intercom equipment utilizing ceramic receivers and carbon element noise cancelling microphones by GAI-TRONICS.

Early metal melting operations, by partly melting some plastic objects on the furnace room walls, revealed the need to shield the relatively small furnace room from the radiant heat emitted when the ingot is poured. This problem was corrected by devising a heat shield, like a cake pan, that envelops most of the ingot mold and from which air is drawn via a flexible duct to the ventilation exhaust system. The top of the initial heat shield turned cherry red and sagged slightly, and so was replaced by a second model that has worked well.

Although a closed circuit television camera with a neuvicon tube and an automatic iris was installed for viewing into the crucible from the control room, it has not worked well due to emf noise generated during operation of the furnace. However, a metal mirror installed at a slant on the ceiling has served the purpose nicely.

An optical pyrometer installed on the ceiling of the furnace room (reportedly made for this kind of service) has thus far not provided crucible temperature readings at all close to actual temperatures--even after repeated efforts to get it to work satisfactorily. Immersion thermocouples with replaceable heads have worked well and are in use.

A considerable number of sparks emanated from the furnace crucible during metal melting, and these were considered likely proportional to particulate radioactive contamination spread within the furnace room during later operations with contaminated metal. Nevertheless it is necessary to be able to see into the crucible during melting operations. To minimize these sparks, a hinged metal screen was installed atop the ventilation hood on top of the furnace, and this prevents nearly all sparks from escaping, while still being easy to see through. The entire melting operation involves very few escaping sparks and virtually no smoke in the furnace room.

Ferrous metal not known to be free of plating such as cadmium and zinc should be tested before insertion into the furnace, as these plating materials will boil off vigorously and could displace molten metal from the furnace.

Excessive metal superheat in the furnace tends to increase the erosion rate of the crucible refractory, and paint on the metal being melted may tend to do the same. So far as many as forty-four 1400 lb melts have been made before a refractory change, but it appears likely that between 50 and 100 can be obtained through close control of operating conditions.

After a metal pour it is best to leave the crucible tilted about 30 degrees from vertical for a short time so that the small heel of metal remaining in it can solidify off the crucible centerline. Otherwise its presence at the centerline on the crucible bottom leads to inaccurate measurements of the interior dimensions of the crucible refractory--measurements taken between melts that are important to guard against excessive thinning of the refractory wall and a molten metal run-out as a result of refractory failure.

To improve radiological control and decrease the likelihood of contamination spread through the transfer room when the newly cast ingot is transferred to the ingot cooling room, a track-mounted cart was devised for supporting the mold while within the heat shield during pouring, and for allowing the mold with its ingot to be withdrawn by a reach-rod and picked up from the cart by a forklift--without necessity for the forklift to enter the furnace room.

CONTAMINATED METAL PROCESSING

Thus far, the contaminated metal processed has mainly consisted of about 150,000 lbs of SPERT III reactor piping, which was completed recently. This piping was lightly contaminated--up to about 1,000 counts per minute above background.

After each contaminated melt, samples and smears from various locations have been analyzed for radioactive isotopes and none has been found except very light (several hundred cpm) non-smearable radioactivity at near contact with the ingots themselves. None has been found remaining in the sorting/sizing room, in the mold, in the furnace crucible, on the furnace room floor, or in the offgas control system. Only very slight traces of contamination (pico-curie amounts of Co^{60}) have been found on any of the continuous air monitors or other air particle detector filters.

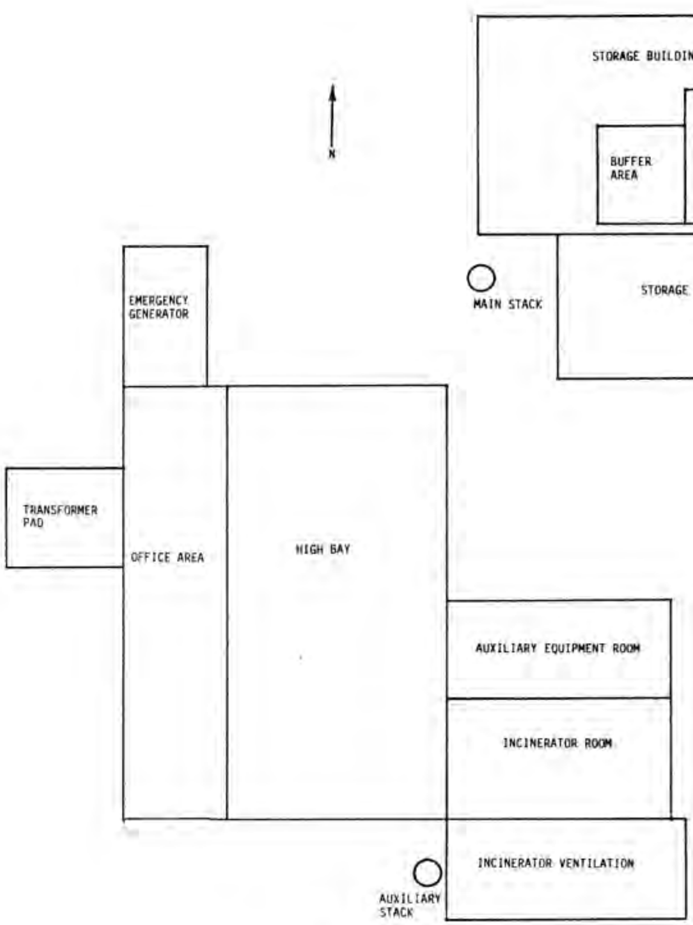

Fig. 1. WERF Processing Areas

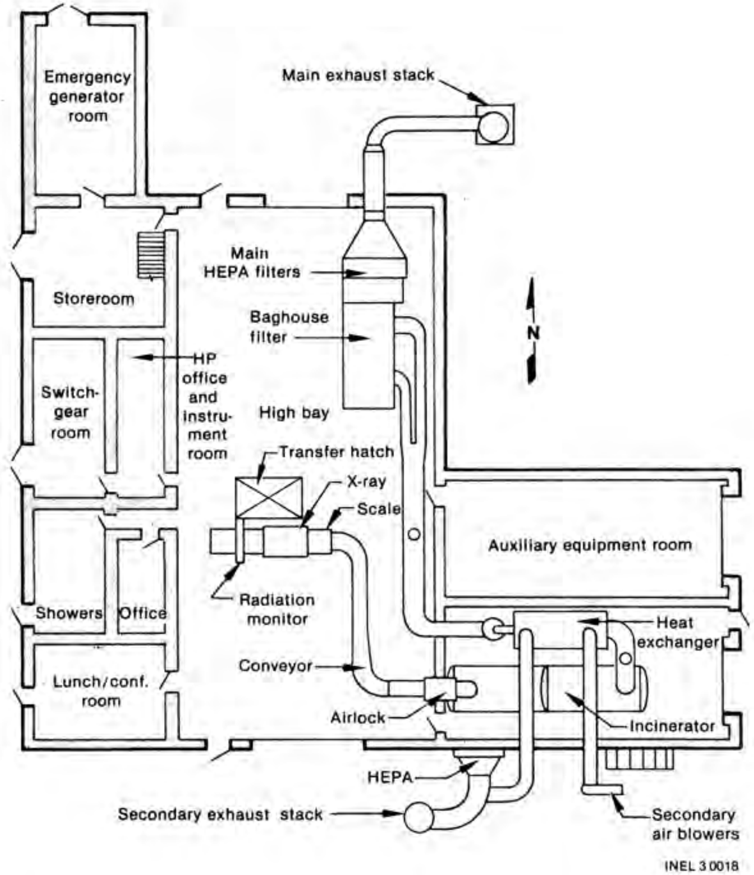

Fig. 2. Waste Experimental Reduction Facility - Main Floor Plan

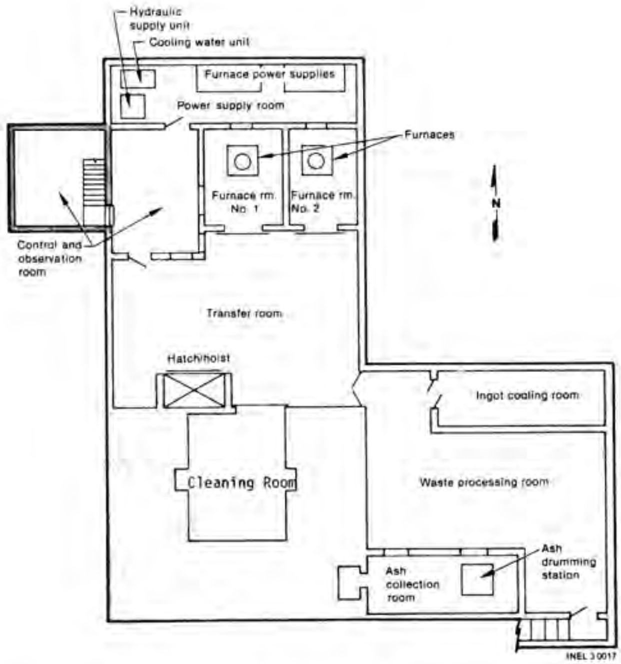

Fig. 3. Waste Experimental Reduction Facility - Basement Floor Plan

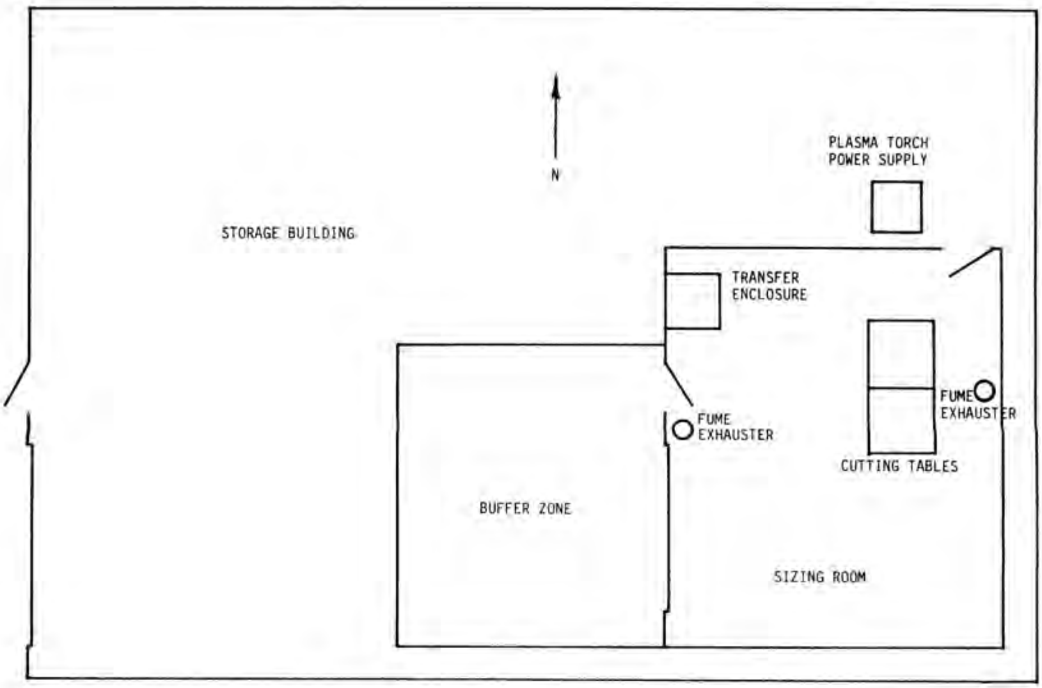

Fig. 4. Storage Building & Sizing Facility