DAB, SOUTH SIDE, ODH ANALYSIS

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DAB SOUTH SIDE, ODH ANALYSIS

DAB SOUTHSIDE ODH HAZARD OUTLINE

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Introduction

This report covers the ODH concerns of the south side of the DØ Assembly Building, from the bottom (el. 700') to the top (774'6''), volume by volume. Each volume is covered in its own section, with each section broken down into three parts. The first is a description of the volume, including its function, dimensions, and all relative ODH concerns; cryogenic piping and ventilation. Second, the actual ODH analysis of the volume is shown. Third, the provisions for the ODH condition of the volume are detailed, including securing the area and the posting of signs.

LAr DEWAR ROOM

DESCRIPTION; LAr Dewar Room

The liquid argon dewar room is at an elevation of 707'6" (38' underground), with the dewar surrounded by 7700 cubic feet of air. The area is accessible only through a single door, which has a small window and a lock (lock out only). There is small metal scaffolding in front of the dewar to facilitate maintenance and U-tube pulling and installation. The room is directly on top of the Pipe Chase Well and the Cryo Sump, and the bottom of the Stairway is just outside the door.

The dewar is designed to be completely operated by remote computer control and the area will be unmanned during normal operation. Room occupancy will occur only during dewar or central control junction box maintenance, or U-tube changes.

The dewar has these additions to it: 20 valves, 10 bayonet connections (or 5 U-tubes), 8 bolted flanges, 100 pipe sections (approx.), 100 brazed joints and welds (approx.), and 10 pipe elbows. In addition, 3 of the U-tubes will be changed twice a year on average.

ODH ANALYSIS; LAr Dewar Room

There are two ODH situations the LAr dewar room will encounter. The first is normal operating conditions, and the second is the time during U-tubes changes. The ODH status of these conditions are outlined in Table A. The pipe leak rates shown are the only leak rates not documented, so they are set to the upper limit for the LAr dewar room to remain at ODH class 0. Compared to actual experimental leak rates, such as for flanges and bayonets and for Cryolab valves (shown in table A), the tolerable leak rates for pipes, joints, and elbows calculated (475 cfm) are far in excess of the expected leak rates. A pipe leak of more than 20 scfm is highly improbable, leaving the ODH considerations of the LAr dewar room well within the class 0 limits. For a column by column explanation of the tables, see appendix A.

PROVISIONS; LAr Dewar Room

Due to the high concentration of stored inert gas in this area, access to the room will be controlled by the cryoexperts (via the key/alarm scheme). The room will be equipped with an ODH head, a horn and light alarm, a sign displaying emergency procedures, and an ODH area sign.
PIPE CHASE WELL

DESCRIPTION; Pipe Chase Well
This area is directly connected to, and beneath (el. 700'), the LAr Dewar Room floor and accessible through a man sized hole. A lockable hatchway connects it to the Cryo Sump. It contains the elbows of all the pipes running through the Pipe Chase, so that they may reach the main DAB hall through the sidewalk culvert. The culvert carrying this piping is sealed from the well, so that no significant leaks can travel to the main hall. The Pipe Chase Well has a volume of 247 cubic feet. It is expected that any liquid spill from the LAr dewar will gravity flow through the pipe chase well on its way to the Cryo Sump.

ODH ANALYSIS; Pipe Chase Well
This room will feel all the effects of the LAr Dewar Room, but has a much smaller volume. The specific hazard Is a significant spill of liquid or dense gas from the dewar room while occupied. However, all of the exhaust air flowing through the dewar room will also flow through the pipe chase well (see the ODH/Ventilation schematic). Thus, the ratio of the exhaust rate to the leak rate for the pipe chase well is the same as the dewar room. The ODH classification must, therefore, also be zero. The decreased volume only affects the rate \(\frac{V}{E}\) at which the volume reaches equilibrium, not the final O2 partial pressure.

PROVISIONS; Pipe Chase Well
Since this area has a very short time constant and is normally unmanned, it will be declared off-limits except for warranted occasions limited to authorized personnel. The access to the area will be controlled by the cryoexperts (see ref. 5) through individually designed, special procedures. The well has an ODH head (see ref. 6) which is merely the lower head for the dewar room since the well is the lowest place in the LAr dewar room.

CRYO SUMP

DESCRIPTION; Cryo Sump
The sole purpose of this area is to provide an escape route for leaking argon fluid. The area is accessible only through the Pipe Chase Well, via a lockable hatch. The ventilation flows through louvers that prevent backflow, into the sump volume of 3750 cubic feet. Further duct work connects this volume to the Exhaust Fan suction and thus to the Vent Area.
Two temperature sensors in the sump are used to activate the high volume exhaust fan in the unlikely event of a LAr dewar spill. Temperature sensors mounted on the detector spillway serve the same purpose for improbable detector spills.
A sump/water pump located in the cryo sump functions to remove any ground water reaching the floor of the cryo sump.

ODH ANALYSIS, PROVISIONS; Cryo Sump
Ideally, no one will ever occupy this area once everything is up and running. The Cryo Sump will be defined as a dangerous, and limited access area (declared OFF LIMITS while any of the calorimeters contain liquid). Access will be controlled by the cryoexperts (see ref. 5) through individually
PIPE CHASE

DESCRIPTION; Pipe Chase

This chimney of pipes conveys all the necessary piping arrangements needed to transfer the required mixed gases, to connect the LAr and liquid nitrogen dewars, and to provide vent line and relief valve flow to the outside. The total enclosed volume from the top of the LAr Dewar Room to the top of DAB (elevation from 715' to 775') is approximately 2160 cubic feet. The entire length is sealed from neighboring rooms, essentially isolating the Pipe Chase. Access from the TRD Gas Room, Cryo Pump Room and Equipment Room 511 is through a sealed and lockable door. The ventilation of this volume is through a louvered hatch at the top of the pipe chase, sized at 100 scfm.

ODH ANALYSIS; Pipe Chase

The Pipe Chase contains no valves, flanges, bayonets, packings, connectors, or other mechanical pipe connections. An ODH analysis based on the number and size of the contained pipe sections and joints is presented in table B. The leak rates shown are the maximum rates for the volume to maintain ODH class 0. A pipe leak of more than 20 scfm is highly improbable thus making the tolerable leak rates well in excess of any probable leak rates. The volume must then be ODH class zero.

PROVISIONS; Pipe Chase

The Pipe Chase need only be accessed for additions to the installation (no maintenance is required by the pipes). The three doors to the Pipe Chase are constantly monitored by the alarm system, and locked with the key controlled by D0 Cryoexperts (see ref. 5) through individually designed, special procedures. All doors will have restricted access signs and reference to the controlled entry procedures required. An ODH head is mounted near the top of the pipe chase (ref. 6).

STAIRWAY

DESCRIPTION; Stairway

The stairway contains no cryogenic piping, but is a heavily traveled area and an important means of egress from the high bay, south side, 707' and higher levels. The Stairway is considered in its five elevations:

LAr DEWAR ROOM LEVEL, Elevation 707'6"-715'

This is the lowermost level of the Stairway, and the most prone to heavy gas accumulation as a secondary involvement during a catastrophic and communicating accident. It has an approximate volume of 1408 cubic feet. The door to the high bay will be maintained normally open by a magnetic latch that is released by the fire alarm system.

INTERMEDIATE LEVEL, E1. 715'-725'

This is a piece of connecting stairway, and contains two tool cabinets on an intermediate landing. Approximate volume is 2560 cubic feet.
TRD GAS ROOM LEVEL, El. 725'-732'

This section of stairway runs directly past the TRD Gas Room. Approximate volume is 900 cubic feet.

GROUND LEVEL, El. 732'-745'

This section leads to the Cryo Control Room, room 317, and includes a corridor of approximately 1536 cubic feet. The corridor has doors to the outside and the High Bay catwalk.

UPPER LEVEL, El. 745'-775

This section leads to Equipment Rooms 510 and 511. It has an approximate volume of 900 cubic feet.

ODH ANALYSIS; Stairway

The only ODH hazard to this area is communicating spillage from other areas. There is no inherent ODH problem. Should a catastrophic and stairway communicating accident occur, it will be indicated by standard alarm hardware to preclude stairwell entry and signal evacuation. See PROVISIONS below.

PROVISIONS; Stairway

Horn and light alarms within range of any place on the stairway will activate during an ODH hazard, warning against entry from the high bay, and directing personnel in the stairwell to exit up and out of doors (or into the high bay and then outside) since cold dense gases don’t rise quickly.

EQUIPMENT PLATFORM ROOM

DESCRIPTION; Equipment Platform Room

This small alcove Equipment Platform Room contains no detector piping. It does contain building sump water piping at the 707' level, and an elevated, 713', platform containing the ODH alarm and Vacuum readout equipment racks. The platform is accessible only by ladder from the bottom of the stairway, the same level as the LAr Dewar Room. The area of the volume is 1225 cubic feet. The only time any personnel will be in this area is during the installation and modification of the electronic equipment.

ODH ANALYSIS; Equipment Platform Room

As with the Stairway, there are no inherent ODH problems associated with this area. ODH involvement can only be secondary.

PROVISIONS; Equipment Platform Room

The room is equipped with an ODH head (ref.6).

TRD GAS ROOM

DESCRIPTION; TRD Gas Room

This room is composed of the Transition Radiation Detector (TRD) gas mixing and purification system. This system will mix and maintain the purity of 90% XE and 10% CH4. The TRD Gas Room is located on the Southside of the D-Zero DAB at an elevation of 731'8" and has an approximate volume of 1872 cubic feet. Furthermore, it has a single door leading to the stairwell, a connecting door (locked and monitored) to the Pipe Chase and a door to the ventilation system (including fans). The room has been cored on a EAD 35 series key. The TRD Gas Room (Room 215) has
been denoted as a Risk Class 0 according to Fermilab Engineering Standard SD-45. However, the D-Zero gas system designers have upgraded the facility as though it were at Risk Class 1.

**ODH ANALYSIS: TRD Gas Room**

The external gas shed will be the depository for all gas bottles for the D-Zero central tracking system. Their regulators will be followed by orifices that restrict the maximum gas flow. These orifices are needed to limit the maximum rate at which bottled gas can be transferred to the D-Zero gas mixing rooms and the D-Zero detector. Each regulator is equipped to deliver up to 200 psig (14.6 bar absolute). The restricting orifice is so specified that the pressure delivered to the gas mixing rooms will be at least 150 psig (11.2 bar absolute). Therefore, the maximum pressure drop across the orifices will be 50 psig. Great care has been exercised to insure that the gas mixing systems are leak free. Gas connections are of metal construction using standard fittings rated well above the service pressure. The gas lines are stainless steel with welded fittings. All vessels that are part of the mixing systems are protected from overpressure by safety valves vented outside the building. In the worst case, a gas line leading to one of the gas mixing rooms could fall to 0 psig and receive the full flow allowed by a restricting orifice. Such an incident would require at least two failures: a failure causing a leak and a failure of pressure and gas detecting equipment designed to detect the leak and shut off gas flow.

In Room 215 (the TRD gas mixing room), Xe and CH4 are supplied to a room volume of approximately 1872 cubic feet. Based on the chosen orifice diameters and the maximum flow rate (SCFH) the following percentage of the room volume per hour can be calculated.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Chosen orifice diameter (in)</th>
<th>Maximum flow rate (SCFH)</th>
<th>Percent of room volume per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xe</td>
<td>.015</td>
<td>17.8</td>
<td>.95%</td>
</tr>
<tr>
<td>CH4</td>
<td>.006</td>
<td>8.14</td>
<td>.44%</td>
</tr>
</tbody>
</table>

These flow rates can then be taken as the maximum leak rates for ODH purposes.

The room is connected to the building's heating and air conditioning ducting which supplies 150 cfm of air to the room continuously. 23 cfm (15%) of that air comes directly from outside the D0 assembly building (see ref. 7). Thus, the exhaust rate of the room for ODH purposes can be conservatively estimated as 23 cfm. Table F shows the ODH classification calculation. The leak rates were taken to be 1 cfm (equivalent to 60 cfh) which is as small a number as the calculations can handle. In addition, the probability of a failure was taken to be unity for the sake of argument. As the figures show, the room is clearly within the limits for an ODH class zero volume even with the ridiculously high probability of failure.

**SYSTEM DESCRIPTION: TRD Gas Room**

Since the XE/CH4 mixture is on the borderline of being flammable, this room has been denoted as a SD-45, Risk Class 1 by the D-Zero gas system designers. Safety provisions, such as appropriate commercial fittings, non-flammable gas purging, pressure relief, outdoor venting, labeling and secure mounting of mixing and purification apparatus have been implemented. Moreover, flammable gas and ODH monitoring systems have
been installed to 1) monitor gas buildup due to leaks, 2) monitor improper gas mixtures and 3) shutdown gas from the external gas shed which could fuel a fire within the D-Zero Hall. Gas connection are of all metal construction using standard fittings rated well above the service pressure. Gas lines are stainless steel with welded fittings, except for short lengths of Nylon-11 in two locations in the experimental hall requiring flexibility. The mixing systems and gas lines have been and will be thoroughly leak checked prior to active service. All vessels that are part of the mixing systems are protected from overpressure by safety valves vented outside the building. (See References D0-708/D0-868 for a Safety Analysis Review/Safety Orifices).

**PROVISIONS: TRD Gas Room**

This room is equipped with an ODH head and two flammable gas heads. Moreover, each system of heads will have a horn/light alarm. In addition, the exterior walls of the room will be equipped with these local signal/alarms installations and signs displaying emergency procedures under flammable gas/ODH conditions plus Flammable Gas and ODH area signs (showing risk conditions). Since the area is potentially dangerous, it will be declared off-limits except for authorized personnel. The access to the area will be controlled by the TRD gas experts and individually designed, special procedures. However, it is anticipated that a recovery from a ODH or flammable gas incident will begin in the control room where remote signal processing of alarm conditions will be monitored and evaluated.

**CRYO CONTROL ROOM**

**DESCRIPTION:** Cryo Control Room

This room is the source of the remote controls for the cryo system. All the relevant ODH information is sent to the computers there, as well as to FIRUS. The room is sealed from the connecting hallway and stairwell by a tightly fit mandoor, and has a double door access directly to the outside. It contains no process lines and is isolated from the pipe chase by a blank-off flange with electrical feedthroughs. It has a volume of 2560 cubic feet.

**ODH ANALYSIS:** Cryo Control Room

This room has no direct ODH hazard, any ODH hazard can only be secondary.

**PROVISIONS:** Cryo Control Room

This room is equipped with an ODH head and a horn/light alarm (see ref. 6). An ODH alarm map board posted on the outside wall will indicate the area of alarm. It is anticipated that recovery from an ODH incident will begin in the control room. The computers inside can be used to analyze and control an ODH problem, provided there is no hazard in the Cryo Control Room itself. The double doors connecting the room with the outside can be opened to aid ventilation for ODH recovery operations.

**CRYO PUMP ROOM**

**DESCRIPTION:** Cryo Pump Room

This room provides the system instrument air, and all the vacuum
pumping for the pump and purge of cryogenic volumes and the maintenance of insulating vacua. It has connecting doors to the Pipe Chase and opens to the catwalk overlooking the DAB main hall. It is at ground level, el. 745'. A fan, providing a continuous ventilation of approximately 1200 scfm, is mounted on the ceiling, creating a current from the top of the room which vents through a grating on the catwalk door.

**ODH ANALYSIS; Cryo Pump Room**

The room contains instrument air compressors, tanks and driers, two mechanical vacuum pumps and a roots blower. None of these pose an ODH threat. There are argon and nitrogen purge lines, and instrument air backup (GN2) lines of all welded and screwed fittings in the room. None of the purge lines open to the room, but a pipe or joint failure could contribute to an ODH situation. Note that none of the lines contain cryogenic fluids. The ODH analysis is found in table C, with the leak rates either quoted from engineering notes or set at the highest value for the volume to remain ODH class 0. A pipe leak rate of more than 20 cfm is highly improbable. In which case the tolerable leak rates are well above the expected leak rates. Thus, the ODH classification must be zero.

**PROVISIONS; Cryo Pump Room**

The cryo pump room is noisy and normally not inhabited. It is equipped with an ODH head and horn/light alarm to warn of a possible threatening condition.

**EQUIPMENT ROOM 510**

**DESCRIPTION:** Equipment Room 510

This room is composed of the gas mixing systems associated with D-Zero's muon detectors. The Room 510 is located on the Southwest side of the D-Zero DAB at an elevation of 756'6" and has an approximate volume of 5480 cubic feet. This room has a single door leading to the stairwell and small doors (locked and monitored) leading to the Pipe Chase. The room has been cored on a EAD 35 series key. The Room 510 has been denoted as a Risk Class 0 according to Fermilab Engineering Standard SD-45. However, the D-Zero gas system designers have upgraded the facility as though it were at Risk Class 1.

**ODH ANALYSIS; Equipment Room 510**

The external gas shed will be the depository for all gas bottles for the D-Zero central tracking system. Their regulators will be followed by orifices that restrict the maximum gas flow. These orifices are needed to limit the maximum rate at which bottled gas can be transferred to the D-Zero gas mixing rooms and the D-Zero detector. Each regulator is equipped to deliver up to 200 psig (14.6 bar absolute). The restricting orifice is so specified that the pressure delivered to the gas mixing rooms will be at least 150 psig (11.2 bar absolute). Therefore, the maximum pressure drop across the orifices will be 50 psig. Great care has been exercised to insure that the gas mixing systems are leak free. Gas connections are of metal construction using standard fittings rated well above the service pressure. The gas lines are stainless steel with welded fittings. All vessels that are part of the mixing systems are protected from overpressure by safety valves vented outside the building. In the worst case, a gas line leading to one of the gas
mixing rooms could fall to 0 psig and receive the full flow allowed by a restricting orifice. Such an incident would require at least two failures: a failure causing a leak and a failure of pressure and gas detecting equipment designed to detect the leak and shut off gas flow.

In Room 510 (the muon gas mixing room), Argon and CO2 are supplied to a room volume of approximately 5480 cubic feet. Based on the chosen orifice diameters and the maximum flow rate (SCFH) the following percentage of the room volume per hour can be calculated.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Chosen orifice diameter (SCFH)</th>
<th>Maximum flow rate (in emergency)</th>
<th>Percent of room volume per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argon</td>
<td>.022 in.</td>
<td>69.2</td>
<td>1.3 %</td>
</tr>
<tr>
<td>CO2</td>
<td>.015</td>
<td>30.7</td>
<td>.56 %</td>
</tr>
</tbody>
</table>

These flows can be taken to be the maximum leak rates for ODH analysis purposes.

The room is connected to the building's heating and air conditioning ducting which supplies 100cfm to the room continuously. 15 cfm of the air supplied comes directly from outside the D0 assembly building (see ref. 7). Thus, the exhaust rate for ODH purposes can be conservatively estimated as 15cfm. Table D shows the ODH classification calculation. The leak rates were taken to be 1cfm (equivalent to 60cfh) since that is the smallest number the calculation will allow. In addition, the probability of failure was taken to be unity for the sake of argument. As the figures show, the room is clearly within the limits for an ODH class zero volume even with the ridiculously high probability of failure.

**SYSTEM DESCRIPTION: Equipment Room 510**

The Muon detectors are currently designed to use 80% Argon and 20% CO2. This room has been denoted as a SD-45, Risk Class 1 by the D-Zero gas system designers. Safety provisions, such as appropriate commercial fittings, non-flammable gas purging, pressure relief, outdoor venting, labeling and secure mounting of mixing and purification apparatus have been implemented. Moreover, flammable gas and ODH monitoring systems have been installed to 1) monitor gas buildup due to leaks, 2) monitor improper gas mixtures and 3) shutdown gas from the external gas shed which could fuel a fire within the D-Zero Hall. Gas connection are of all metal construction using standard fittings rated well above the service pressure. Gas lines are stainless steel with welded fittings, except for short lengths of Nylon-11 in two locations in the experimental hall requiring flexibility. The mixing systems and gas lines have been and will be thoroughly leak checked prior to active service. All vessels that are part of the mixing systems are protected from overpressure by safety valves vented outside the building. (See References D0-708/D0-868 for Safety Analysis Review/Safety Orifices)

**PROVISIONS: Equipment Room 510**

This room is equipped with an ODH head and two flammable gas heads. Moreover, each system of heads will have a horn/light alarm. In addition, the exterior walls of the room will be equipped with these local signal/alarm installations and signs displaying emergency procedures under flammable gas/ODH conditions plus Flammable Gas and ODH area signs (showing risk conditions). Since the area is potentially dangerous, it will be
declared off-limits except for authorized personnel. The access to the area will be controlled by the muon gas experts and individually designed, special procedures. However, it is anticipated that a recovery from a ODH or flammable gas incident will begin in the control room where remote signal processing of alarm conditions will be monitored and evaluated.

**EQUIPMENT ROOM 511**

**DESCRIPTION:** Equipment Room 511

This room is composed of the gas mixing systems associated with D-Zero's central tracking drift chambers. They are better known as 1) the central drift chamber, "CDC"; 2) the forward drift chamber, "FDC"; and 3) the vertex chamber, "VTX". The Room 511 is located on the Southeast side of the D-Zero DAB at an elevation of 756'6" and has an approximate volume of 5831 cubic feet. This room has a single door leading to the stairwell and locked double doors two floors above ground level. All of the rooms piping has been routed through the rooms west wall. The room has been cored on a EAD 35 series key. The Room 511 has been denoted as a Risk Class 0 according to Fermilab Engineering Standard SD-45. However, the D-Zero gas system designers have upgraded the facility as though it were at Risk Class 1.

**ODH ANALYSIS: Equipment Room 511**

The external gas shed will be the depository for all gas bottles for the D-Zero central tracking system. Their regulators will be followed by orifices that restrict the maximum gas flow. These orifices are needed to limit the maximum rate at which bottled gas can be transferred to the D-Zero gas mixing rooms and the D-Zero detector. Each regulator is equipped to deliver up to 200 psig (14.6 bar absolute). The restricting orifice is so specified that the pressure delivered to the gas mixing rooms will be at least 150 psig (11.2 bar absolute). Therefore, the maximum pressure drop across the orifices will be 50 psig. Great care has been exercised to insure that the gas mixing systems are leak free. Gas connections are of metal construction using standard fittings rated well above the service pressure. The gas lines are stainless steel with welded fittings. All vessels that are part of the mixing systems are protected from overpressure by safety valves vented outside the building. In the worst case, a gas line leading to one of the gas mixing rooms could fall to 0 psig and receive the full flow allowed by a restricting orifice. Such an incident would require at least two failures: a failure causing a leak and a failure of pressure and gas detecting equipment designed to detect the leak and shut off gas flow.

In Room 511 (the FDC/CDC/VTX gas mixing room), Argon, CO2, CH4 and C2H6 are supplied to a room volume of approximately 5831 cubic feet. Based on the chosen orifice diameters and the maximum flow rate (SCFH) the following percentage of the room volume per hour can be calculated.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Chosen orifice diameter</th>
<th>Maximum flow rate in emergency (SCFH)</th>
<th>Percent of room volume per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDC/CDC</td>
<td>.022 in.</td>
<td>69.2</td>
<td>1.2 %</td>
</tr>
</tbody>
</table>
APPENDIX A: Explanation of Table Columns

ITEM: component type
N: number of components of item.
FAIL RATE(P): probability of failure, one item.
LEAK RATE(L): most probable leakage upon failure of component.
L/E: ratio of leak rate to exhaust rate.

[\[\frac{fO2}{\infty}\]: 0.21 (1 - L/E)

p: pressure, in mmHG.

FATALITY FACTOR(F) (truncates with if-then):

\[
\text{IF } 10^4\left(6.5-(p/10)(fO2)\right) \leq 0, \text{ THEN } F = 0, \text{ ELSE }
\]
\[
\text{IF } 10^4\left(6.5-(p/10)(fO2)\right) \geq 1, \text{ THEN } F = 1, \text{ ELSE }
\]
\[
F = 10^4\left(6.5-(p/10)(fO2)\right)
\]

FATALITY RATE(\(\phi\)): N(P)(F)

ODH CLASS (uses if-then-else logical operators):

\[
\text{IF } \phi \leq 10^{-7}, \text{ THEN ODH class } = 0, \text{ ELSE }
\]
\[
\text{IF } \phi \leq 10^{-5}, \text{ THEN ODH class } = 1, \text{ ELSE }
\]
\[
\text{IF } \phi \leq 10^{-3}, \text{ THEN ODH class } = 2, \text{ ELSE }
\]
\[
\text{IF } \phi \leq 10^{-1}, \text{ THEN ODH class } = 3, \text{ ELSE }
\]
\[
\text{ODH class } = 4
\]
1 DØ Engineering Note 3740.510-EN-229, General ODH Analysis Method and Conclusions, Sept. 19, 1989, Rev. B.


3 DØ Engineering Note 3740.EN, Leak Analysis, Bayonet and Flange, Oct. 11, 1989, Rev. C.


5 **Key and alarm scheme** - Access to the cryo control room, pipe chase, dewar room, etc. will be limited to those persons with an EAD 29 key, namely the building manager, Pete Simon, the cryoexperts, and co-op students. In addition, the opening of one of these doors will sound an alarm in the control room consisting of a flashing icon on the appropriate graphics page, input to the hard disk, and a printer readout of the alarm.

6 All ODH heads sound an alarm consisting of horn sounding and strobe flashing. An alarm is also sent to Firus as well as to a cryoexpert via the autodialer. The plc in the control room monitors the system.

7. See drawing number M-9 636A for the south side heating and cooling duct work with ventilation flow rates.
POST DAB, South

ODH Horn or Light Alarm

EVACUATE the building by the most direct means to the outdoors or to the High Bay and then outdoors. CALL 3131 AND THE CRYOEXPERT. Do not re-enter the building until cleared to do so by a Fireman and/or Cryo expert.

1. An Area Status panel indicating alarmed areas and a Cryoexpert List are mounted on the wall just outside Cryocontrol room.

2. Close the destination marked "close on ODH" process line valves that are outside and feeding areas currently in alarm.

3. Cryoexperts may enter the nonalarmed control room if the double doors are locked open and they are wearing a personal ODH monitor, to control other process valving.

4. Responding Fireman may be asked to enter the building to sweep for personnel, but will await LOCAL guidance about the possible problem(s) inside before doing so.
DØ - SOUTH DAB ODH ALARM RESPONSE

THE FIRST PHASE OF LIQUID ARGON (LAr) OPERATIONS IN DAB WILL BE THE FILLING AND OPERATION OF THE LAr STORAGE DEWAR LOCATED AT THE 707.5' LEVEL ON THE SOUTH SIDE OF DAB. INSTALLATION AND TESTING OF GAS SYSTEMS IN SMALL ROOMS ALSO POSES A POSSIBLE ODH SITUATION. AN ODH MONITOR SYSTEM HAS BEEN INSTALLED IN THE POTENTIAL HAZARD AREAS OF DAB SOUTH. SEE ATTACHED MAP FOR HARDWARE LOCATIONS. THIS PROCEDURE ADDRESSES THE PROPER RESPONSE TO ALARMS FROM THE ODH MONITOR SYSTEM.

1. HORNS AND STROBES WILL BE ACTIVATED IF AN ODH CONDITION IS SENSED BY THE MONITOR SYSTEM.

2. ALL PERSONNEL IN THE SOUTH SECTIONS OF DAB MUST EVACUATE TO THE OUTDOOR AREA ADJACENT TO THE CRYO CONTROL ROOM WHERE THE SENIOR PERSON MUST ACCOUNT FOR PERSONNEL.

3. INFORMATION FROM THE ODH STATUS PANEL MOUNTED ON THE OUTSIDE WALL NEAR THE EXIT DOOR AND REPORTS FROM THE PERSONNEL EXITING WILL HELP DETERMINE IF THERE IS A REAL ODH HAZARD. IF THERE IS ANY UNCERTAINTY, ASSUME A REAL EVENT AND CALL X3131 FOR FIRE DEPARTMENT ASSISTANCE. DO NOT REENTER THE BUILDING DURING A REAL EVENT WITHOUT FIRE DEPARTMENT SUPPORT AND SCBA EQUIPMENT.

4. IF THE ODH HEAD IN THE CRYO CONTROL ROOM IS NOT IN ALARM, CRYO OPERATORS MAY ACCESS THE ROOM THROUGH THE DOUBLE DOORS AND CHECK THE CRYO CONTROL SYSTEM TO HELP ANALYZE THE SITUATION.
5. The ODH monitoring system is tied to the FIRUS system, which will alert the communications center and activate a call-in list for expert assistance in cryo or gas system problems.

6. In the event of a real ODH incident a plan of action will be coordinated by the emergency response team and the system experts.

7. In the event of a false alarm the system experts with assistance from the ODH monitor experts must take corrective action to restore the ODH monitoring system to normal operating condition.
# TABLE A - LAr DEWAR ROOM

## STANDARD OPERATING CONDITIONS

*Italicized* leak rates are the roughly maximized values for the ODH class to remain 0.

<table>
<thead>
<tr>
<th>Exhaust ETC, min. V/E</th>
<th>Volume V Elevation Pressure</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>7700</td>
<td>707 ft</td>
<td>742 mmHg</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>ITEM</th>
<th>TYPE, SIZE</th>
<th>N</th>
<th>P</th>
<th>GROUP</th>
<th>L</th>
<th>L/E</th>
<th>fO2(∞)</th>
<th>F</th>
<th>Ø</th>
<th>ODH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves*</td>
<td></td>
<td>20</td>
<td>1.00E-08</td>
<td>2.00E-07</td>
<td>33</td>
<td>0.033</td>
<td>2.03E-01</td>
<td>2.75E-09</td>
<td>5.51E-16</td>
<td>0</td>
</tr>
<tr>
<td>Bayonets** Cryo, 1-1/2&quot;</td>
<td></td>
<td>10</td>
<td>3.00E-06</td>
<td>3.00E-05</td>
<td>10</td>
<td>0.01</td>
<td>2.08E-01</td>
<td>1.21E-09</td>
<td>3.62E-14</td>
<td>0</td>
</tr>
<tr>
<td>Flanges** Bolted</td>
<td></td>
<td>8</td>
<td>3.00E-06</td>
<td>2.40E-05</td>
<td>100</td>
<td>0.1</td>
<td>1.89E-01</td>
<td>3.04E-08</td>
<td>7.30E-13</td>
<td>0</td>
</tr>
<tr>
<td>Pipes &lt;3&quot; Sections</td>
<td></td>
<td>100</td>
<td>1.00E-09</td>
<td>1.00E-07</td>
<td>475</td>
<td>0.475</td>
<td>1.10E-01</td>
<td>2.11E-02</td>
<td>2.11E-09</td>
<td>0</td>
</tr>
<tr>
<td>Joints Process</td>
<td></td>
<td>100</td>
<td>3.00E-09</td>
<td>3.00E-07</td>
<td>475</td>
<td>0.475</td>
<td>1.10E-01</td>
<td>2.11E-02</td>
<td>6.32E-09</td>
<td>0</td>
</tr>
<tr>
<td>Elbows</td>
<td></td>
<td>10</td>
<td>3.00E-07</td>
<td>3.00E-06</td>
<td>475</td>
<td>0.475</td>
<td>1.10E-01</td>
<td>2.11E-02</td>
<td>6.32E-08</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.16E-08</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

## U-TUBE/FILTER CHANGES

<table>
<thead>
<tr>
<th>ITEM</th>
<th>TYPE, SIZE</th>
<th>N</th>
<th>P</th>
<th>GROUP</th>
<th>L</th>
<th>L/E</th>
<th>fO2(∞)</th>
<th>F</th>
<th>Ø</th>
<th>ODH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves*</td>
<td></td>
<td>20</td>
<td>1.00E-08</td>
<td>2.00E-07</td>
<td>33</td>
<td>0.033</td>
<td>2.03E-01</td>
<td>2.75E-09</td>
<td>5.51E-16</td>
<td>0</td>
</tr>
<tr>
<td>Flanges** Bolted</td>
<td></td>
<td>8</td>
<td>3.00E-06</td>
<td>2.40E-05</td>
<td>100</td>
<td>0.1</td>
<td>1.89E-01</td>
<td>3.04E-08</td>
<td>7.30E-13</td>
<td>0</td>
</tr>
<tr>
<td>Pipes &lt;3&quot; Sections</td>
<td></td>
<td>100</td>
<td>1.00E-09</td>
<td>1.00E-07</td>
<td>400</td>
<td>0.4</td>
<td>1.12E-01</td>
<td>1.43E-03</td>
<td>1.43E-10</td>
<td>0</td>
</tr>
<tr>
<td>Joints Process</td>
<td></td>
<td>100</td>
<td>3.00E-09</td>
<td>3.00E-07</td>
<td>350</td>
<td>0.35</td>
<td>1.37E-01</td>
<td>2.38E-04</td>
<td>7.15E-11</td>
<td>0</td>
</tr>
<tr>
<td>Elbows</td>
<td></td>
<td>10</td>
<td>3.00E-07</td>
<td>3.00E-06</td>
<td>300</td>
<td>0.3</td>
<td>1.47E-01</td>
<td>3.96E-05</td>
<td>1.19E-10</td>
<td>0</td>
</tr>
<tr>
<td>U-tube changes***</td>
<td></td>
<td>1</td>
<td>1.00E-03</td>
<td>4.00E-03</td>
<td>287</td>
<td>0.287</td>
<td>1.50E-01</td>
<td>2.49E-05</td>
<td>9.95E-08</td>
<td>0</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>9.98E-08</td>
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<td></td>
</tr>
</tbody>
</table>

Special Notes: all event rates are per hour, flows are in scfm, volumes in cf and times in minutes.

* Leak taken from EN-192, using the highest value (80°C N2, ΔP = 3 atmos, annular gap 0.01")

** Leak taken from EN-232, using the highest value for a likely leak in each case.

*** Leak and probabilities taken from EN-233, using the specific large event values.
### TABLE B - PIPE CHASE

<table>
<thead>
<tr>
<th>ITEM</th>
<th>TYPE, SIZE</th>
<th>N</th>
<th>P</th>
<th>GROUP FAIL RATE</th>
<th>L</th>
<th>L/E LEAK/EXH</th>
<th>fO2(=) FRACT O2</th>
<th>F Fatal. Factor</th>
<th>Ø Fatal. Rate</th>
<th>ODH Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipes &gt;3&quot; Sections</td>
<td>15</td>
<td>1.00E-10</td>
<td>1.50E-09</td>
<td>59</td>
<td>0.59</td>
<td>8.61E-02</td>
<td>1.00E+00</td>
<td>1.50E-09</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pipes &lt;3&quot; Sections</td>
<td>69</td>
<td>1.00E-09</td>
<td>6.90E-08</td>
<td>59</td>
<td>0.59</td>
<td>8.61E-02</td>
<td>1.00E+00</td>
<td>6.90E-08</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Joints Process</td>
<td>84</td>
<td>3.00E-09</td>
<td>2.52E-07</td>
<td>50</td>
<td>0.5</td>
<td>1.05E-01</td>
<td>5.29E-02</td>
<td>1.33E-08</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.38E-08</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Italicized leak rates are the roughly maximized values for the ODH class to remain 0.

### TABLE C - CRYO PUMP ROOM

<table>
<thead>
<tr>
<th>ITEM</th>
<th>TYPE, SIZE</th>
<th>N</th>
<th>P</th>
<th>GROUP FAIL RATE</th>
<th>L</th>
<th>L/E LEAK/EXH</th>
<th>fO2(=) FRACT O2</th>
<th>F Fatal. Factor</th>
<th>Ø Fatal. Rate</th>
<th>ODH Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves*</td>
<td>8</td>
<td>1.00E-08</td>
<td>8.00E-08</td>
<td>33</td>
<td>0.0275</td>
<td>2.04E-01</td>
<td>2.37E-09</td>
<td>1.89E-16</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Flanges** Bolted</td>
<td>12</td>
<td>3.00E-06</td>
<td>3.60E-05</td>
<td>10</td>
<td>0.00833</td>
<td>2.08E-01</td>
<td>1.19E-09</td>
<td>4.29E-14</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pipes &lt;3&quot; Sections</td>
<td>11</td>
<td>1.00E-09</td>
<td>1.10E-08</td>
<td>695</td>
<td>0.579167</td>
<td>8.84E-02</td>
<td>9.01E-01</td>
<td>9.91E-09</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Joints Process</td>
<td>33</td>
<td>3.00E-09</td>
<td>9.90E-08</td>
<td>670</td>
<td>0.558333</td>
<td>9.28E-02</td>
<td>4.27E-01</td>
<td>4.23E-08</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Elbows</td>
<td>9</td>
<td>3.00E-07</td>
<td>2.70E-06</td>
<td>560</td>
<td>0.466667</td>
<td>1.12E-01</td>
<td>1.60E-02</td>
<td>4.33E-08</td>
<td>0</td>
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</tr>
<tr>
<td>TOTAL</td>
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<td></td>
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<td>9.55E-08</td>
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</tr>
</tbody>
</table>

Special Notes: all event rates are per hour, flows are in scfm, volumes in cf and times in minutes.

* Leak taken from EN-192, using the highest value (80°K N2, ΔP = 3 atm, annular gap 0.01")

** Leak taken from EN-232, using the highest value for a likely warm flange leak.
### Table D - Equipment Room 510

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Orifice Dia.</th>
<th>N</th>
<th>FAIL RATE</th>
<th>GROUP FAIL RATE</th>
<th>L/E LEAK/EXH</th>
<th>F</th>
<th>FRACT O2</th>
<th>FATAL. FACT</th>
<th>ORIFICE DIA.</th>
<th>PRESSURE</th>
<th>VOLUME</th>
<th>ELEVATION</th>
<th>TC, min. V/E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argon</td>
<td>0.022 in</td>
<td>1</td>
<td>1.00E+00</td>
<td>1.00E+00</td>
<td>1</td>
<td>0.066667</td>
<td>1.96E-01</td>
<td>9.76E-09</td>
<td>9.76E-09</td>
<td>0</td>
<td></td>
<td>756.5 ft</td>
<td>365.33</td>
</tr>
<tr>
<td>CO2</td>
<td>0.015 in</td>
<td>1</td>
<td>1.00E+00</td>
<td>1.00E+00</td>
<td>1</td>
<td>0.066667</td>
<td>1.96E-01</td>
<td>9.76E-09</td>
<td>9.76E-09</td>
<td>0</td>
<td></td>
<td>756.5 ft</td>
<td>365.33</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Table E - Equipment Room 511

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Orifice Dia.</th>
<th>N</th>
<th>FAIL RATE</th>
<th>GROUP FAIL RATE</th>
<th>L/E LEAK/EXH</th>
<th>F</th>
<th>FRACT O2</th>
<th>FATAL. FACT</th>
<th>ORIFICE DIA.</th>
<th>PRESSURE</th>
<th>VOLUME</th>
<th>ELEVATION</th>
<th>TC, min. V/E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argon</td>
<td>0.022 in</td>
<td>1</td>
<td>1.00E+00</td>
<td>1.00E+00</td>
<td>1</td>
<td>0.02</td>
<td>2.06E-01</td>
<td>1.84E-09</td>
<td>1.84E-09</td>
<td>0</td>
<td></td>
<td>756.5 ft</td>
<td>116.62</td>
</tr>
<tr>
<td>CO2</td>
<td>0.015 in</td>
<td>2</td>
<td>1.00E+00</td>
<td>2.00E+00</td>
<td>1</td>
<td>0.02</td>
<td>2.06E-01</td>
<td>1.84E-09</td>
<td>3.67E-09</td>
<td>0</td>
<td></td>
<td>756.5 ft</td>
<td>116.62</td>
</tr>
<tr>
<td>CH4</td>
<td>0.006 in</td>
<td>1</td>
<td>1.00E+00</td>
<td>1.00E+00</td>
<td>1</td>
<td>0.02</td>
<td>2.06E-01</td>
<td>1.84E-09</td>
<td>1.84E-09</td>
<td>0</td>
<td></td>
<td>756.5 ft</td>
<td>116.62</td>
</tr>
<tr>
<td>C2H6</td>
<td>0.006 in</td>
<td>1</td>
<td>1.00E+00</td>
<td>1.00E+00</td>
<td>1</td>
<td>0.02</td>
<td>2.06E-01</td>
<td>1.84E-09</td>
<td>1.84E-09</td>
<td>0</td>
<td></td>
<td>756.5 ft</td>
<td>116.62</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Special Notes: all event rates are per hour, flows are in scfm, volumes in cf and times in minutes.
**TABLE F - TRD GAS ROOM**

<table>
<thead>
<tr>
<th>Exhaust E</th>
<th>TC, min.</th>
<th>V/E</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>81.39</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume V</th>
<th>Elevation Av.</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1872</td>
<td>731.8 ft</td>
<td>741 mmHG</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Orifice Dia.</th>
<th>N</th>
<th>P</th>
<th>GROUP FAIL RATE</th>
<th>L</th>
<th>L/E LEAK/EXH</th>
<th>fO2(∞)</th>
<th>F</th>
<th>Ø</th>
<th>ODH Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xenon</td>
<td>0.015 in</td>
<td>1</td>
<td>1.00E+00</td>
<td>1.00E+00</td>
<td>1</td>
<td>0.047826</td>
<td>2.00E-01</td>
<td>4.83E-09</td>
<td>4.83E-09</td>
<td>0</td>
</tr>
<tr>
<td>CH4</td>
<td>0.006 in</td>
<td>1</td>
<td>1.00E+00</td>
<td>1.00E+00</td>
<td>1</td>
<td>0.047826</td>
<td>2.00E-01</td>
<td>4.83E-09</td>
<td>4.83E-09</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>9.65E-09</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

SPECIAL NOTE: All events are per hour, flows are in scfm, volumes are in cf, times are in minutes