DØ DETECTOR COLLISION HALL OXYGEN DEFICIENCY HAZARD ANALYSIS

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8/6/92

DØ Engineering Note
3740.510-EN-332

Approved: Date: 8/10/92

ABSTRACT

EN-258, DØ Platform ODH Analysis, provided the oxygen deficiency hazard analysis for the DØ detector in the Assembly Hall. This note covers the same analysis, but revised for the Collision Hall. Liquid cryogenics, released and warming to atmosphere conditions, expand to, on average, seven hundred times their liquid volume, and displace vital atmospheric oxygen. An oxygen deficiency hazard analysis assesses the increased risk to personnel in areas containing cryogenic systems. The DØ detector Collision Hall ODH analysis has been approached five different ways using established methods. If the low beta quad magnets are powered, and the exhaust rate is below 4220 scfm, the area is ODH class 1. In any other case, the analysis shows the area to be ODH class 0 as equipped (with ventilation fans) and requiring no special safety provisions. System designers have provided for a reduced oxygen level detection and warning system as well as emergency procedures to address fault conditions.

INTRODUCTION

The Oxygen Deficiency Hazard of any particular area is defined by these parameters: the nature of the accidental supply of inert gas (probability of occurrence and quantity then released), the area's volume, the area's ventilation rate, and to a small degree the elevation of the area. Once this information is assembled, the ODH classification can be determined through standardized calculations.¹

The platform area under the DØ detector contains much of the cryogenic and gas system piping necessary for the DØ experiment. EN-258 assessed the increased risk to personnel in the platform level to a reduced oxygen atmosphere during the cool down and subsequent operation of the calorimeters in the Assembly Hall. The entire platform moves with the detector into the Collision Hall, therefore the fans embedded in the platform will continue to maintain uniform ventilation throughout. This note differs from EN-258 in that it also analyzes the low beta quad magnets that extend into the Collision Hall.

¹ DØ Engineering Note 3740.510-EN-229, General ODH Analysis Methods and Conclusions, Sept. 19, 1989, Rev. B.

FIG. 1 DØ DETECTOR PLATFORM SUPPORT BEAMS

ODH ANALYSIS

The platform area can be divided into nine sections separated by the support beams (see fig. 1). Of the nine sections of the platform, none are completely isolated from either another section or the Collision Hall. In the case of the east and west alcoves, there is a considerable distance between the platform and the nearest wall² (>4 ft). The mid section is potentially the most isolated volume, and yet it too is connected via two large openings and 16 fans to both the east and west alcoves (see Collision Hall Ventilation).

Each of these sections contains some cryogenic and/or gas system piping in addition to being encased by the B (above) and C (below) layer muon gas chamber planes. The following is a list with estimated quantities of all the components involved in the platform area and above, broken down into sections.

ODH COMPONENT LISTING 160 muon gas chambers

ABOVE PLATFORM:

351 pipe sections
121 elbows
41 tees
562 welds
112 screw connectors
16 plastic manifolds
112 plastic/flex lines
30 rotary bayonets

CRYOCORNER:

94 pipe sections
57 elbows
3 tees
11 valves
168 welds
12 connectors
2 brass flex hoses
10 bayonets

² DØ Detector Parameter Layout, Plan View, Drawing Number 3740.000 MC 222134 rev. A.

GAS CORNER:

122 pipe sections
29 elbows
58 tees
56 valves
267 welds
7 connectors

NE CORNER:

25 pipe sections
26 elbows
4 valves
52 welds
2 screw connections
2 plastic/flex lines

SOUTH ALCOVE:

113 pipe sections
7 elbows
17 valves
147 welds
17 swagelok hose connectors

MID SECTION:

4 pipe sections
4 welds

ALONG SOUTH WALL:

145 pipe sections
41 elbows
28 tees
26 valves
273 welds
23 hose connections
23 swagelok flexible hoses

WEST/EAST ALCOVE (EACH):

51 pipe sections
49 elbows
8 tees
2 valves
116 welds
28 connectors
2 plastic manifolds
26 plastic/flex lines

All of the gas system lines except one have flow restrictions which limit their failure leak rates to under 1 scfm. The 2" SAMUS supply line has a maximum flow rate of 140 lpm, or about 5 scfm, which is the highest flow rate of any of the detector gas supply/exhaust lines.³ As a conservative measure, all of the gas system lines are assumed to have a failure leak rate of 10 scfm. None of the vacuum jacketed lines, except the GN2 purge line, have restricting orifices. The 1" line 488GN does have a restricting orifice for each cryostat, tag numbers RO136N, RO236N, and RO336N. Note that vacuum jacketed lines have a significantly lower probability of failure in comparison to the rest of the piping components. From an external viewpoint, two pipes would have to fail to cause a cryogen leak, making the probability of a leak the product of two high quality pipe failure rates of $1 \times 10^{-10}/\text{hr}$, or $1 \times 10^{-20}/\text{hr}$. This rate has a negligible contribution to the ODH classification. However, there still exists the possibility of an internal failure. An internal leak would have an easy task of finding a way to atmosphere through the vacuum jacket pump outs. The leak would be restricted, though, due to the warming effect of the outside jacket, vaporizing and expanding the leaking cryogen before they vent to the air. The failure in the internal line would also be restricted by the size of the crack and

³ reference Kelly Dixon, 12/91.

the PO opening as well. The internal pipe in the vacuum jacketed lines used at DØ is not only high quality, but it is 100% analyzed for potential stress problems (see e.g. EN-162). There is also the possibility of a line rupture to consider. In the case of a heavy object being dropped accidentally onto a vacuum jacketed pipe, it is possible that both the internal pipe and the vacuum jacket could rupture. Most of the pipe sections are protected by the sidewalk, platform, cryobridge, or end irons. When the detector is closed, it is virtually impossible to drop something directly onto a pipe, but the possibility is included in the analysis. A single high quality pipe has a rupture failure rate of $1 \times 10^{-10}/\text{hr}$,⁴ so two independent pipes would have a rupture failure rate of $1 \times 10^{-20}/\text{hr}$. Vacuum jacketed pipes should have a failure rate somewhere in between, so as a conservative measure, a failure rate of $1 \times 10^{-11}/\text{hr}$ is used in the spreadsheet. The rupture leak rate is calculated from the largest expected flowrate in any of the pipes, which at this time would be 100 gpm, the maximum flow of liquid nitrogen from the dewar to the ECN cryostat.⁵ Note that an internal leak would be a better case, with a much lower leak rate. The resulting ODH classification is 0 because of the low probability of failure. Also note that the high flow rate results in an oxygen concentration of 0% at infinity, however, if a line were to rupture, a flow switch would prompt the PLC to automatically shut a valve, limiting the total volume of escaped cryogens.⁶

The insulating vacuum line was not counted, as that line cannot create an ODH situation. The same is true of the instrument air lines. The utility vacuum line, however, can contain gases during backfill, so it was included in the analysis.

The CC to EC extension piping includes a system of rotary bayonets which allow the EC's to open and close without the removal of hard piping on top of the cryostats. There are three rotary bayonets in each assembly, and each of the six lines (LAr Fill/Drain, LN2, Gas, Ar/N2 Vent, UV, and IV) contains a rotary bayonet assembly for both the ECS and the ECN. This makes a total of 36 rotary bayonets, however, since the insulating vacuum line does not contribute to an ODH hazard, only 30 of these bayonets are considered in this analysis. The leak rate chosen was from EN-231 for a bayonet and flange. Although the volume used was of the area under the platform level, the rotary bayonets extend out into the surrounding space, so the volume used in the

⁴ Fermilab Safety Manual section 5064TA-7 rev. 6/86, Table III, NRC Equipment Failure Rate Estimates.

⁵ reference Kelly Dixon, 12/91.

⁶ see DØ Engineering Note 3740.000-EN-147, Cryogen Spills Due to Line Rupture, March 31, 1988.

calculation is actually smaller and more conservative. The rotary bayonet analysis resulted in an ODH classification of 0.

COLLISION HALL VENTILATION

Because of the need to keep the dew point in the Collision Hall as low as possible, there are a number of ventilation fans designed to provide circulation throughout the detector. The main Collision Hall ventilation is furnished by AHU-1, a fan which provides 18,000 cfm of ventilation. The return for this air is the exhaust fan EF-1. There are also two other exhaust fans which can pull on the spill trough through the argon sump. These are EF-6 and EF-7, which operate at 13,000 cfm and 4,500 cfm, respectively. Two additional fans mounted low on the east side of the Collision Hall each provide 6,100 cfm of ventilation, however, these fans do not provide a fresh air supply, they simply cool and recirculate the existing room air through the detector, ensuring uniform ventilation and providing air cooling to equipment. There are two return fans mounted low on the west side which pull the air through the detector and exhaust it up into the room. The following is a description of the physical locations of the fans and ducts. The main 18,000 cfm flows through a number of ducts, supplying air from 6 diffusers located high on the west wall, 4 located low on the west wall (two on the lower north side, two on the lower south side), and 8 other ducts, four on the north wall, and four on the south wall, both on the west side of these walls. The return for this air flows through 8 ducts, located on the north and south walls, 4 on each wall, and all on the east side. EF-7 pulls on the spill trough, taking in air from the area above the detector. The location of the four 6,100 cfm fans (two on the east side, two on the west) has been described before. For more detailed information, see drawings 6-3-3 M-4, 6-3-6A M-1, 6-3-6A M-9, and 6-3-6A M-15.⁷ The design of the fans allows every area to receive adequate ventilation, however, most of this ventilation is actually recirculation of the existing air. In addition to the main room fans, there are several fans embedded in the platform which maintain uniform ventilation throughout the platform. The ventilation diagram included in the appendix (page A-1) shows the exact location and size of the fans located in the platform as well as the supply of air the building provides. In an ODH situation, the louver for the main fan would be completely open, providing a fresh air supply of 18,000 cfm. In addition, EF-6 would turn on,

⁷ reference Steve Krstulovich (FESS) or Ed Lober.

providing up to 13,000 cfm of exhaust through the spill trough and argon sump. Under normal conditions, EF-7 would run continuously, maintaining a nominal ventilation exhaust rate of about 1500 cfm. Note that if the normal exhaust rate dropped below the control system alarm setting, EF-6 would also turn on to ensure that there is sufficient ventilation.

CALCULATION

For the ODH analysis of the area, there were five considerations involved. The first was simply to sum all the components throughout the platform with their appropriate estimated failure rates, and use the ODH calculations as per EN-229. This approach seems logical since none of the volumes are in fact isolated. Each volume is related to the others by the ventilation scheme and by the fact that much of the piping runs through more than one section. The total live volume under the platform is 8095 cf, from EN-258. The normal ventilation exhaust rate is 1500 cfm. The first spreadsheet in the appendix (page A-2) shows the calculation, resulting in an ODH classification of 0.

The second consideration is the cryostat/trough system. If the cryostats leak, any leakage will flow through a trough system, designed to bypass the platform completely. In the unlikely event that the trough system fails, there could be leakage into the platform area. In order to estimate the chance for this occurrence, the highest component failure rate of 3×10^{-6} /hr was multiplied by the failure rate for the trough system. Since there are no reference numbers for the failure rate of the trough system, it was calculated by assuming that the trough would only leak through one of its 12 flanges,⁸ (4 of which are welded) where the failure rate per flange is 3×10^{-7} /hr (the same for all of the flanges). The leak rate for the trough was estimated by analyzing the largest flange, a 24" diameter flange,⁹ and scaling the leak rate calculated from EN-231 for a flange to adjust for the larger size. A 1/16" gap in the gasket was used for the calculation. Since a liquid cryogen spill flows through the spill trough by gravity, ΔP was arbitrarily chosen to be 5 psid. Using Equation 3 in EN-231, where $r_H = 12"$, $S = (1/16")(2)(\pi)(12") = 4.712 \text{ in}^2$, and $\Delta L = 3"$. The mass flow leak rate, M , is then 7.56 lbm/s, or 106 scfm. The first spreadsheet shows the fatality rate calculation, resulting in an ODH classification of 0.

The third consideration would be the failure of the muon chamber supply

⁸ reference Gary Trotter, 12/91.

⁹ DØ Detector Liquid Argon Spill Duct System, Drawing number 3740.512-ME-278820 rev. A.

line, which could result in the release of the gas (90% argon, 5% carbon dioxide, 5% tetrafluoromethane) in up to 5 full muon chambers (the associated spill from the supply side has already been accounted for in the first consideration). The muon chamber spill can be dealt with here:

Volume of gas released (90% Ar, 5% CO₂, 5% CF₄):

The chambers operate at a pressure of 4"Hg, and atmospheric pressure here is approximately 28"Hg.

$$5 \text{ chambers} \times \frac{2,000 \text{ L}}{\text{chamber}} \times \frac{0.0353 \text{ ft}^3}{\text{L}} \times \frac{4 \text{ "Hg}}{28 \text{ "Hg}} = 50.43 \text{ scf total}$$

This release would be essentially instantaneous. The smallest volume of air into which one can release this amount of gas and not cause an ODH problem (i.e., the fraction of oxygen remains above 18%) is:

$$\text{volume} = \frac{(21\%)(50.43 \text{ cf})}{(21\% - 18\%)} = 353 \text{ cf}$$

Since the smallest volume we could possibly consider in the platform would be one of the corners, and each of the corners are 386 cf in volume, this could not cause an ODH problem.

The fourth calculation involves the low beta quad magnets in the Main Ring, some of which extend partially into the DØ Collision Hall. There are two strings of four magnets each; it is assumed that the strings are independent from each other. In DØ's case, only 2/3 of one of the magnets in each string protrudes into the Collision Hall.¹⁰ However, since a magnet cannot fail partially, in the spreadsheet calculation the number of components, N, is set to 2, since there are two strings of magnets. There is also a wall at each end of the DØ Collision Hall, acting as a barrier to effectively isolate the room from the rest of the Main Ring. The closed volume assumed for the analysis is the volume within these barriers, subtracting the volume taken up by the detector and other equipment. There are two possible failure rates, depending on whether or not the magnets are powered. If the magnets are powered, a failure rate of 1×10^{-6} /hr was used, for a leak or rupture in a cryogenic magnet.¹¹

¹⁰ DØ Detector Accelerator Beam Tubes Assembly, Drawing Number 3740.220-ME-279493.

¹¹ Fermilab Safety Manual section 5064TA-6 rev. 6/86, Table II, Fermilab Equipment Failure Rate Estimates.

If the magnets are unpowered, a failure rate can be constructed using historical data on cryogenic magnets in the accelerator ring. There have not been any ODH sized leaks in any of the magnets over the time they have been operating, at least 5 years, or 43,800 hours. Estimating about 1,000 magnets, this results in a total number of operating hours equal to 4.38×10^7 hours. If we postulate that there was one failure in one of the magnets during this time, then a conservative failure rate would be $1/4.38 \times 10^7$, or $2.3 \times 10^{-8}/\text{hr}$. This is the failure rate used in the calculation for unpowered magnets.

Specifications of the low beta quads are as follows:

Referenced from Jay Theilacker:

magnet pressures are

2.1 atm, single-phase helium

1.3 atm, two-phase helium

1.2 to 2.1 atm, nitrogen shield

less than 300L LN_2 stored in a string

Steady state flow LN_2 based thru valve of

$C_v = 0.05$ w/3.5 atm subcooled liquid

approx. 450L He stored in a string (300L

single-phase, 150L two-phase helium)

helium from CHL flows thru valve of $C_v = 0.32$

helium from refrigerator flows from either

JT valve ($C_v = 0.5$) or liquid engine

(2-2"dia cyl. @ 2" stroke @ 200 rpm)

at inlet cond's of 18 atm at 4.6 K

helium from CHL and refrigerator flow in parallel

Referenced from CHL:

48 psia, 5.0K helium from CHL

There are two possibilities for a failure in the low beta quads. The first is an instantaneous rupture of the stored volume of either nitrogen or helium. The two are considered separately, since the chance of both occurring at the same time has a negligible effect on the ODH classification.

Volume of nitrogen gas released:

300L LN2 stored in a string = 10.59 cf

Conservatively assume all saturated LN2 @ 1.2 atm

Density of LN2 @ magnet pressure of 1.2 atm = .80119722 g/cc

Density of GN2 @ STP (1 atm, 300K) = .00113844 g/cc

Volume of nitrogen at STP $\approx$ 7,453 scf

The smallest volume of air into which one can release this amount of gas and not cause an ODH problem (i.e., the oxygen level remains above 18%) is:

$$\frac{(21\%)(7,453 \text{ cf})}{(21\% - 18\%)} = 52,171 \text{ cf}$$

Since the magnets would essentially be releasing the gas into the entire Collision Hall (not just the platform, as in the spreadsheet calculations), and the volume available is: (volume of entire Collision Hall) - (volume of detector and equipment) = (about 139,000 cf¹²) - (about 39,000 cf¹³) $\approx$ 100,000 cf, there would not be an ODH problem. Next we consider helium.

Volume of helium gas released:

Single-phase volume:

300L He stored in a string = 10.59 cf

Density of LHe @ magnet pressure of 2.1 atm = 0.09313 g/cc

Density of GHe @ STP (1 atm, 300K) = 0.0001625 g/cc

Volume of helium at STP $\approx$ 6,069 scf

Two-phase volume:

150L He stored in a string = 5.295 cf

The two-phase helium is supplied by expanding the single-phase helium through a JT valve from 2.1 atm to 1.3 atm. Assuming saturated LHe at 2.1 atm and constant enthalpy across the JT valve, the quality of the two-phase helium is approximately 0.4, with 60% liquid, 40% gas.

Density of LHe @ magnet pressure of 1.3 atm = 0.11855 g/cc

¹² see Building Envelope Criteria, Plan and Section, Drawing Number 6-3-1, G-7, and Building Envelope Criteria Sections, Drawing Number 6-3-1, G-8, approx. 65' x 50' x 43'.

¹³ reference Kurt Krempetz, 12/91, from approximate dimensions of 30' x 36' x 36'.

Density of GHe @ magnet pressure of 1.3 atm = 0.02254 g/cc

Density of GHe @ STP (1 atm, 300K) = 0.0001625 g/cc

Volume of helium at STP $\approx$ 2,318 scf + 294 scf = 2,612 scf

Total volume of helium at STP = 8,681 scf

Again, the smallest volume of air into which one can release this amount of gas and not cause an ODH problem is:

$$\frac{(21\%)(8,681 \text{ cf})}{(21\% - 18\%)} = 60,767 \text{ cf}$$

And again, the volume available is 100,000 cf, so there would not be an ODH problem.

The next concern involves the additional flow of nitrogen or helium after a rupture in a line. Note that this also covers the possibility of a leak, since the rupture would be a worse case because of the higher flow rate, and the failure rate is estimated for either a leak or rupture. The worst case scenario involves the instantaneous release of the entire stored volume of helium or nitrogen, followed by a large flow rate continuing to release into the room. Using the general method described in EN-229, the fraction of oxygen after the release of the entire stored volume of helium or nitrogen can be determined.

Fraction of oxygen after nitrogen gas released:

$$\frac{(21\%)(7,453 \text{ cf})}{(21\% - fO_2)} = 100,000 \text{ cf}$$

$$\Rightarrow fO_2 = 19.43\%$$

Fraction of oxygen after helium gas released:

$$\frac{(21\%)(8,681 \text{ cf})}{(21\% - fO_2)} = 100,000 \text{ cf}$$

$$\Rightarrow fO_2 = 19.18\%$$

Theoretically, the flow of nitrogen or helium after this point continues to reduce the oxygen level. The failure rate is not affected by the initial oxygen content, since it is merely a probability of component failure. The fatality

factor, however, depends on the fraction of oxygen, therefore, in the magnet calculations, the equations are modified to account for the initial level of oxygen. Specifically, the fraction of oxygen equations are changed to:

$$fO_2\{\infty\} = 0.1943(1 - L/E) \text{ for nitrogen, and}$$

$$fO_2\{\infty\} = 0.1918(1 - L/E) \text{ for helium.}$$

The fatality factor equations then use these adjusted values for the fraction of oxygen. Assuming the same ventilation of 1500 scfm (it will be much higher in an ODH situation of course) and maximum rupture flows, the ODH class remains at 0, even though the oxygen level drops significantly. The first spreadsheet in the appendix includes the magnet failures for unpowered magnets, with relevant leak flow rates and failure rates. The result is that the area remains ODH class 0 with the parameters shown. Nitrogen and helium leak flow rates are derived in the appendix, pages A-7 to A-10. Note that the fatality factor for the magnet helium supply reaches the maximum of 1.0. However, as with the vacuum jacketed pipes, the ODH classification remains at 0 when the failure rate is accounted for.

The appendix includes two different spreadsheet calculations. The first (page A-2) assumes a nominal ventilation of 1500 scfm, and unpowered magnets. The second spreadsheet (page A-3) calculates the minimum ventilation required when the magnets are powered. With the normal ventilation of 1500 scfm and powered low beta quad magnets, the DØ Collision Hall is ODH class 1. To remain at an ODH class 0, the ventilation rate must be increased to at least 4220 scfm. This can be done by turning on EF-6, the large 13,000 cfm fan. The normal ventilation will be monitored by a fixed flowmeter in the argon sump line. An alarm setting at 1000 scfm has been determined through discussion. If the measured flow drops below the alarm setting, EF-6 will turn on, providing up to 13,000 cfm of additional ventilation. If EF-6 fails, or does not increase the flow above the alarm setting, the control system will activate the ODH alarm, and the Collision Hall will be evacuated.

In the first spreadsheet, it was assumed that the ventilation system was operating and maintaining the normal ventilation of 1500 scfm. The fifth and final calculation considers the case in which the ventilation system fails to operate properly. In this case, virtually any leak or rupture can result in an ODH condition. Essentially, the ratio of the leak rate to the exhaust rate would

approach infinity, so the fatality factor would be equal to 1.0. However, even though this reduces the final oxygen level to 0%, it does not change the ODH class when the failure rates are accounted for. As with the spill trough, the maximum component failure rate of 3×10^{-6} /hr is multiplied by the failure rate of the ventilation, which in this case is taken to be 1.3×10^{-5} /hr, derived from the failure of an electric motor to run.¹⁴ This results in an ODH classification of 0. Note that for an ODH class 0, the maximum failure rate for just the ventilation alone can be up to 3.33×10^{-2} /hr, determined by dividing the maximum fatality rate of 1×10^{-7} /hr by the component failure rate of 3×10^{-6} /hr.

The first spreadsheet on page A-2 in the appendix outlines the risk assessment presented in the text. The five analyses cover the cryogenic piping components, muon gas chamber lines, vacuum jacketed lines, utility vacuum line, rotary bayonet assemblies, spill trough system, low beta quad magnets, and the ventilation system. In each case it is clear that with the nominal ventilation of 1500 scfm, the ODH classification of the DØ Collision Hall is zero. The analysis also shows that there are three scenarios which can lower the oxygen level below the safe 18%. The first is a complete rupture of a vacuum jacketed pipe, coupled with a failure in the control system to close the supply valve, resulting in the maximum flow of liquid cryogen. The probability of this double failure has a negligible contribution to the ODH classification. The second scenario is a failure in the low beta quad helium supply. The initial instantaneous release of a stored volume of either cryogen does not lower the oxygen level below 18%, but the additional flow rate of helium continues to lower the fraction of oxygen below that level. With the magnets unpowered however, the analysis shows that the area remains ODH class 0. The third scenario is a failure in ventilation, in which the exhaust rate drops to 0 scfm, and any significant leak or rupture can lower the oxygen level. As with the vacuum jacketed pipes, however, the probability of this double failure has a negligible contribution to the ODH classification. The additional spreadsheet calculates the minimum ventilation for powered magnets. The Collision Hall is ODH class 1 if the magnets are powered and the ventilation is below 4220 scfm. The minimum ventilation for an ODH class 1 is 25 scfm. In any of the other cases considered, the Collision Hall is ODH class 0.

¹⁴ CDF Oxygen Deficiency Hazard Analysis, Craig Drennan, 5/13/92.

ODH ALARM PROVISIONS

Areas defined to be ODH class 0 do not require the installation of any special hardware or the posting of any signs. However, in order to foresee and safeguard against any possible accident in and around the detector, it is necessary to design and install a detection and warning system. Therefore the DØ Cryogenics group has implemented the Research Division ODH monitoring system consisting of oxygen sensing cells and horn/strobe alarms. Included in the appendix is a diagram showing the placement and number of ODH heads and the placement of horn strobe alarms (see ODH Alarm Provisions) within the platform area.

The heads and alarms are all controlled from the ODH chassis in the ODH chassis rack platform located near the south stairway above the building sump. The ODH chassis are in turn connected to a programmable logic controller (PLC) accessed through two user interface computers in the cryogenic control room. A control system page much like the Alarm Provisions diagram can be accessed on these computers showing which ODH heads, if any, are in alarm. A summation of the status of the ODH heads—OK, trouble or alarm—is sent (independently from the PLC) to FIRUS, which activates a call-in list in an emergency. The control system will also turn on EF-6, providing an additional 13,000 cfm of exhaust ventilation. The system designers have also installed an autodialer as part of the control system hardware. Any alarm, including any ODH alarm, will trigger a call-in list on the autodialer to specified cryoexperts.

At this time, it is not expected that access to the Collision Hall would be required during a time when the magnets are powered, however, if the situation arises, the large fan EF-6 can be turned on, ensuring that the minimum ventilation of 4220 scfm is maintained. The Collision Hall would then remain an ODH class 0 area.

NOTES ON THE DIAGRAM:

The placement of the ODH heads covers all areas of the platform where personnel can enter. The power corner (NW) and the cable corner (NE) are full of equipment and did not require heads.

The platform ODH system protects the localized area under the calorimeters. If all design measures to preclude ODH problems fail, the

monitoring system will alarm warning workers to exit the area. The system has been tested and operated successfully.¹⁵ The horns are audible throughout the platform area and are uncomfortable enough to prevent anyone from ignoring them and continuing work in the area.

ODH EMERGENCY PROCEDURES

In the event of an oxygen deficiency hazard in the platform level (detected by the ODH heads), the alarms will sound, warning personnel in the area of the impending danger. Signs posted adjacent to the alarms will instruct personnel to exit the Collision Hall area surrounding the detector as quickly as possible. Personnel should then congregate in the Assembly Hall high bay area near the large overhead door.

In addition to activating the horns and strobes in the platform level (see alarm provisions), the ODH system sends an alarm to FIRUS which will activate a call in list as well as notify the Fire Department of the impending emergency. The signal is also sent to a cryosystems autodialer which will attempt to contact individuals on a call list and inform them of the emergency. The autodialer will continue to phone the people on the call list until it receives an acknowledgement that the message was received.

Once the Fire Department and/or cryoexpert has arrived, an area status panel mounted near each of the main entrances to the DØ assembly building as well as the main control room will help to determine the nature of the emergency. This panel includes a summation of ODH alarms and flammable gas alarms. From there, emergency responders can access the ODH control page in either the cryo control room or the main control room to determine the location of the alarm. A plan of action will then be coordinated by the Fire Department and system experts.

Included in the appendix are two documents which contain the procedures to be followed in an ODH emergency. The first is a sign which will be posted adjacent to the horns/strobes in the platform level informing them to evacuate the Collision Hall. The second is a more general procedure. It describes in detail the proper sequence of events during an emergency.

¹⁵ Urbin, John, "DØ ODH System (Southside DAB) Test Procedure," DØ Cryogenic Operating Procedures Manual, 4/05/90.

GENERAL NOTES ON ODH

Virtually every ODH analysis currently in use makes certain assumptions to simplify the analysis. These include assuming a defined volume, and uniform mixing and exhaust throughout the volume. In reality, helium will tend to rise, while argon and nitrogen will tend to fall because of the difference in the density of air and of the leaking cryogen. In the DØ Collision Hall, there are a large number of ventilation ducts which extend from the floor to the ceiling to ensure uniform ventilation and a low dew point. This analysis assumes that the entire Collision Hall volume of 100,000 cf has the same oxygen concentration throughout.

Some of the failure rates are referenced from Tables II and III in the Fermilab Safety Manual, section 5064, rev. 6/86. These tables are often subject to interpretation, as currently no details are available on the specific failure modes and item specifications. Other failure rates are derived from historical data or combinations of single failure rates. Leak rates are either conservatively estimated, calculated, measured, or referenced from previous engineering notes.

This analysis does not take into account any failure rate in the ODH detection system, including failure in the ODH heads, the control system, or the building ventilation. The analysis relies only on the normal operating ventilation provided by EF-7, an exhaust fan independent of the building ventilation and controlled by cryoexperts. The analysis does consider the possibility of a failure in EF-7, in which case the ventilation rate would drop to 0 scfm (assuming no fresh air from the building ventilation), and any leak would result in an ODH condition. To guard against this possibility, the ventilation flow is continuously monitored, and if the flow drops below an alarm setting of 1000 scfm and EF-6 is not able to restore the required flow, an ODH alarm is initiated, and the Collision Hall is evacuated.

There are a number of factors which have been conservatively estimated or assumed to simplify the analysis. First, it is assumed that all leak rates exist indefinitely, so that the oxygen level is determined at infinity. In reality, rupture flows would be sensed by a flow switch and the supply would be shut off at the source. Second, the failure rate for an unpowered magnet is based on an estimate of 5 years and 1000 magnets, when in fact the magnets in the Tevatron have been operating since June 3, 1983, or at least 9 years, and there

are 772 dipoles and 245 quads. Third, the vacuum jacketed lines are assumed to undergo a catastrophic rupture, but in such a way that the pipes remain completely open, allowing the maximum liquid flow of 100 gpm of nitrogen (11,000 scfm) to release into the atmosphere.

In general, a wide variety of assumptions are necessary for any practical ODH analysis. The assumptions outlined above may be modified at a later date, but under the current methodology, the DØ Collision Hall is an ODH class 0.

APPENDIX

DØ ENGINEERING NOTE 332 DØ COLLISION HALL ODH ANALYSIS

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PLATFORM VENTILATION DIAGRAM

See DWG 3740.522-ME-222433

DØ COLLISION HALL ODH ANALYSIS NORMAL VENTILATION RATE

Exhaust E 1,500	TC, min. V/E 66.67									
Volume V 100,000	Elevation 701 ft		Pressure 742 mmHG							
ITEM	TYPE	N	P FAIL RATE	GROUP FAIL RATE	L leak rate	L/E LEAK/EXH	fO2{∞} FRACT O2	F Fatal. Factor	Ø Fatal. Rate	ODH Class
Pipes <3"	Sections	520	3.00E-06	1.56E-03	10	0.006667	20.86%	1.06E-09	1.66E-12	0
Elbows		255	3.00E-07	7.65E-05	10	0.006667	20.86%	1.06E-09	8.13E-14	0
Tees		110	3.00E-07	3.30E-05	10	0.006667	20.86%	1.06E-09	3.51E-14	0
Pipes***	vac jacketed	436	1.00E-11	4.36E-09	11000	7.333333	0.00%	1.00E+00	4.36E-09	0
Elbows	vac jacketed	124	1.00E-11	1.24E-09	11000	7.333333	0.00%	1.00E+00	1.24E-09	0
Tees	vac jacketed	36	1.00E-11	3.60E-10	11000	7.333333	0.00%	1.00E+00	3.60E-10	0
Valves**		59	1.00E-08	5.90E-07	33	0.022000	20.54%	1.84E-09	1.09E-15	0
Bayonets*	cryocorner	10	3.00E-06	3.00E-05	10	0.006667	20.86%	1.06E-09	3.19E-14	0
Bayonets	rotary, EC	30	3.00E-06	9.00E-05	10	0.006667	20.86%	1.06E-09	9.57E-14	0
Joints	welded/brazed	1705	3.00E-09	5.12E-06	10	0.006667	20.86%	1.06E-09	5.44E-15	0
Connectors	screw	229	3.00E-06	6.87E-04	10	0.006667	20.86%	1.06E-09	7.30E-13	0
Manifolds	plastic	20	3.00E-06	6.00E-05	10	0.006667	20.86%	1.06E-09	6.38E-14	0
Hose	plastic/flex	191	3.00E-06	5.73E-04	10	0.006667	20.86%	1.06E-09	6.09E-13	0
Magnets - no power, LN2		2	2.30E-08	4.60E-08	17	0.011333	19.21%	1.78E-08	8.19E-16	0
Magnets - no power, He		2	2.30E-08	4.60E-08	1898	1.265333	0.00%	1.00E+00	4.60E-08	0
TOTAL									5.20E-08	0

Trough (Failure of a component and concurrent trough failure)

leak/catastrophic overflow	12	9.00E-13	1.08E-11	106	0.023556	20.51%	1.95E-09	2.10E-20	0
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Ventilation (Failure of a component and concurrent ventilation failure)

leak/catastrophic overflow	1	3.90E-11	3.90E-11	any	infinite	0.00%	1.00E+00	3.90E-11	0
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* Leak taken from EN-231, using the highest value for a likely leak in each case.

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

*** Leak derived from 100 gpm maximum N2 flow (reference Kelly Dixon 12/91).

Explanation of Table Columns and Special Notes

ITEM and TYPE: component description.

N: number of components of item.

FAIL RATE(P): probability of failure, one item, in units of hr^{-1} .

LEAK RATE(L): maximum leakage upon failure of component, in units of scfm.

L/E: ratio of leak rate to exhaust ventilation rate.

FRACTION OF OXYGEN(f_{O_2}):

IF $L/E > 1$, THEN $f_{O_2\{\infty\}} = 0$, ELSE

$f_{O_2\{\infty\}} = 0.21 (1 - L/E)$

p: pressure, in mmHG.

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

IF $10^{(6.5 - (p/10)(f_{O_2}))} \geq 1$, THEN $F = 1$, ELSE

$F = 10^{(6.5 - (p/10)(f_{O_2}))}$

FATALITY RATE(Φ): $N(P)(F)$

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

IF $\Phi \leq 10^{-7}$, THEN ODH class = 0, ELSE

IF $\Phi \leq 10^{-5}$, THEN ODH class = 1, ELSE

IF $\Phi \leq 10^{-3}$, THEN ODH class = 2, ELSE

IF $\Phi \leq 10^{-1}$, THEN ODH class = 3, ELSE
ODH class = 4.

SPECIAL NOTES: Volume, V, is in ft^3 , and time constant, TC, is in minutes. On the normal ventilation table, trough failure rate was derived from the highest component failure rate ($3 \times 10^{-6}/\text{hr}$) multiplied by the failure rate for a leak or rupture of a flange ($3 \times 10^{-7}/\text{hr}$, see text). Note that the leak and exhaust rates are not critical in the vacuum jacketed lines or the ventilation failure, because the maximum fatality factor is 1.00 for any oxygen level under 8.553% (see EN-229). The magnet failure rates were derived from historical data on unpowered magnets, or from Fermilab Safety Manual section 5064TA-6 rev. 6/86 (see text). Ventilation failure rate was derived from the highest component failure rate ($3 \times 10^{-6}/\text{hr}$) multiplied by the failure of an electric motor to run ($1.3 \times 10^{-5}/\text{hr}$, see text). For an ODH class 0, the failure rate of the ventilation itself can be as high as $3.33 \times 10^{-2}/\text{hr}$ (see text).

**DØ COLLISION HALL ODH ANALYSIS
POWERED LOW BETA QUAD MAGNETS**

Exhaust E 4,220	TC, min. 23.70	V/E								
Volume V 100,000	Elevation 701 ft	Pressure 742 mmHG								
ITEM	TYPE	N	P FAIL RATE	GROUP FAIL RATE	L leak rate	L/E LEAK/EXH	{O2}{∞} FRACT O2	F Fatal. Factor	Ø Fatal. Rate	ODH Class
Pipes <3"	Sections	520	3.00E-06	1.56E-03	10	0.002370	20.95%	9.11E-10	1.42E-12	0
Elbows		255	3.00E-07	7.65E-05	10	0.002370	20.95%	9.11E-10	6.97E-14	0
Tees		110	3.00E-07	3.30E-05	10	0.002370	20.95%	9.11E-10	3.01E-14	0
Pipes***	vac jacketed	436	1.00E-11	4.36E-09	11000	2.606635	0.00%	1.00E+00	4.36E-09	0
Elbows	vac jacketed	124	1.00E-11	1.24E-09	11000	2.606635	0.00%	1.00E+00	1.24E-09	0
Tees	vac jacketed	36	1.00E-11	3.60E-10	11000	2.606635	0.00%	1.00E+00	3.60E-10	0
Valves**		59	1.00E-08	5.90E-07	33	0.007820	20.84%	1.11E-09	6.54E-16	0
Bayonets*	cryocorner	10	3.00E-06	3.00E-05	10	0.002370	20.95%	9.11E-10	2.73E-14	0
Bayonets	rotary, EC	30	3.00E-06	9.00E-05	10	0.002370	20.95%	9.11E-10	8.20E-14	0
Joints	welded/brazed	1705	3.00E-09	5.12E-06	10	0.002370	20.95%	9.11E-10	4.66E-15	0
Connectors	screw	229	3.00E-06	6.87E-04	10	0.002370	20.95%	9.11E-10	6.26E-13	0
Manifolds	plastic	20	3.00E-06	6.00E-05	10	0.002370	20.95%	9.11E-10	5.47E-14	0
Hose	plastic/flex	191	3.00E-06	5.73E-04	10	0.002370	20.95%	9.11E-10	5.22E-13	0
Magnets - powered, LN2		2	1.00E-06	2.00E-06	17	0.004028	19.35%	1.40E-08	2.80E-14	0
Magnets - powered, He		2	1.00E-06	2.00E-06	1898	0.449763	10.55%	4.70E-02	9.39E-08	0
TOTAL									9.99E-08	0

Special Notes: This table determines the minimum ventilation exhaust rate required for an ODH class 0 when the low beta quad magnets are powered. The required exhaust rate of 4220 scfm can be supplied by the large fan EF-6, which is rated for 13,000 cfm. If the normal ventilation of 1500 scfm is operating, the DØ Collision Hall is an ODH class 1. The minimum ventilation rate required for an ODH class 1 is 25 scfm, so any flow between 25 scfm and 4220 scfm results in an ODH class 1. Exhaust rates above 4220 scfm result in an ODH class 0.

Calculation of Maximum Low Beta Quad Magnet Leak Rates

Maximum LN2 Flow:

Assume flow is limited by valve, $C_v = 0.05$, 3.5 atm subcooled liquid.

Pick inlet temperature of 88K.

$$\rho (3.5 \text{ atm}, 88\text{K}) = 0.75672896 \frac{\text{g}}{\text{cc}}$$

Reference: ISA Standard ISA-S75.01-1985, Flow Equations for Sizing Control Valves,
Section 5, Incompressible Fluid - Choked Flow of Vaporizing Liquid

$$q_{\max} = N_1 F_L C_v \sqrt{\frac{p_1 - F_F p_v}{G_f}}$$

where N_1 = numerical constant = 1.00 for q in gpm and p in psia
 F_L = liquid pressure recovery factor = 0.9 (max. value in Table D-1)
 C_v = valve flow coefficient = 0.05 (ref: Jay Theilacker)
 p_1 = absolute upstream pressure = 3.5 atm = 51.436 psia
 p_v = absolute vapor pressure at inlet = 2.98 atm = 43.794 psia
 p_c = absolute critical pressure = 33.49 atm = 492.2 psia
 F_F = liquid critical pressure ratio factor

$$F_F = 0.96 - 0.28 \sqrt{\frac{p_v}{p_c}} = 0.96 - 0.28 \sqrt{\frac{43.794 \text{ psia}}{492.2 \text{ psia}}} = 0.8765$$

G_f = liquid specific gravity upstream

$$G_f = \frac{\rho_{\text{LN}_2}}{\rho_{\text{H}_2\text{O}}} = \frac{0.75672896 \frac{\text{g}}{\text{cc}}}{0.998 \frac{\text{g}}{\text{cc}}} = 0.7582$$

$$\Rightarrow q_{\max} = (1.0)(0.9)(0.05) \sqrt{\frac{51.436 - 0.8765(43.794)}{0.7582}} = 0.1867 \text{ gpm}$$

$$\rho (1 \text{ atm}, 300 \text{ K}) = 0.00113844 \frac{\text{g}}{\text{cc}}$$

$$0.1867 \frac{\text{gal}}{\text{min}} = 0.0250 \text{ cfm} = 8.913 \frac{\text{g}}{\text{s}} = \boxed{16.59 \text{ scfm}}$$

Maximum LHe Flow:

Helium from the CHL flows in parallel with flow from the refrigerator, which is limited either by the JT valve, or by the liquid expansion engine.

Refrigerator flow through liquid expansion engine:

$$2'' \text{ diameter cylinders} \Rightarrow \frac{\pi(2'')^2}{4} = \pi \text{ in}^2$$

$$2'' \text{ stroke} \Rightarrow 3.14 \text{ in}^2 \times 2 \text{ in} = 2\pi \text{ in}^3$$

$$2 \text{ cylinders} \Rightarrow 4\pi \text{ in}^3$$

$$\text{maximum intake cutoff of } 0.70 \Rightarrow 2.8\pi \text{ in}^3 \text{ (ref: TM-1036, T. Peterson, 5/8/81)}$$

$$200 \text{ rpm} \Rightarrow 560\pi \frac{\text{in}^3}{\text{min}}$$

$$\rho (18 \text{ atm, } 4.6\text{K}) = 0.1595 \frac{\text{g}}{\text{cc}}$$

$$560\pi \frac{\text{in}^3}{\text{min}} = 76.6 \frac{\text{g}}{\text{s}} = \boxed{1000 \text{ scfm}}$$

Refrigerator flow through JT valve:

Assume flow is limited by JT valve, $C_v = 0.5$, 18 atm, 4.6K.

Reference: ISA Standard ISA-S75.01-1985, Flow Equations for Sizing Control Valves, Section 6, Compressible Fluid - Flow of Gas and Vapor

$$x = \text{pressure ratio} = \frac{\Delta p}{p_1} = \frac{18 \text{ atm} - 1 \text{ atm}}{18 \text{ atm}} = 0.9444$$

First, check if this is choked flow:

$$C_p (18 \text{ atm, } 4.6\text{K}) = 2.860 \text{ J/g-K}$$

$$C_v (18 \text{ atm, } 4.6\text{K}) = 2.156 \text{ J/g-K}$$

$$k = \frac{C_p}{C_v} = \frac{2.860 \frac{\text{J}}{\text{g-K}}}{2.156 \frac{\text{J}}{\text{g-K}}} = 1.327$$

$$F_k = \text{ratio of specific heats factor} = \frac{k}{1.40} = \frac{1.327}{1.40} = 0.9479$$

Model the JT valve as a single port globe valve with contoured plug.

$$x_T = \text{pressure drop ratio factor} = 0.72 \text{ (Table D-1)}$$

$$\text{So } F_k x_T = 0.9479(0.72) = 0.6825$$

Since $x = 0.9444$, and $x > F_k x_T$, the flow is choked

Use the value of $F_k x_T$ in place of x in the calculations.

Maximum mass flow rate:

$$w = N_6 F_p C_v Y \sqrt{x p_1 \gamma_1}$$

where N_6 = numerical constant = 27.3 for w in kg/h, p in bars, and γ in kg/m³

F_p = piping geometry factor = 1.0 (straight pipe, no fittings)

C_v = valve flow coefficient = 0.5 (ref: Jay Theilacker)

Y = expansion factor = $1 - \frac{x}{3F_k x_T} = 1 - \frac{0.6825}{3(0.6825)} = 0.667$ (choked flow)

x = pressure ratio = $F_k x_T = 0.6825$ (choked flow)

p_1 = absolute upstream pressure = 18 atm = 18.24 bars

γ_1 = specific weight upstream = ρg

$$\rho (18 \text{ atm}, 4.6\text{K}) = 0.1595 \frac{\text{g}}{\text{cc}} = 159.5 \frac{\text{kg}}{\text{m}^3}$$

$$\rho g = 159.5 \frac{\text{kg}}{\text{m}^3} \times 9.807 \frac{\text{m}}{\text{s}^2} \times 1 \frac{\text{N} \cdot \text{s}^2}{\text{kg} \cdot \text{m}} \times \frac{0.10197 \text{ kg}_f}{\text{N}} = 159.5 \frac{\text{kg}_f}{\text{m}^3}$$

$$\Rightarrow w = 27.3(1.0)(0.5)(0.667)\sqrt{0.6825(18.24)(159.5)} = 405.7 \frac{\text{kg}}{\text{h}}$$

$$\rho (1 \text{ atm}, 300\text{K}) = 0.0001625 \frac{\text{g}}{\text{cc}}$$

$$405.8 \frac{\text{kg}}{\text{h}} = 112.7 \frac{\text{g}}{\text{s}} = \boxed{1470 \text{ scfm}}$$

Since the flow through the JT valve is higher than the flow from the liquid engine, use the JT valve flow of 1470 scfm in the spreadsheet ODH analysis.

CHL Flow:

Assume flow is limited by valve, $C_v = 0.32$, 48 psia, 5.0K.

Reference: ISA Standard ISA-S75.01-1985, Flow Equations for Sizing Control Valves, Section 6, Compressible Fluid - Flow of Gas and Vapor

$$x = \text{pressure ratio} = \frac{\Delta p}{p_1} = \frac{48 \text{ psia} - 14.7 \text{ psia}}{48 \text{ psia}} = 0.694$$

First, check if this is choked flow:

$$C_p (3.266 \text{ atm}, 5.0\text{K}) = 6.465 \text{ J/g-K}$$

$$C_v (3.266 \text{ atm}, 5.0\text{K}) = 2.621 \text{ J/g-K}$$

$$k = \frac{C_p}{C_v} = \frac{6.465 \frac{\text{J}}{\text{g-K}}}{2.621 \frac{\text{J}}{\text{g-K}}} = 2.467$$

$$F_k = \text{ratio of specific heats factor} = \frac{k}{1.40} = \frac{2.467}{1.40} = 1.762$$

The valve is a Fermilab-designed right-angle valve with a 100 to 1 "equal percentage" valve bullet. Model as a single port globe valve with contoured plug.

$$x_T = \text{pressure drop ratio factor} = 0.72 \text{ (Table D-1)}$$

$$\text{So } F_k x_T = 1.762(0.72) = 1.269$$

Since $x = 0.694$, and $x < F_k x_T$, the flow is not choked

Use the actual value of x in the calculations.

Maximum mass flow rate:

$$w = N_6 F_p C_v Y \sqrt{x p_1 \gamma_1}$$

where N_6 = numerical constant = 27.3 for w in kg/h, p in bars, and γ in kg/m³

F_p = piping geometry factor = 1.0 (straight pipe, no fittings)

C_v = valve flow coefficient = 0.32 (ref: Jay Theilacker)

$$Y = \text{expansion factor} = 1 - \frac{x}{3F_k x_T} = 1 - \frac{0.694}{3(1.269)} = 0.8177$$

x = pressure ratio = 0.694 (from before)

p_1 = absolute upstream pressure = 48 psia = 3.309 bars

γ_1 = specific weight upstream = ρg

$$\rho \text{ (3.266 atm, 5.0K)} = 0.1193 \frac{\text{g}}{\text{cc}} = 119.3 \frac{\text{kg}}{\text{m}^3}$$

$$\rho g = 119.3 \frac{\text{kg}}{\text{m}^3} \times 9.807 \frac{\text{m}}{\text{s}^2} \times 1 \frac{\text{N} \cdot \text{s}^2}{\text{kg} \cdot \text{m}} \times \frac{0.10197 \text{ kgf}}{\text{N}} = 119.3 \frac{\text{kgf}}{\text{m}^3}$$

$$\Rightarrow w = 27.3(1.0)(0.32)(0.8177)\sqrt{0.694(3.309)(119.3)} = 118.2 \frac{\text{kg}}{\text{h}}$$

$$\rho \text{ (1 atm, 300K)} = 0.0001625 \frac{\text{g}}{\text{cc}}$$

$$118.2 \frac{\text{kg}}{\text{h}} = 32.8 \frac{\text{g}}{\text{s}} = \boxed{428 \text{ scfm}}$$

This matches with the flow rate from the Accelerator Division (Jay Theilacker, Joel Fuerst), which was approximately 30 g/s. This flow is in parallel to the refrigerator flow, so the total flow leak rate of helium used in the ODH analysis is:

$$1470 \text{ scfm} + 428 \text{ scfm} = \underline{1898 \text{ scfm}}.$$

D. CLARK
11/07/90

ODH ALARM PROVISIONS

A-9

○ ODH HEAD

▣ STROBE/HORN

Orig. JM

ODH ALARM

**EVACUATE DØ
DETECTOR AREA**

DØ Detector Platform ODH Alarm Response

An ODH monitoring system has been installed in the platform level below the DØ detector. This procedure addresses the proper response to alarms from the ODH monitoring system.

1. HORNS AND STROBES WILL BE ACTIVATED IF AN ODH CONDITION IS SENSED BY THE MONITOR SYSTEM.
2. ALL PERSONNEL IN THE PLATFORM AREA AND THE COLLISION HALL AREA MUST EVACUATE TO THE ASSEMBLY HALL AREA NEAR THE LARGE OVERHEAD DOOR.
3. INFORMATION FROM THE ODH STATUS PANEL MOUNTED IN THE MAIN CONTROL ROOM AND NEAR THE NORTH ENTRANCE AND REPORTS FROM THE PERSONNEL EXITING WILL HELP DETERMINE IF THERE IS A REAL ODH EMERGENCY. IF THERE IS ANY UNCERTAINTY, ASSUME A REAL EVENT AND CALL X3131 FOR FIRE DEPARTMENT ASSISTANCE. DO NOT RE-ENTER THE BUILDING DURING A REAL EVENT WITHOUT FIRE DEPARTMENT SUPPORT AND SCBA EQUIPMENT.
4. IF THE ODH HEAD IN THE CRYO CONTROL ROOM AND/OR MAIN 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 AND THE CRYO SYSTEM'S AUTODIALER, 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 WILL TAKE CORRECTIVE ACTION TO RESTORE THE ODH MONITORING SYSTEM TO NORMAL OPERATING CONDITION.