DØ CLEAN ROOM
ODH ANALYSIS

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REV. A

DØ Engineering Note
3740.510-EN-253

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The following is an ODH analysis of the DØ clean room with the following parameters:

2 – 160 liter LAr or LN_2 dewars.
Exhaust – 2500 cfm recirculated, 520 cfm fresh air.
Volume –57,170 cf.
Elevation, Pressure – 707.5', 742 mmHG.

Table A shows the steady state situation. One of the two dewars would be supplying purge gas at (a maximum of) 20 scfm, which would leak into the room through the welding orifice. Instantaneous, uniform diffusion and exhaust are assumed. Note the probability is 1 for the 20 scfm leak since it is a planned occurrence.

Table B is the same situation in the event of a power failure, estimated for twice a year ($2.29x10^{-4}$ fails/hour). This assumes that the exhaust is shut down, and the dewars are not turned off. This would require the minimum exhaust to be the same as the leak (as an approximation).

These results, however, would only be valid for an infinite supply of the purge gas, and for an exceedingly long power failure. Since the supply of LAr would only last a day at most, and the power failure would not last for weeks, this result has no real significance. In fact, the time constant for the ODH equation in this case is 5717 minutes, which means it would take 20 days for all the oxygen to be displaced.

A worst case scenario would be a full dewar completely emptying into the clean room in a short time relative to the ventilation rate, but slow enough for uniform dispersion. We can do a leak/exhaust independent (ventilation rate=0) analysis:

ρ of LAr: 1.393 g/cc
ρ of GAr: 0.00161 g/cc

$$(160)\left(\frac{1.393}{0.00161}\right)\left(\frac{10}{2.54\,(12)}\right)^3 = (160\text{ L})(29.95) = 4792\text{ scf}$$

Accounting for this displacement and the corresponding decrease in Oxygen:

$$21\,(57{,}170 - 4792)\,/\,57{,}170 = \mathbf{19.2}\,\%\ O_2$$

This also assumes instantaneous and uniform mixing. This suggests that even with a complete dewar failure, the oxygen content would not decrease to a safety hazard. The probability of a simultaneous, catastrophic, dewar failure would be so low as to offset the consequences as insignificant, and even so, those consequences would be only a slight oxygen deficiency (17.5% O_2)

These same arguments could be followed for LN2 dewars, and would have the same results except for the last case. Since nitrogen would not expand as much, the displaced volume would only be 3945 cf, and the resulting displacement would lower the oxygen content to 19.55 %. In fact, emptying both dewars would only decrease the oxygen content to 18.1 %.

None of these analyses suggest a safety hazard in any manner, so no ODH equipment need be present.

Note: Standard conditions defined at 70 °F, 1 atm.

Clean Room, Oxygen Deficiency Hazard Analysis.

TABLE A – STEADY STATE

Exhaust **E**	TC, min. **V/E**	
520	109.94	
Volume **V**	Elevation	Pressure
57170	707 ft	742 mmHG

ITEM	TYPE, SIZE	**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**
Dewar		1	1.00E+00	1.00E+00	20	0.03846	2.02E-01	3.35E-09	3.35E-09	0

TABLE B – POWER FAILURE
(See text for ODH 0 qualification)

Exhaust **E**	TC, min. **V/E**	
20	2858.50	
Volume **V**	Elevation	Pressure
57170	707 ft	742 mmHG

ITEM	TYPE, SIZE	**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**
Dewar		1	2.29E-04	2.29E-04	20	1	0.00E+00	1.00E+00	2.29E-04	2

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

REFERENCE: DØ Engineering Note 3740.510-EN-229, "General ODH Analysis Method and Conclusions" Sept. 19, 1989, Rev. B.

APPENDIX:
SPREADSHEAT VARIABLE DESCRIPTIONS

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.

$fO_2\{\infty\}$: 0.21 (1 - L/E)

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

IF 10^(6.5-(p/10)(fO_2)) ≤ 0, THEN F = 0, ELSE
IF 10^(6.5-(p/10)(fO_2)) ≥ 1, THEN F = 1, ELSE
F = 10^(6.5-(p/10)(fO_2))

p is pressure (mmHG) of elevation in question.

FATALITY RATE(**Ø**): N(P)(F)

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

IF Ø ≤ 10-7, THEN	ODH class = 0, ELSE
IF Ø ≤ 10-5, THEN	ODH class = 1, ELSE
IF Ø ≤ 10-3, THEN	ODH class = 2, ELSE
IF Ø ≤ 10-1, THEN	ODH class = 3, ELSE
	ODH class = 4