Fermilab

Particle Physics Division
Mechanical Department Engineering Note

Number: MD-ENG-135 Date: 5 November 2007

Project Internal Reference:

Project: HIL Canberra detector cryostats

Title: HIL ODH Analysis

Author(s): Dave Pushka

Reviewer(s):

Key Words: ODH, HIL, LN2

Abstract Summary: ODH Calculations for Japanese visitors who hope to use four 30 liter cryostats filled with LN2 in the north most counting house room at HIL.

Applicable Codes: FESHM 5064

Discussion:

The north most room at HIL is being considered as a location to install four cryostats. Each cryostat is 30 liters. The installation will last several weeks and will be used by some Japanese collaborators.

The room is not actively ventilated with fresh air, although it does have a forced air HVAC system ducted into part of the room. The insulation along the two outside walls is in poor repair. Numerous holes have been patched in the outside walls, especially the north wall. Insulation has not been

repaired in most locations where holes have been patched. This room is far from hermitically sealed.

LN2 will be supplied by 160 liter portable Dewars available from the stock room. 160 liter supply Dewars will be stored outside. LN2 may be brought into the room with 2 or 5 liter hand carried Dewars. It is possible that the 160 liter supply Dewars will be brought into the room for the initial fill of the four 30 liter cryostats.

Seven LN2 Loss cases have been examined to determine the oxygen (O2) concentration level. These cases are:

Case 1,	Full Loss of 122 liters of LN2 with no ventilation
Case 2,	Full Loss of 30 liters of LN2 with no ventilation
Case 3,	Full Loss of 5 liters of LN2 with no ventilation
Case 4,	Full Loss of 2 liters of LN2 with no ventilation
Case 5,	Full Loss of 160 liters of LN2 with no ventilation
Case 5a,	Full Loss of 160 liters of LN2 over 10 minutes with 5000 cfm ventilation
Case 6,	20 liter per day LN2 boil off rate with no ventilation
Case 7,	20 liter per day LN2 boil off rate with 10 cfm minimal ventilation.
Case 7a,	20 liter per day LN2 boil off rate with 100 cfm minimal ventilation.

Conclusions:
Installation of a 5000 cfm exhaust fan operated whenever a 160 liter Dewar is brought into the room will ensure that the oxygen concentration level remains above 19 % and the room remains an ODH class 0. But, 5000 cfm is very large and therefore, it makes sense to use smaller hand carried Dewars to fill the cryostats.

Installation of a very small 10 cfm fan, operated continuously while the cryostats have LN2 in them will ensure that the oxygen concentration level remains above 19 % and the room remains an ODH class 0 while using a minimal amount of energy to heat make-up air. A small muffin fan like that used to cool electronics (NMB Model 4715FS) has a capacity of 110 cfm at minimal pressure drop. This is more than adequate capacity.

Exhaust fan should be located near the floor so that the relatively cold GN2 boil off is exhausted. The north wall on the north most HIL counting house room has metal siding and has been cut into at numerous locations. The room just to the south has its only outside wall constructed of concrete from the floor to about 5 feet above the floor, making installation of the fan near the floor more difficult. For this reason, the north room is preferable.

Concentration of O2 in the HIL North Room as a function of time for several LN2 release scenerios

The room 3 volume is based on a room 13 feet tall, 20.5 feet long and 28 feet wide as I measured on 11/5/07. This is not as tall as described in previous emails. The total LN2 capacity is 132 liters as indicated by Masayuki Hagiwara in an email he sent to Tony Leveling on 10/28/2007. This is for 4 Dewars with detectors at 30 liters each and one 2 liter. Sum inventory is 122 liters (not 132 liters as listed elsewhere).

Case 1: Full Loss of 122 liters of LN2

Volume of room (cubic feet):	7462	ft^3
Volume of LN2 is	122	liters
Volume of LN2 is (# of liters * 0.0353146667 ft^3 / liter) =	4.31	ft^3
Density of LN2 is 50 lbs / ft^3	50	lbs / ft^3
Mass of LN2 is	215.42	lbs
Density of GN2 at 70 F	0.075	lbs / ft^3
Volume of GN2 from total inventory loss of all Dewars	2872	ft^3
O2 concentration with instant loss of all inventory, perfect mixing and no ventilation =	15.16335	% oxygen

Case 2: Full Loss of 30 liters of LN2

Volume of room (cubic feet):	7462	ft^3
Volume of LN2 is	30	liters
Volume of LN2 is (# of liters * 0.0353146667 ft^3 / liter) =	1.06	ft^3
Density of LN2 is 50 lbs / ft^3	50	lbs / ft^3
Mass of LN2 is	52.97	lbs
Density of GN2 at 70 F	0.075	lbs / ft^3
Volume of GN2 from total inventory loss of one Dewar	706	ft^3
O2 concentration with instant loss of one Dewar inventory, perfect mixing and no ventilation =	19.18418	% oxygen

Case 3: Full Loss of 5 liters of LN2

Volume of room (cubic feet):	7462	ft^3
Volume of LN2 is	5	liters
Volume of LN2 is (# of liters * 0.0353146667 ft^3 / liter) =	0.18	ft^3
Density of LN2 is 50 lbs / ft^3	50	lbs / ft^3
Mass of LN2 is	8.83	lbs
Density of GN2 at 70 F	0.075	lbs / ft^3
Volume of GN2 from total inventory loss of one 5 liter portable fill Dewar	118	ft^3
O2 concentration with instant loss of one 5 liter portable dewar, perfect mixing and no ventilation =	20.67386	% oxygen

Case 4: Full Loss of 2 liters of LN2

Volume of room (cubic feet):	7462	ft^3
Volume of LN2 is	2	liters
Volume of LN2 is (# of liters * 0.0353146667 ft^3 / liter) =	0.07	ft^3
Density of LN2 is 50 lbs / ft^3	50	lbs / ft^3
Mass of LN2 is	3.53	lbs
Density of GN2 at 70 F	0.075	lbs / ft^3
Volume of GN2 from total inventory loss of one 2 liter portable fill Dewar	47	ft^3
Volume of GN2 from total inventory loss of one 2 liter portable fill Dewar	20.86832	% oxygen

Case 5: Full Loss of 160 liters of LN2

Volume of room (cubic feet):	7462	ft^3
Volume of LN2 is	160	liters
Volume of LN2 is (# of liters * 0.0353146667 ft^3 / liter) =	5.65	ft^3
Density of LN2 is 50 lbs / ft^3	50	lbs / ft^3
Mass of LN2 is	282.52	lbs
Density of GN2 at 70 F	0.075	lbs / ft^3
Volume of GN2 from total inventory loss of one 160 liter portable fill Dewar	3767	ft^3
O2 concentration with instant loss of an entire 160 liter Dewar, perfect mixing and no ventilation =	13.95524	% oxygen

Case 5a: Full Loss of 160 liters of LN2 over 20 minutes with ventillation

VERY (!) Simple O2 concentration Calculations

Vent rate	Spill Rate	Volume
Q, cfm	R, cfm	V, cfm
5000	376.7	7556

* Here is the worst case of HIL Room B

t, min	t, hrs	C, %
0	0	21.00
1	0.02	20.25
2	0.03	19.88
3	0.05	19.70
4	0.07	19.61
5	0.08	19.57
6	0.10	19.55
7	0.12	19.54
8	0.13	19.53
9	0.15	19.53
10	0.17	19.53
11	0.18	19.53
12	0.20	19.53
13	0.22	19.53
14	0.23	19.53
15	0.25	19.53
16	0.27	19.53
17	0.28	19.53
18	0.30	19.53
19	0.32	19.53
20	0.33	19.53

Case 6: Steady - State Boil Off of 20 liters per day, no ventillation:

Boiloff at	20	liters of LN2 per day
Boiloff at	0.833333	liters of LN2 per hour
Boiloff at	0.013889	liters of LN2 per min
Boiloff at	0.00049	cubic feet of LN2 per min
Boiloff at	0.326988	Cubic feet of GN2 per min

VERY (!) Simple O2 concentration Calculations

Vent rate	Spill Rate	Volume
Q, cfm	R, cfm	V, cfm
0	0.326988	7556

Just enter Q, R, V and see the O2(t)

t, min	t, hrs	C, %
0	0	21.00
60	1	20.95
120	2	20.89
180	3	20.84
240	4	20.78
300	5	20.73
360	6	20.68
420	7	20.62
480	8	20.57
540	9	20.51
600	10	20.46
660	11	20.41
720	12	20.36
780	13	20.30
840	14	20.25
900	15	20.20
960	16	20.15
1020	17	20.09
1080	18	20.04
1140	19	19.99
1200	20	19.94
1260	21	19.89
1320	22	19.83

1380	23	19.78
1440	24	19.73
2160	36	19.13
2880	48	18.54
3600	60	17.97
4320	72	17.42
5040	84	16.88

Case 7: Steady - State Boil Off of 20 liters per day, with ventillation:

Boiloff at	20	liters of LN2 per day
Boiloff at	0.833333	liters of LN2 per hour
Boiloff at	0.013889	liters of LN2 per min
Boiloff at	0.00049	cubic feet of LN2 per min
Boiloff at	0.326988	Cubic feet of GN2 per min

VERY (!) Simple O2 concentration Calculations

Vent rate	Spill Rate	Volume
Q, cfm	R, cfm	V, cfm
10	0.326988	7556

Just enter Q, R, V and see the O2(t)

t, min	t, hrs	C, %
0	0	21.00
60	1	20.95
120	2	20.90
180	3	20.85
240	4	20.81
300	5	20.78
360	6	20.74
420	7	20.71
480	8	20.68
540	9	20.65
600	10	20.63
660	11	20.60
720	12	20.58
780	13	20.56
840	14	20.55
900	15	20.53
960	16	20.51
1020	17	20.50
1080	18	20.49
1140	19	20.48
1200	20	20.46
1260	21	20.45
1320	22	20.44
1380	23	20.44

1440	24	20.43
2160	36	20.37
2880	48	20.35
3600	60	20.34
4320	72	20.34
5040	84	20.34

Case 7a: Steady - State Boil Off of 20 liters per day, with ventillation:

Boiloff at	20	liters of LN2 per day
Boiloff at	0.833333	liters of LN2 per hour
Boiloff at	0.013889	liters of LN2 per min
Boiloff at	0.00049	cubic feet of LN2 per min
Boiloff at	0.326988	Cubic feet of GN2 per min

VERY (!) Simple O2 concentration Calculations

Vent rate	Spill Rate	Volume
Q, cfm	R, cfm	V, cfm
100	0.326988	7556

Just enter Q, R, V and see the O2(t)

t, min	t, hrs	C, %
0	0	21.00
60	1	20.96
120	2	20.95
180	3	20.94
240	4	20.93
300	5	20.93
360	6	20.93
420	7	20.93
480	8	20.93
540	9	20.93
600	10	20.93
660	11	20.93
720	12	20.93
780	13	20.93
840	14	20.93
900	15	20.93
960	16	20.93
1020	17	20.93
1080	18	20.93
1140	19	20.93
1200	20	20.93
1260	21	20.93
1320	22	20.93
1380	23	20.93

1440	24	20.93
2160	36	20.93
2880	48	20.93
3600	60	20.93
4320	72	20.93
5040	84	20.93