DØ CONTROL ROOM
ARGON TEST CELL PLACEMENT

April 1, 1991
Rev. May 10, 1991
Rev. June 11, 1991

DØ Engineering Note
3740.512-EN-295

J. Michael

Approved________________ Date 25 June 91

Due to the need of maintaining and providing high purity argon for the DØ experiment, it is necessary to have a purity verifying device readily available. The testing equipment used by the DØ cryo group is called the Argon Test Cell (ATC). It operates by taking a sample of the argon to be tested and running it through a test cell for purity determination. Liquid nitrogen cooling loops are used to to keep the argon cold during the testing.

The initial placement of the ATC was outside of the DØ Cryo Control Room. This was not a favorable place, mainly because of exposure to the elements on the operators and the device. A plan was made to move the ATC from outside to inside the control room. This would allow security, favorable environment conditions, and general overall improved access and operability.

Having the ATC inside causes some concern over some issues. It is true that the ATC employs cryogenic piping components, so there is an ODH possibility if those components were to fail and leak. However, there are ways by which we can determine the ODH class fairly easily. Using the methods outlined in DØ EN-229, the components of the cryogenic pipe lines are summed and grouped according to failure possibility and likely leakage upon failure. (Note that this is the reason that one type of component may be listed a multiple number of times in the appendix spreadsheet, as the different components have different possible leak rates, depending on position or size, etc.). The result is an ODH class 0, since the fatality rate has to be above 10^{-7} for a hazard condition to be present. The fatality rates in this analysis only come within an order of magnitude of this safety limit due to using conservative estimates.

Note that the 130 scfm fan must be active for the ODH status to remain 0. The control room ventilation is on emergency power. An alarm attached to the fan will notify the operators of fan failure, but both the fan and the alarm can be turned off when they are not needed. The fan need not be active as long as there are no cryogens in the ATC, and the argon and nitrogen supply line valves have been secured closed. For ODH detection purposes, an ODH head has already been installed in the control room as a result of the DAB southside ODH plan. For a fuller picture, see chapter 6 of Kelly Dixon's "DØ Cryogenic Operating Procedures".

NOTE ON PROJECTED LEAK RATES:

The highest projected leak rate in the analysis, 120 scfm, is based on the maximum expected flow rate from the high pressure nitrogen dewar that supplies the cooling coils for the ATC (1200 scfm, see below). This value makes a lot of assumptions--that the dewar is fully pressurized and filled, that the flow is fully developed, that no flashing occurs until the liquid enters the control room atmosphere, etc. In actuality, the flow would be much lower.

But in this particular case, it is a moot point, due to the low probability of this type of failure. In fact, the calculated hazard from that valve would not decrease until it's leakage was projected below the ventilation rate. It is at that point that the leak does not overwhelm the room.

The piping components with the high projected leak rate (120 scfm), are components on the liquid nitrogen inlet line. This is a 1/10 projection as to what the leak would be if the liquid nitrogen supply valve was flowing full and a leak occurred in the line. This is the most conservative way to estimate those leak rates, as even 120 scfm is an order of magnitude greater than what would be expected.

There are several adjustments that have been made to insure the ODH safety of the control room, among them being: routing the removable solenoid valve outside due to the unreliability of screwed connections, routing the vessel relief vents and main vent line outside, and replacing the couplings on the liquid nitrogen inlet line with welded pipe connections.

APPENDICES:

Note on 120 scfm leak rate; Note on extra analyses;
Old control room setup (picture); Current setup (picture);
ODH analysis (spreadsheet); ATC piping schematic (drawing).

REFERENCES:

DØ Engr. Note 3740.510-EN-229, General ODH Analysis Method and Conclusions, Sept. 19, 1989, Rev. B.

DØ Engr. Note 3740.512-EN-231, Leak Analysis, Bayonet and Flange, Oct. 11, 1989, Rev. C.

DØ Engr. Note 3740.512-EN-243, Argon Test Cell (ATC) Cryostat, February, 1990.

NOTE ON CALCULATION FOR 120 SCFM LEAK RATE:

This rate was determined using the Cv and flow equations pertaining to the valve supplying those components. The flow was determined using cryogenic fluid, which was scaled afterwards to standard condition gaseous form, for analysis purposes. As a conservative estimate, the leak of those components can be estimated at at most 1/10 of that rate, or 120 scfm.

EQUATIONS:

$$\bar{v}^2 = \frac{2\,\Delta p\, g_c}{\rho\left(\Sigma K + 1\right)} \qquad \Sigma K = f\left(\frac{L_e}{d}\right) + K_{inlet} + K_{outlet} + K_{valve}$$

$$f = f\left(R_d, \frac{\varepsilon}{d}\right) \qquad K_{valve} = \left(\frac{29.9\ d^2}{C_v}\right)^2$$

Where: Δ**p** is pressure drop, $\bar{v}$ is average velocity, ρ is density, Σ**K** is coefficient of losses summation (assumed K_{inlet}=0.5, K_{outlet}=1.0 for this case), g_c is gravitational constant (32.2, English units), **f** is friction factor (based on pipe smoothness and diameter, and the Reynold's number, read from Moody chart. In this case, first assumed to be .02), L_e is the equivalent in straight pipe length for the pipe configuration considered (the ATC piping in question runs from the dewar to the control room, and has two elbows. It's L_e is 8.5'), **d** is the inner diameter of the pipe (.43" for 1/2 line), and ε is the inner surface roughness of the pipe (pipe is assumed to be smooth, ratio ε/**d** being negligible). The C_v of the valve in question has a highest possible Cv of 2.2, as detailed by the manufacturers.

From these calculations (see next page), average velocity can be determined as 31 ft/s, and the scfm rate then to be about 1200 scfm when multiplying the velocity by the cross sectional area and scaling by the density ratio.

est. $f = 0.02$

$$\Sigma K = 0.02\left(\frac{8.5'}{0.43''\left(\frac{1'}{12''}\right)}\right) + 0.5 + 1.0 + 6.3 = 12.6$$

$$K_v = \left(\frac{29.9\,(0.43'')^2}{2.2}\right)^2 = 6.3$$

$$\bar{V}^2 = \frac{2\,\Delta p\, g_c}{\rho(\Sigma K+1)} = \frac{2\left(50\,\frac{\#_f}{si}\left(\frac{144\ si}{sf}\right)\right)\left(32.2\,\frac{ft}{s^2}\left(\frac{\#_m}{\#_f}\right)\right)}{\left(45\,\frac{\#_m}{cf}\right)(12.6)} = \frac{10{,}304}{12.6}\,\frac{ft^2}{s^2} = 826\,\frac{ft^2}{s^2}$$

$\bar{V} = 28.6$ ft/s

$$R_d = \frac{\rho \bar{V} d}{\mu} = \frac{\left(0.73\,\frac{g}{cc}\right)\left(28.6\,\frac{ft}{s}\right)\left(0.43''\right)\left(\frac{12''}{ft}\right)\left(\frac{2.54\ cm}{in}\right)^2}{0.000903\,\frac{g}{cm\cdot s}} = 26{,}912\,(28.6)$$

$\cong 770{,}900$

from Moody chart, $f \approx 0.012$ (for smooth pipes)

$$\Sigma K = (0.012)(237) + 7.8 \rightarrow 10.6$$

$$\bar{V}^2 = \frac{10{,}304}{10.6} = 968 \qquad \bar{V} = 31.1\ \frac{ft}{s}$$

$R_d = 26{,}912\,(31.1) = 837{,}230$, no sig. change

$$\dot{V} = \left(31.1\,\frac{ft}{s}\right)\left(\frac{1}{4}\pi\left(\left(\frac{0.43}{12}\right)'\right)^2\right)\left(\frac{60\ s}{min}\right)\left(\frac{878.4\ cc/g}{1.369\ cc/g}\right) \cong 1{,}210\ \text{scfm}$$

NOTE ON EXTRA ODH ANALYSES:

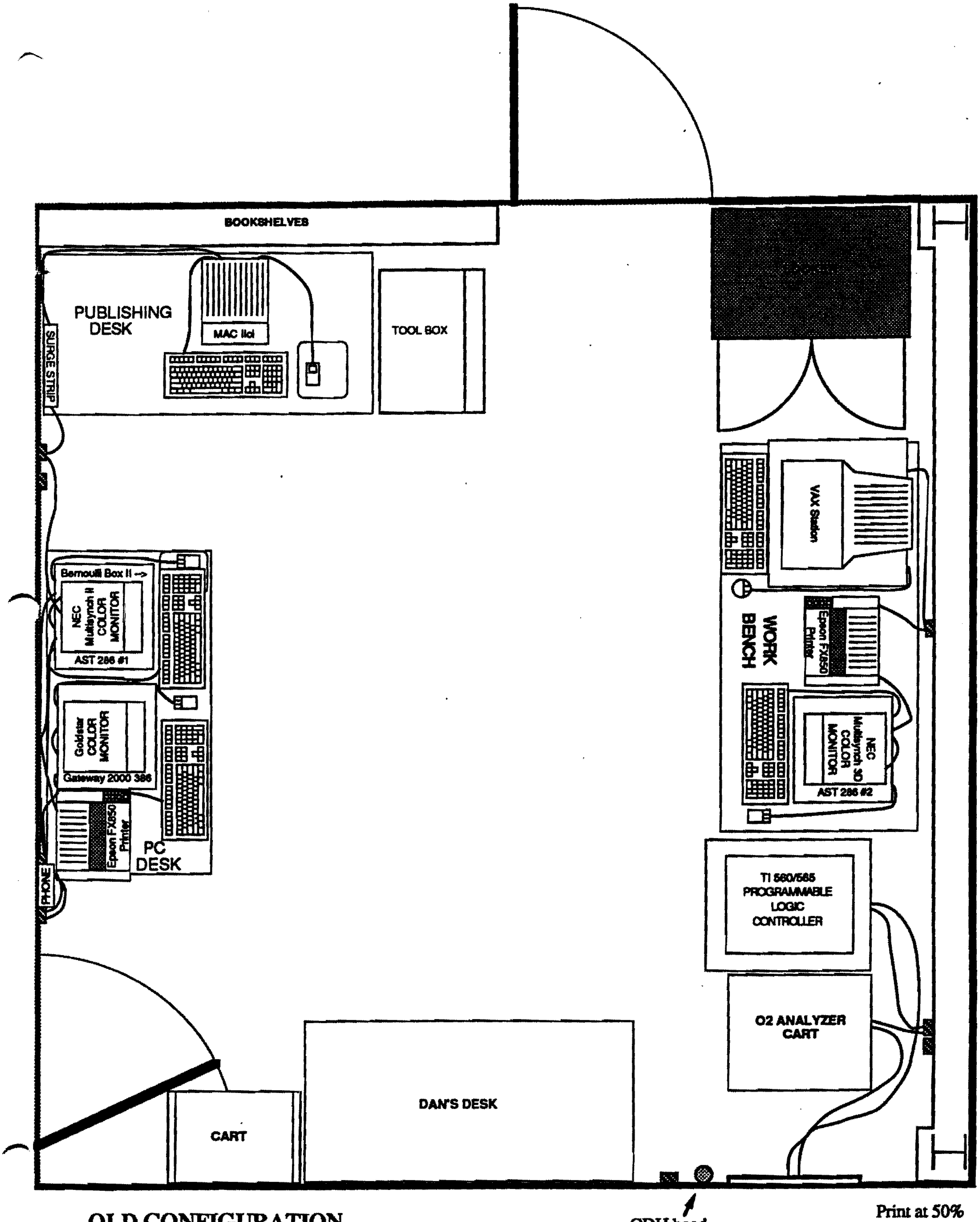
There has been some concern over whether the standard ODH analysis was complete enough to determine the safety of the control room, so a few different perspectives were taken. The first was to consider what would happen if a 1200 scfm leak actually did occur. The fail rate probabilities normally used only cover average possible leaks, and do not specifically address a particular kind of leak (e.g. catastrophic). A catastrophic leak of this nature, where there is full flow from the supply line into the control room, would certainly have a lesser chance of occurring than a normal leak, but for now we will use the same probability and see what happens. As an aside, the severing of the pipe lines would probably coincide with the inadvertent destruction of the control room, due to the relative lack of physical labor done in or around the room (i.e. a truck would have to crash into the wall, or the ceiling would have to collapse). In any event, the result is still well within the safety margin at a fatality rate of $1 \bullet 10^{-9}$.

Another concern was since the special ventilation fan did not need to run continuously, the possibility of it being neglected became a factor in the analysis. The solution to this was to assume that if the fan was not activated, the fatality factor for all leaks would become one. The corresponding probability for this factor was the chance of the fan not being turned on (an operator error, assumed to be $3 \bullet 10^{-3}$/demand for an obvious omission in procedure. Signs attached to vital components of the ATC will aid as reminders). It is estimated that the ATC would be operated 10 times a year.

$$(3 \bullet 10^{-3}/\text{demand})\ (10\ \text{demands/year})\ (1\ \text{year}/8760\ \text{hours}) \approx 3.5 \bullet 10^{-6}/\text{hour}$$

Another concern would be the possibility of the fan failing during operation, which corresponds to a motor failure rate of 10^{-5}/hr (fans, in general, are known to be less reliable as a whole than plain motors are, so 10^{-4}/hr is used to reflect this). The analysis is otherwise the same as the operator failure analysis, except that in this case the results are independent of the number of times the ATC is used, and applies only during operation. In either of these cases, the ODH class is 0. See the analysis spreadsheet for specific results.

CRYO CONTROL ROOM, Scale:1/2"=1'

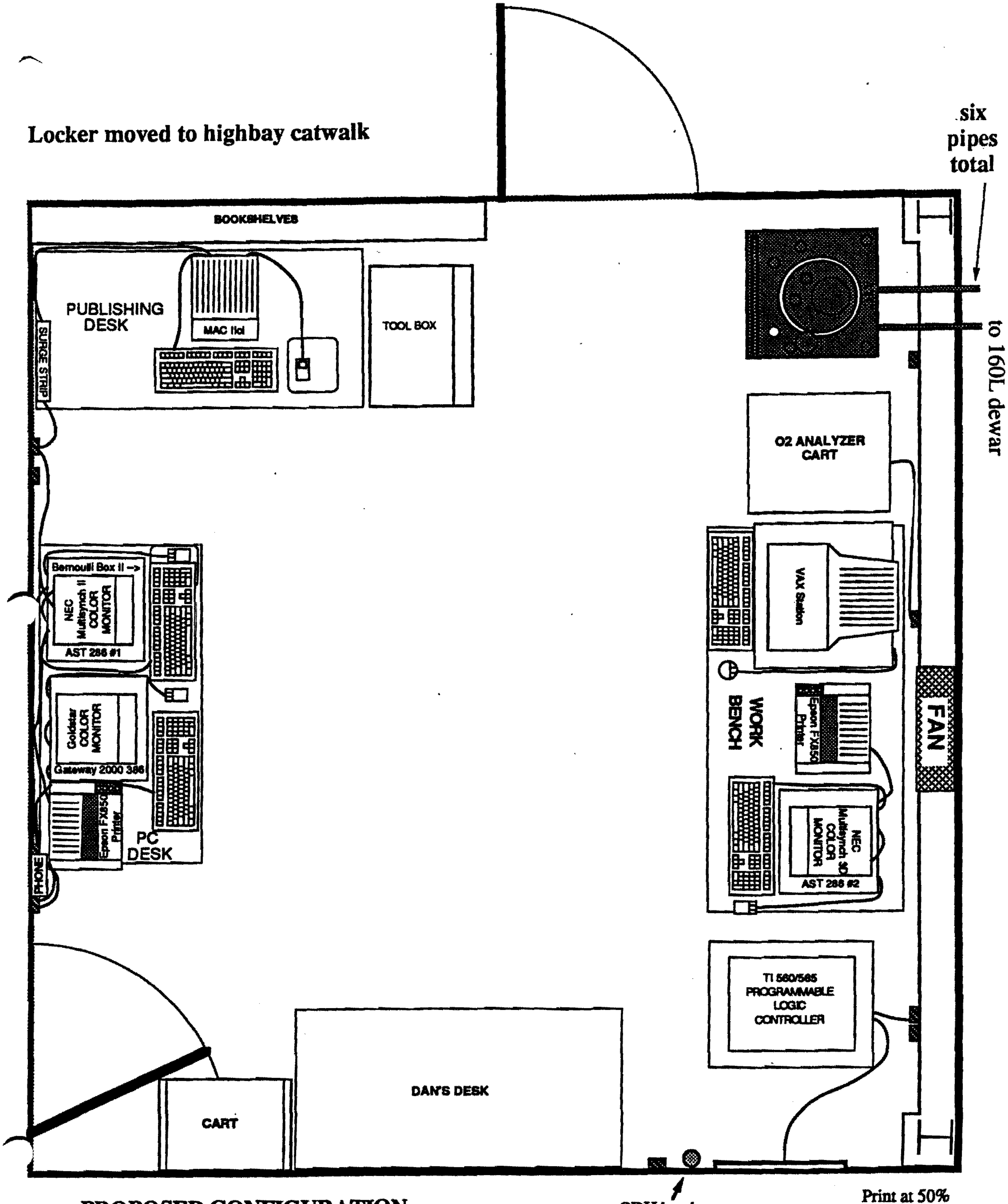


OLD CONFIGURATION

Print at 50%

GTM 9/3/88
JRM 3/21/91

CRYO CONTROL ROOM, Scale:1/2"=1'



PROPOSED CONFIGURATION

Print at 50%

GTM 9/3/88
JRM 3/21/91,4/25/91

DØ Cryo Control ATC ODH

Operation Mode

Exhaust E	TC, min. V/E	
130	17.77	
Volume V	Elevation	Pressure
2310	745 ft	741 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
Valves*	1/4, 3/8"	2	1.00E-08	2.00E-08	120	0.923077	1.62%	1	2.00E-08	0
Valves*	65# relief	1	1.00E-08	1.00E-08	48	0.369231	13.25%	0.000489	4.89E-12	0
Valves*	1/4,3/8,1/2"	5	1.00E-08	5.00E-08	10	0.076923	19.38%	1.39E-08	6.95E-16	0
Valves*	1/4, 3/4"	10	1.00E-08	1.00E-07	4.4	0.033846	20.29%	2.97E-09	2.97E-16	0
Open purge valve		1	9.00E-06	9.00E-06	4	0.030769	20.35%	2.66E-09	2.40E-14	0
Couplings**	Cryo	7	3.00E-06	2.10E-05	10	0.076923	19.38%	1.39E-08	2.92E-13	0
Flanges***	Bolted	3	3.00E-06	9.00E-06	10	0.076923	19.38%	1.39E-08	1.25E-13	0
Pipes <3"	Sections	5	1.00E-09	5.00E-09	120	0.923077	1.62%	1	5.00E-09	0
Pipes <3"	Sections	40	1.00E-09	4.00E-08	10	0.076923	19.38%	1.39E-08	5.56E-16	0
Joints	Process	5	3.00E-09	1.50E-08	120	0.923077	1.62%	1	1.50E-08	0
Joints	Process	80	3.00E-09	2.40E-07	10	0.076923	19.38%	1.39E-08	3.34E-15	0
Elbows		15	3.00E-07	4.50E-06	10	0.076923	19.38%	1.39E-08	6.25E-14	0
TOTAL									4.00E-08	0

CATASTROPHIC LEAK-pipe	1	1.00E-09	1.00E-09	1200	9.230769	0.00%	1	1.00E-09	0

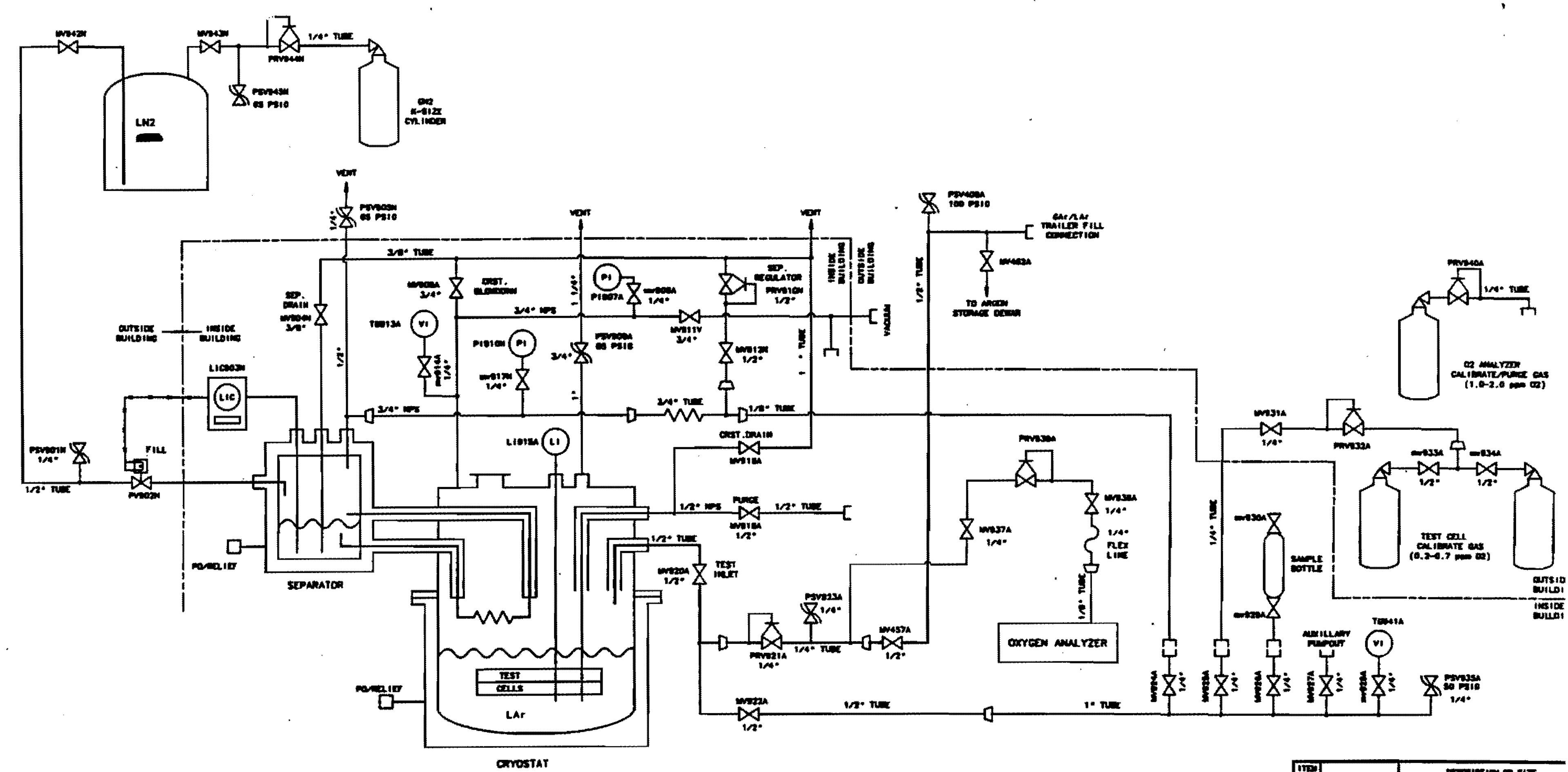
Group Fail Rate Sum = 4.40E-05

	Oper. Fail Rate	(Group Fail Rate sum) x Oper. Fail Rate	No fan, F=1	Ø Fatal. Rate	ODH Class
FAN FAILURE	3.50E-06	1.54E-10	1	1.54E-10	0
	Motor Fail Rate	(Group Fail Rate sum) x Motor Fail Rate	No fan, F=1 for all leaks		
FAN FAILURE	1.00E-04	4.40E-09	1	4.4E-09	0

Special Notes: all event rates are per hour, flows are in scfm, volumes in cf and times in minutes.
* Leak taken from maximum flow value of valves in question, as a conservative estimate.
** Leak estimated as flange, taken from EN-232, using the highest value likely.
*** Leak taken from EN-232, using the highest value for a likely leak.

GRAND TOTAL

Ø Fatal. Rate	ODH Class
4.56E-08	0



ITEM NO.		DESCRIPTION OR SIZE
PARTS LIST		

ORIGINATOR	K. DIXON
DRAWN	W. CADENA

FERMI NATIONAL ACCELERATOR LABOR
UNITED STATES DEPARTMENT OF ENERGY

RD/CRYOGENICS
DO-ATC PIPING SCHEMATIC

DRAWING NUMBER 3740.512-MD-295144 SHEET 1

DØ CONTROL ROOM ARGON TEST CELL PLACEMENT

April 1, 1991
Rev. May 10, 1991

DØ Engineering Note
3740.512-EN-295

J. Michael

Approved Kelly Dixon

Date 13 May 91

Due to the need of maintaining and providing high purity argon for the DØ experiment, it is necessary to have a purity verifying device readily available. The testing equipment used by the DØ cryo group is called the Argon Test Cell (ATC). It operates by taking a sample of the argon to be tested and running it through a test cell for purity determination. Liquid nitrogen cooling loops are used to to keep the argon cold during the testing.

The initial placement of the ATC was outside of the DØ Cryo Control Room. This was not a favorable place, mainly because of exposure to the elements on the operators and the device. A plan was made to move the ATC from outside to inside the control room. This would allow security, favorable environment conditions, and general overall improved access and operability.

Having the ATC inside causes some concern over some issues. It is true that the ATC employs cryogenic piping components, so there is an ODH possibility if those components were to fail and leak. However, there are ways by which we can determine the ODH class fairly easily. Using the methods outlined in DØ EN-229, the components of the cryogenic pipe lines are summed and grouped according to failure possibility and likely leakage upon failure. (Note that this is the reason that one type of component may be listed a multiple number of times in the appendix spreadsheet, as the different components have different possible leak rates, depending on position or size, etc.). The result is an ODH class 0, since the fatality rate has to be above 10^{-7} for a hazard condition to be present. The fatality rates in this analysis only come within an order of magnitude of this safety limit due to using conservative estimates.

Note that the 130 scfm fan must be active for the ODH status to remain at 0. The control room ventilation is on emergency power, but can be activated and inactivated at will. The fan need not be active as long as there are no cryogens in the ATC, and the argon and nitrogen supply line valves are secured closed. For ODH detection purposes, an ODH head has already been installed in the control room as a result of the DAB southside ODH plan. For a fuller picture, see Kelly Dixon's ATC operating procedures, chapter 6.

NOTE ON PROJECTED LEAK RATES:

The highest projected leak rate in the analysis, 120 scfm, is based on the maximum expected flow rate from the high pressure nitrogen dewar that supplies the cooling coils for the ATC (1200 scfm, see below). This value makes a lot of assumptions--that the dewar is fully pressurized and filled, that the flow is fully developed, that no flashing occurs until the liquid enters the control room atmosphere, etc. In actuality, the flow would be much lower.

But in this particular case, it is a moot point, due to the low probability of this type of failure. In fact, the calculated hazard from that valve would not decrease until it's leakage was projected below the ventilation rate. It is at that point that the leak does not overwhelm the room.

The piping components with the high projected leak rate (120 scfm), are components on the liquid nitrogen inlet line. This is a 1/10 projection as to what the leak would be if the liquid nitrogen supply valve was flowing full and a leak occurred in the line. This is the most conservative way to estimate those leak rates, as even 120 scfm is an order of magnitude greater than what would be expected.

There are several adjustments planned to insure the ODH safety of the control room, among them being routing the removable solenoid valve outside, due to the unreliability of screwed connections, routing the vent line outside, and replacing the couplings on the liquid nitrogen inlet line with welded pipe connections.

APPENDICES:

Note on 120 scfm leak rate; Note on extra analyses;
Old control room setup (picture); Planned setup (picture);
ODH analysis (spreadsheet); ATC piping schematic (drawing).

REFERENCES:

DØ Engr. Note 3740.510-EN-229, General ODH Analysis Method and Conclusions, Sept. 19, 1989, Rev. B.

DØ Engr. Note 3740.512-EN-231, Leak Analysis, Bayonet and Flange, Oct. 11, 1989, Rev. C.

DØ Engr. Note 3740.512-EN-243, Argon Test Cell (ATC) Cryostat, February, 1990.

NOTE ON CALCULATION FOR 120 SCFM LEAK RATE:

This rate was determined using the Cv and flow equations pertaining to the valve supplying those components. The flow was determined using cryogenic fluid, which was scaled afterwards to standard condition gaseous form, for analysis purposes. As a conservative estimate, the leak of those components can be estimated at at most 1/10 of that rate, or 120 scfm.

EQUATIONS:

$$\bar{v}^2 = \frac{2\,\Delta p\, g_c}{\rho\left(\Sigma K + 1\right)} \qquad \Sigma K = f\left(\frac{L_e}{d}\right) + K_{inlet} + K_{outlet} + K_{valve}$$

$$f = f\left(R_d, \frac{\varepsilon}{d}\right) \qquad K_{valve} = \left(\frac{29.9\ d^2}{C_v}\right)^2$$

Where: Δ**p** is pressure drop, $\bar{v}$ is average velocity, Σ**K** is coefficient of losses summation (assumed K_{inlet}=0.5, K_{outlet}=1.0 for this case), g_c is gravitational constant (32.2, English units), **f** is friction factor (based on pipe smoothness and diameter, and the Reynold's number, read from Moody chart. In this case, first assumed to be .02), L_e is the equivalent in straight pipe length for the pipe configuration considered (the ATC piping in question runs from the dewar to the control room, and has two elbows. It's L_e is 8.5'), **d** is the inner diameter of the pipe (.43" for 1/2 line), and ε is the inner surface roughness of the pipe (pipe is assumed to be smooth, ratio ε/**d** being negligible). The C_v of the valve in question has a highest possible C_v of 2.2, as detailed by the manufacturers.

From these calculations (see next page), average velocity can be determined as 31 ft/s, and the scfm rate then to be about 1200 scfm when multiplying the velocity by the cross sectional area and scaling by the density ratio.

est. $f = 0.02$

$$\Sigma K = 0.02\left(\frac{8.5'}{0.43''\left(\frac{1'}{12''}\right)}\right) + 6.5 + 1.0 + 6.3 = 12.6$$

$$K_v = \left(\frac{29.9\,(0.43'')^2}{2.2}\right)^2 = 6.3$$

$$\bar{V}^2 = \frac{2\,\Delta p\, g_c}{\rho(\Sigma K + 1)} = \frac{2\left(50\,\frac{\#_f}{si}\left(\frac{144\,si}{sf}\right)\right)\left(32.2\,\frac{ft}{s^2}\left(\frac{\#_m}{\#_f}\right)\right)}{\left(45\,\frac{\#_m}{cf}\right)(12.6)} = \frac{10{,}304}{12.6}\frac{ft^2}{s^2} = 826\,\frac{ft^2}{s^2}$$

$$\bar{V} = 28.6\ ft/s$$

$$R_d = \frac{\rho \bar{V} d}{\mu} = \frac{\left(0.73\,\frac{g}{cc}\right)\left(28.6\,\frac{ft}{s}\right)(0.43'')\left(\frac{12''}{ft}\right)\left(\frac{2.54\,cm}{in}\right)^2}{0.000903\,\frac{g}{cm\cdot s}} = 26{,}912\,(28.6)$$

$$\cong 770{,}900$$

from Moody chart, $f \approx 0.012$ (for smooth pipes)

$$\Sigma K = (0.012)(237) + 7.8 \rightarrow 10.6$$

$$\bar{V}^2 = \frac{10{,}304}{10.6} = 968 \qquad \bar{V} = 31.1\ \frac{ft}{s}$$

$$R_d = 26{,}912\,(31.1) = 837{,}230$$, no sig. change

$$\dot{V} = \left(31.1\,\frac{ft}{s}\right)\left(\frac{1}{4}\pi\left(\left(\frac{0.43}{12}\right)'\right)^2\right)\left(\frac{60\,s}{min}\right)\left(\frac{878.4\ cc/g}{1.369\ cc/g}\right) \cong 1{,}210\ scfm$$

NOTE ON EXTRA ODH ANALYSES:

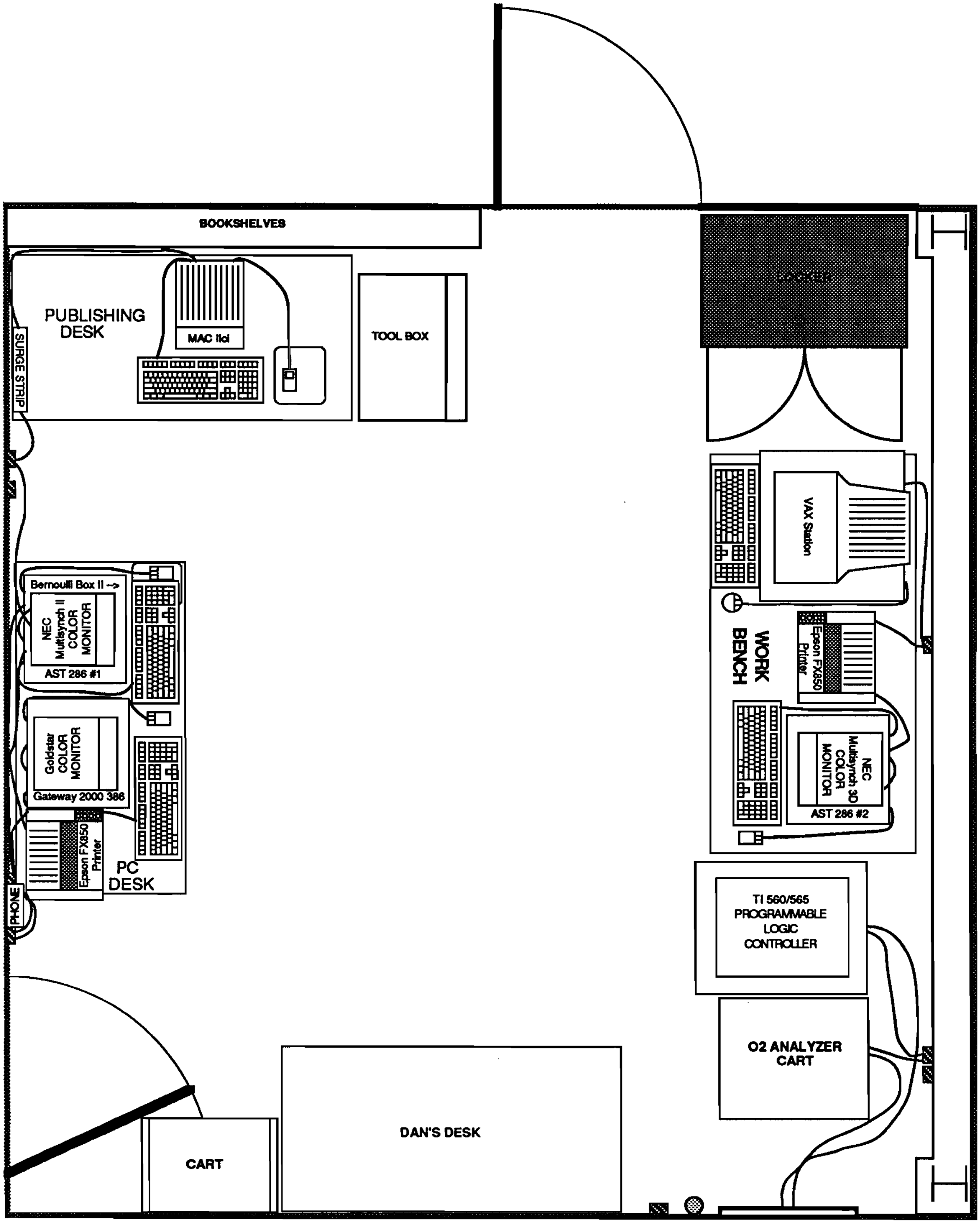
There has been some concern over whether the standard ODH analysis was complete enough to determine the safety of the control room, so a few different perspectives were taken. The first was to consider what would happen if a 1200 scfm leak actually did occur. The fail rate probabilities normally used only cover average possible leaks, and do not specifically address a particular kind of leak (e.g. catastrophic). A catastrophic leak of this nature, where there is full flow from the supply line into the control room, would certainly have a lesser chance of occurring than a normal leak, but for now we will use the same probability and see what happens. As an aside, the severing of the pipe lines would probably coincide with the inadvertent destruction of the control room, due to the relative lack of physical labor done in or around the room (i.e. a truck would have to crash into the wall, or the ceiling would have to collapse). In any event, the result is still well within the safety margin at a fatality rate of $1 \cdot 10^{-9}$.

Another concern was since the special ventilation fan did not need to run continuously, the possibility of it being neglected became a factor in the analysis. The solution to this was to assume that if the fan was not activated, the fatality factor for all leaks would become one. The corresponding probability for this factor was the chance of the fan not being turned on (an operator error, assumed to be $3 \cdot 10^{-3}$/demand for an obvious omission in procedure. The absence of the fan would be obvious since the noise and sight of the whirling blades would be missing, as well as the extra circulation that the fan would provide.) It is estimated that the ATC would be operated 10 times a year.

$$(3 \cdot 10^{-3}\text{/demand})\ (10\ \text{demands/year})\ (1\ \text{year/8760 hours}) \approx 3.5 \cdot 10^{-6}\text{/hour}$$

Another concern would be the possibility of the fan failing during operation, which corresponds to a motor failure rate of 10^{-5}/hr. The analysis is otherwise the same as the operator failure analysis. In either of these cases, the ODH class is 0. See the analysis spreadsheet for specific results.

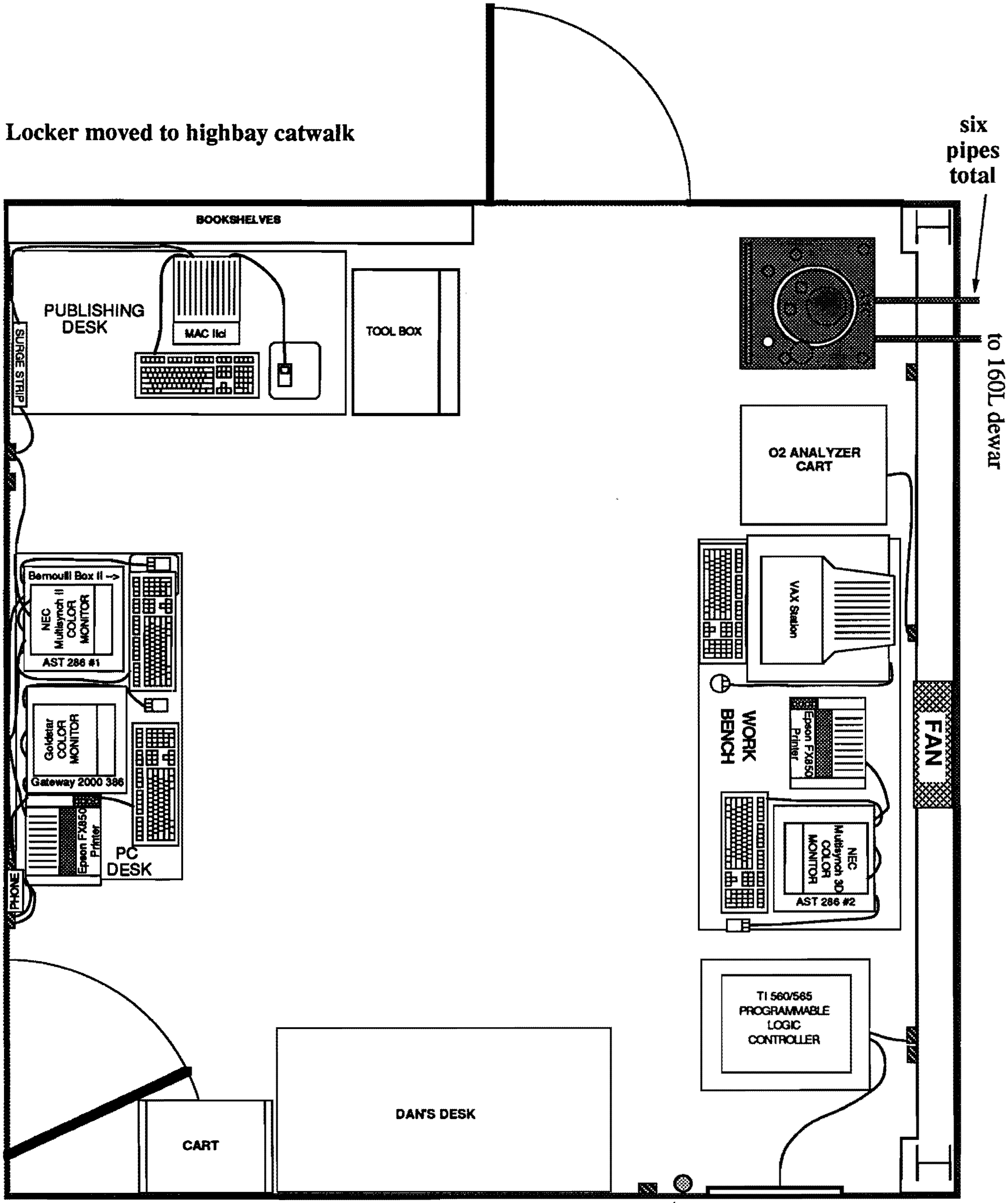
CRYO CONTROL ROOM, Scale:1/2"=1'



OLD CONFIGURATION

Print at 50%
GTM 9/3/88
JRM 3/21/91

CRYO CONTROL ROOM, Scale:1/2"=1'



PROPOSED CONFIGURATION

Print at 50%

GTM 9/3/88
JRM 3/21/91,4/25/91

DØ Cryo Control ATC ODH

Operation Mode

Exhaust E	TC, min. V/E	
130	17.77	
Volume V	**Elevation**	**Pressure**
2310	745 ft	741 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
Valves*	1/4, 3/8"	2	1.00E-08	2.00E-08	120	0.923077	1.62E-02	1.00E+00	2.00E-08	0
Valves*	65# relief	1	1.00E-08	1.00E-08	48	0.369231	1.32E-01	4.89E-04	4.89E-12	0
Valves*	1/4,3/8,1/2"	5	1.00E-08	5.00E-08	10	0.076923	1.94E-01	1.39E-08	6.95E-16	0
Valves*	1/4, 3/4"	10	1.00E-08	1.00E-07	4	0.033846	2.03E-01	2.97E-09	2.97E-16	0
Couplings**	Cryo	7	3.00E-06	2.10E-05	10	0.076923	1.94E-01	1.39E-08	2.92E-13	0
Flanges***	Bolted	3	3.00E-06	9.00E-06	10	0.076923	1.94E-01	1.39E-08	1.25E-13	0
Pipes <3"	Sections	5	1.00E-09	5.00E-09	120	0.923077	1.62E-02	1.00E+00	5.00E-09	0
Pipes <3"	Sections	40	1.00E-09	4.00E-08	10	0.076923	1.94E-01	1.39E-08	5.56E-16	0
Joints	Process	5	3.00E-09	1.50E-08	120	0.923077	1.62E-02	1.00E+00	1.50E-08	0
Joints	Process	80	3.00E-09	2.40E-07	10	0.076923	1.94E-01	1.39E-08	3.34E-15	0
Elbows		15	3.00E-07	4.50E-06	10	0.076923	1.94E-01	1.39E-08	6.25E-14	0
TOTAL									4.00E-08	0

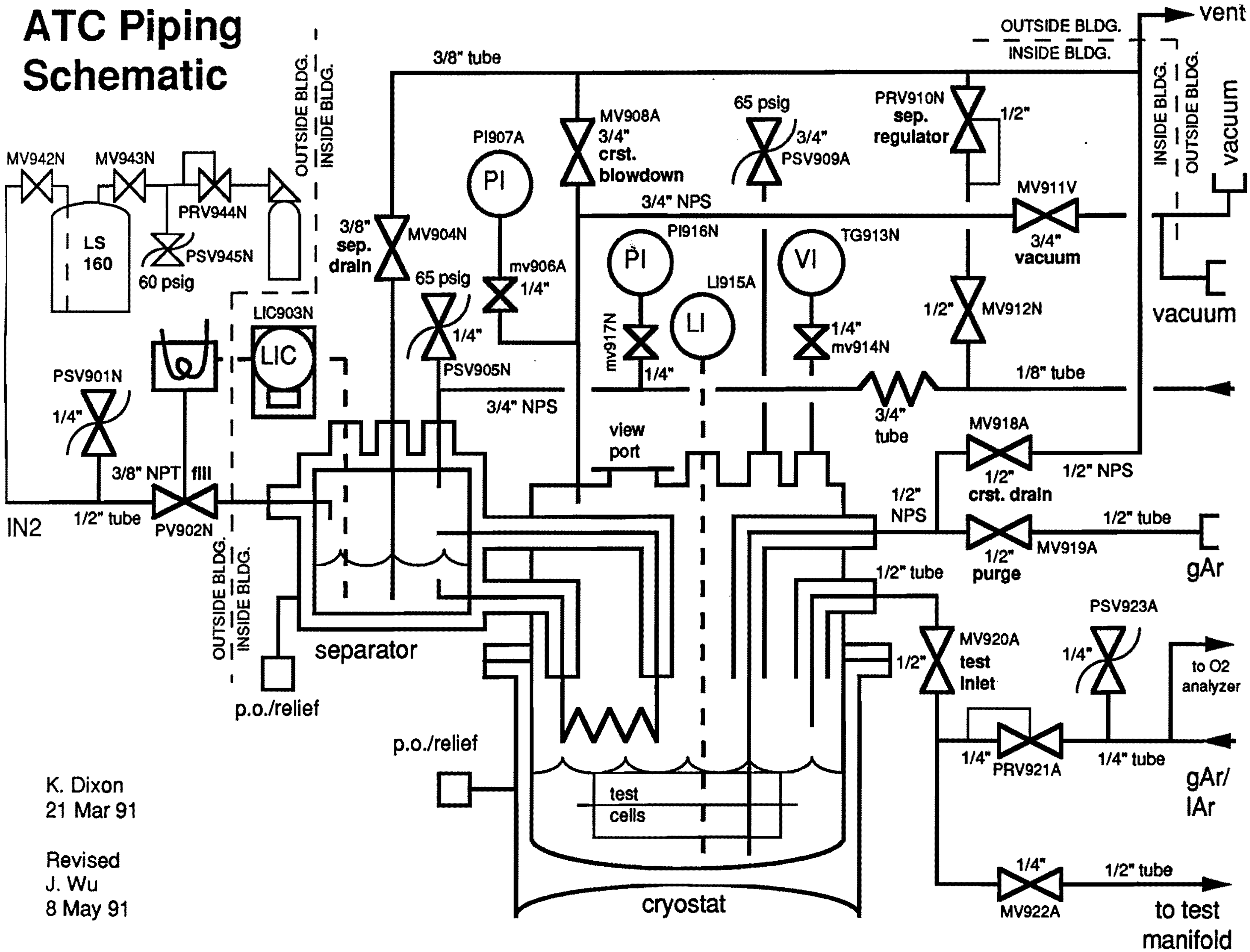
CATASTROPHIC LEAK (pipes	1	1.00E-09	1.00E-09	1E+03	9.230769	-1.73E+00	1.00E+00	1.00E-09	0

Group Fail Rate Sum = 3.50E-05

	Oper. Fail Rate		(Group Fail Rate sum) x Oper. Fail Rate		No fan, F=1 for all leaks	Ø Fatal. Rate	ODH Class
FAN FAILURE	3.50E-06		1.22E-10		1	1.22E-10	0
	Motor Fail Rate		**(Group Fail Rate sum) x Motor Fail Rate**		**No fan, F=1 for all leaks**		
FAN FAILURE	1.00E-05		3.50E-10		1	3.5E-10	0

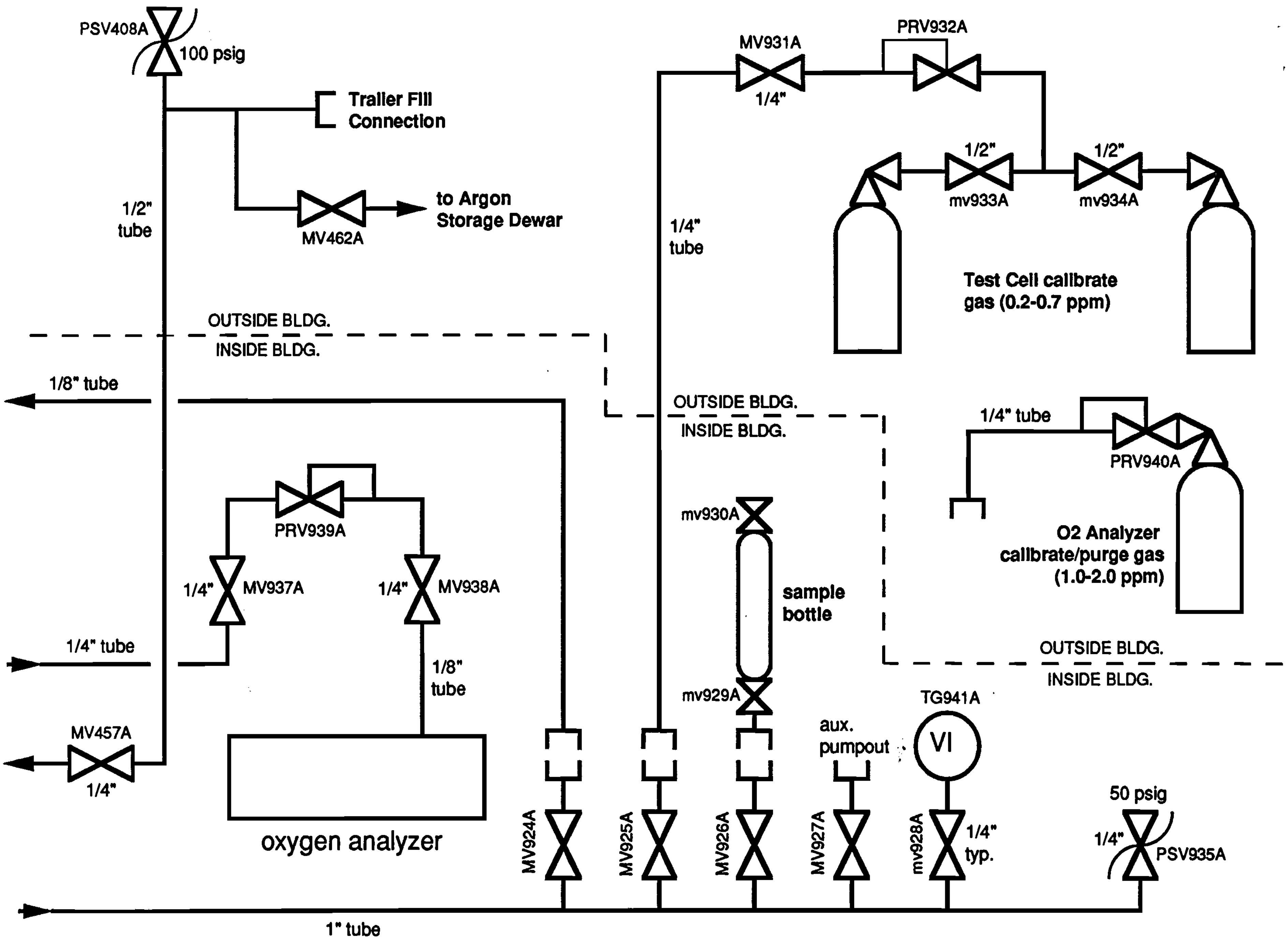
Special Notes: all event rates are per hour, flows are in scfm, volumes in cf and times in minutes.
* Leak taken from maximum flow value of valves in question, as a conservative estimate.
** Leak estimated as flange, taken from EN-232, using the highest value likely.
*** Leak taken from EN-232, using the highest value for a likely leak.

ATC Piping Schematic



K. Dixon
21 Mar 91

Revised
J. Wu
8 May 91



PSV408A
100 psig
Trailer Fill Connection
1/2" tube
MV462A
to Argon Storage Dewar
MV931A
1/4"
PRV932A
1/2"
1/2"
mv933A
mv934A
1/4" tube
Test Cell calibrate gas (0.2-0.7 ppm)
OUTSIDE BLDG.
INSIDE BLDG.
1/8" tube
OUTSIDE BLDG.
INSIDE BLDG.
1/4" tube
PRV940A
PRV939A
mv930A
O2 Analyzer callbrate/purge gas (1.0-2.0 ppm)
1/4"
MV937A
1/4"
MV938A
sample bottle
1/4" tube
1/8" tube
OUTSIDE BLDG.
INSIDE BLDG.
mv929A
TG941A
MV457A
1/4"
aux. pumpout
VI
oxygen analyzer
50 psig
MV924A
MV925A
MV926A
MV927A
mv928A
1/4" typ.
1/4"
PSV935A
1" tube