D-ZERO CENTRAL CALORIMETER

TECHINCAL APPENDIX TO

CRYOGENIC PRESSURE VESSELS

(FSM SECTION 5032 TA)

REVISED

D-ZERO ENGINEERING NOTE #3740.214-EN-267

GT. Mulholland, R.A. Rucinski

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5032TA for CC Cryostat Pressure Vessel Note
November 7,1990, G. T. Mulholland
Revised January 22,1991, K. J. Krempetz

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1.0 DOCUMENTATION REQUIREMENTS

1.1.1 INTRODUCTION

DO (D Zero) is a large Liquid Argon (LAr) HEP Calorimeter designed to function in the laboratories P-Pbar collider at the DO section of the Tevatron accelerator. It contains 5,000 gls. of LAr in the CC cryostat, and 3,000 gls. in each of two, a north and south, EC cryostats.

These low pressure vessels are filled with detector modules built of stainless steel, copper and depleted uranium. The LAr functions as the ionization medium, and the spatial and temporal of the collection of the charge of the electrons produced signals the passsage of charged particles. The collection of these charges in 4 pi is related to the energy of the particles, and their measurement is called calorimetry.

The contained LAr (T=90K) is isolated from the ambient temperatures in specially designed, vacuum and superinsulated, vessels (cryostats) provided with liquid nitrogen, heat of vaporization, cooling.

1.1.2 FLOW SHEETS

System flow sheets, 3740-ME-222394, Rev. U, sheets 1 and 2, where delivered to the safety committee on 11/6/90.

1.1.3 PRELIMINARY OPERATING PROCEDURES

Preliminary procedures will be provided 11/15/90. The detail review of the Operating Procedures group is still in progress. The final, preoperation, Operating Procedures will be provided on a schedule consistent with the initiation of cooldown.

1.1.4 PERSONNEL QUALIFICATION AND TRAINING

The personnel qualification and training of each lead operator has been in Bubble Chamber operation (see paragraph 4.3 for detail), and each functioned in that capacity for a decade or more. It is anticipated the lead and auxillary operators will commission the system and provide a tested and proven operating procedure after one cooldown, fill, and drain cycle. In the second and subsequent fills these operators will carefully and fully train others in the, then, tried and tested procedures (see 4.2).

1.1.5 PARTICULAR DOCUMENTATION

These requirements are answered in the "14.1" written for the cryostat. The pressure vessel and vacuum vessel safety notes by Rucinski and Luther, 3740.214-EN-263, have been completed and are in the review at this time.

1.1.6 PIPING COMPONENTS LIST

The list is in DO Piping Components, 3740.510-EN-193, D. Clark, K. Dixon, T. Serges, G. Ball, and J. Michael, delivered to the Safety committee on 11/7/90.

2.0 ANALYSIS REQUIREMENTS

2.1 FAILURE MODE and EFFECTS ANALYSIS

The FMEA will be appended to this document.

2.2 WHAT IF ANALYSIS

The What-if will be appended to this document.

2.3 HAZARD ANALYSIS

The Hazards analysis is in the form of an ODH analysis, 3740.510 -EN-258, D. Clark and J. Michael.

3.0 ENGINEERING CALCULATIONS

3.1 RELIEF DEVICE ADEQUACY

The adequacy of relief devices is addressed in 1.1.5 above.

3.2 STRESS LEVELS

Flexibility and stress calculations for the cryostat piping are documented in DO Engineering Note 3740.210-EN-25.

3.3 OTHER CALCULATIONS

The only warm structural component having safety implications is the carriage which supports the cryostat on the center beam of the platform. The carriage is a welded structure designed in accordance with the rules of the AISC Specification for Structural Steel for Buildings (by hand calculations). The design was then analyzed for deflections using finite element methods, which also served to verifiy the stress levels in the stuctural members. Upon delivery, the carriage was load-tested to 125% of its design loading and deflections were measured at the design load. The design and the finite element analysis are contained in Engineering Note 3740.215-EN-14, and the measured deflections are documented in Appendix A of Engineering Note 3740.214-EN-103. These Notes were submitted for review to the Cryosafety Review Panel as part of the standard documentation procedure and were accepted by the Panel on 3-30-87 and 12-18-87. The Notes were not submitted to the Mechanical Safety Review Panel for their approval.

4.0 MAINTAINING SAFE OPERATION

4.1 DOCUMENTS

The DO cryogroup has one of the most extensive Engineering Note, Drawing, and Operating Procedures files at the laboratory. It will be maintained and augmented as required to continue this high level of support documentation.

4.2 PLANS

The DO Cryosystem is monitored and controlled by a TI565, Programmable Logic Controller. All of the sensor and controls work has been designed to support unmanned steady state (exclusive of cooldown) LAr operation. The sysytem is monitored by 1) a link to the main DO control room, 2) the laboratory FIRUS system, and 3) a cryoexpert autodialing system. After the initial runnning the experience DO personnel will conduct training and quailfication classes for a broader group of operators in RD Cryo. Long term running would be attended, only as required, by this group. The Cryoexperts would continue in their role for the foreseeable future.

4.3 TRAINING

The designers and builders are training themselves for the initial operation. Formal training classes will subsequently be delivered to all potential operators. Only those operators that have successfully completed the formal classes and a rigorous OJT period will be added to the qualified operator list. Cryoexperts will be trained as necessary to keep a ready supply on hand for each running period.

The Cryoexpert and lead operators are listed below;

NAME	EXPERIENCE
****	**********
Dixon, Kelly	10 years
Markley, Dan	10 years
Rucinski, Russ	2 years
Cross, Pete	11 years
ALTERNATES	
**********	
Ramirez, Ernie	10 years
Urbin, John	10 years
Krempetz, Kurt	13 years

5.0 INSPECTIONS

5.1 INITIAL

DO cryo will provide an initial walk through inspection and answer any safety related question the DO Cryosafety panel may have on a schedule of their choosing.

5.2 SUBSEQUENT

The DO Cryosafety panel is encouraged to schedule visits to the facility to assure the cryosafety provisions are, in fact, in place and functional.

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R. Rucinski 11/19/90
Rev. 1; 1/29/91

D-ZERO CENTRAL CALORIMETER

FMEA ANALYSIS

This failure mode and effects analysis was done in accordance with the Fermilab safety manual section 5032TA appendix A. Flow diagram drg. no. 3740-ME-222394 rev. U was used. Revision 1 updates the analysis thru rev. V of the above flow diagram.

Scope:

All components related to operating the central calorimeter were included. Valves and other components located on the platform or in the cryocorner were included. Components relating specifically to the end calorimeters were excluded. Pipe failures were excluded, they are dealt with in the ODH analysis in D-Zero engineering note 3740.510-EN-258, D. Clark and J. Michael. Instrument air valves and components were excluded. See the "What if" analysis for consequences from loss of instrument air.

Definitions:

Safe - No mechanical damage or personnel injury.

ODH - Releases argon or nitrogen to atomosphere, possibly threatening personnel. This possibility is taken into acount in the ODH analysis.

Mech. Damage - Possible damage to equipment, most likely due to overpressurization. Personnel injury is considered sufficiently unlikely and as such, constitutes an acceptable risk.

Unsafe - More than negligible possibility of personnel injury even if standard ODH procedures are followed.

Note: Failure rates for relief valves taken from Fermilab Standard 5064TA, Table III.

COMPONENT			FAILURE OR ERROR MODE	HAZARD OR EFFECT	HAZARD CLASS	REMARKS OR RECOMENDATIONS
RO	136	N	gets clogged	Lose exhaust purge flow	Safe	Will have possibility of Ar freezing in exhaust line.
PV	201	N	Fails to open	Lose Ln2 to cooldown condenser	Safe	
			close unexpect.	Lose Ln2 to cooldown condenser	Safe	
			Fails to close	Lower pressure in the CC	Safe	Low CC pressure would alarm. Could use PV-513N to limit LN2 flow.
			open unexpect.	Lower pressure in the CC	Safe	Low CC pressure would alarm. Could use PV-513N to limit LN2 flow.
PV	202	N	Fails to open	Lose Ln2 to S.S. operating condenser	Safe	
			close unexpect.	Lose Ln2 to S.S. operating condenser	Safe	
			Fails to close	Lower pressure in the CC	Safe	Low CC pressure would alarm. Could use PV-513N to limit LN2 flow.
			open unexpect.	Lower pressure in the CC	Safe	Low CC pressure would alarm. Could use PV-513N to limit LN2 flow.
MV	203	A	Open	Normal	Safe	
			Closed	PT-204A blocked	Safe	CC pressure is indicated by PT-230A also.
PT	204	A	fails	Lose CC pressure indication	Safe	CC pressure is indicated by PT-230A also.
MV	205	A	Open	Capped after outlet	ODH	CC gas sample port. No safety hazard involved even without cap.
			Closed	Normal	Safe	
HX	206	N	Rupture	Cause CC to relieve	Safe	Relief capacity of CC is adequate to handle this case. See EN-263
HX	207	N	Rupture	Cause CC to relieve	Safe	Relief capacity of CC is adequate to handle this case. See EN-263
PV	208	V	Fails to open	Unable to establish CC vacuum	Safe	Would be discovered before anything was put in the CC.
			close unexpect.	Unable to establish CC vacuum	Safe	Would be discovered before anything was put in the CC.
			Fails to close	Will not be able to use VP246V	Safe	Would be discovered before anything was put in the CC.
			open unexpect.	CC insulating vacuum gets soft	Safe	Insulating vacuum would be on order 10E-4 torr instead 10E-6 torr
PSV	209	V	Fails to relieve	Pressure in the CC Vacuum Vessel	Safe	Lift plate. Relief on vacuum piping would open. [2 level failure case]
			open unexpect.	Lose CC insulating vacuum	Safe	Relief capacity of CC is adequate to handle this case. See EN-263
PT	210	N	fails	Lose indication of condensor pressure	Safe	Affects PV-210N, see PV-210N failure mode effect analysis
PV	210	N	Fails to open	Raise CC condensor temperature	Safe	PSV-211N would relieve. CC pressure would build very slowly.
			close unexpect.	Raise CC condensor temperature	Safe	PSV-211N would relieve. CC pressure would build very slowly.
			Fails to close	Condensors can make LAr rain	Safe	CC pressure would decrease.
			open unexpect.	Condensors can make LAr rain	Safe	CC pressure would decrease.
PSV	211	N	Fails to relieve	Overpressure condensing coils	Mech. Damage	Failure rate: Fail to open 1 in 100,000 demands. [2 level failure case]
			open unexpect.	Vents nitrogen	ODH	Vents inside building
RD	212	A	Fails to rupture	Will not back up a PSV-213A failure	Safe	RD-212A is not needed for any relief case. [3 level failure case]
			Rupture	Will vent CC outside	Safe	

COMPONENT			FAILURE OR ERROR MODE	HAZARD OR EFFECT	HAZARD CLASS	REMARKS OR RECOMENDATIONS
PSV	213	A	Fails to relieve	CC pressure will raise to 18 psig	Safe	RD-212A will back-up this failure mode. [2 level failure case]
			open unexpect.	Will vent CC outside	Safe	
PV	214	A	Fails to open	Block direct GAr line from Ar dewar	Safe	It would be possible to use the UV piping for GAr feed.
			close unexpect.	Block direct GAr line from Ar dewar	Safe	It would be possible to use the UV piping for GAr feed.
			Fails to close	Allows GAr from Ar dewar	Safe	Can stop GAr supply by closing PV-611A or MV-648A.
			open unexpect.	Allows GAr from Ar dewar	Safe	Can stop GAr supply by closing PV-611A or MV-648A.
PV	215	A	Fails to open	Block vac. pumps from CC pres. vess.	Safe	Can evacuate CC press. vessel thru drain line.
			close unexpect.	Block vac. pumps from CC pres. vess.	Safe	Can evacuate CC press. vessel thru drain line.
			Fails to close	CC press. vess. tied into UV piping	Safe	Can isolate UV piping with MV-454UV.
			open unexpect.	Vac. pumps tied into CC's cold GAr	Safe	PV-215A is interlocked, can't open with CC positive pressure.
mv	216	N	Open	Normal	Safe	
			Closed	Blocks PT-210N	Safe	PV-210N will not control correctly.
mv	217	N	Open	Capped after outlet	ODH	Nitrogen sample port from CC condensers
			Closed	Normal	Safe	
PV	218	A	Fails to open	Will not be able to fill CC with LAr	Safe	Will have to fix problem to fill CC with LAr.
			close unexpect.	Stops LAr fill of CC	Safe	Will have to fix problem to fill CC with LAr.
			Fails to close	CC LAr is not doubly isolated.	Safe	Would need 2 additional failures for any problem to occur from this
			open unexpect.	CC LAr is not doubly isolated.	Safe	Would need 2 additional failures for any problem to occur from this
CV	219	H	Sticks closed	Blocks He bottles from PV-219A	Safe	Gas bottle GB-219H has helium to operate PV-219A for some time.
			Sticks open	GB-219H can bleed down	Safe	During a cryostat move could cause PV-219A to open.
PV	219	A	Fails to open	Will not be able to fill CC with LAr	Safe	Will have to fix problem to fill CC with LAr.
			close unexpect.	Stops LAr fill of CC	Safe	Will have to fix problem to fill CC with LAr.
			Fails to close	CC LAr is not doubly isolated.	Safe	Would need 2 additional failures for any problem to occur from this
			open unexpect.	CC LAr is not doubly isolated.	Safe	Would need 2 additional failures for any problem to occur from this
PSV	219	H	Fails to relieve	PV-219A would not work	Safe	PRV-219H would have to fail for this failure to occur [2 level failure]
			Opens unexpect.	Vents helium	ODH	Would increase frequency of changing helium bottles
PRV	219	H	close unexpect.	Lose low pressure He in PV-219A	Safe	PV-219A would still work
			open unexpect.	Causes PSV-219H to relieve	Safe	PV-219A would still work. Would go thru more He bottles.
PS	219	H	fails	Lose indication of PV-219A position	Safe	PS-219H redundantly shows position of PV-219A
EV	219	H	fails	Lose control of PV-219A	Safe	Can use PV-218A in place of PV-219A
EH	220	A	fails	Can't warm up CC contents	Safe	Alternative methods would be possible.
PV	221	V	Fails to open	Would not have VP246V on line	Safe	Insulating vacuum would be on order 10E-4 torr instead 10E-6 torr
			close unexpect.	Turns off VP246V	Safe	Interlocked, insul. vac. d.p. turns off when PV-221V is closed.
			Fails to close	Backstreaming into insu. vac. poss.	Safe	PV-225A upstream protects the insul. vac. from backstreaming.
			open unexpect.	Backstreaming into insu. vac. poss.	Safe	PV-225A upstream protects the insul. vac. from backstreaming.

COMPONENT			FAILURE OR ERROR MODE	HAZARD OR EFFECT	HAZARD CLASS	REMARKS OR RECOMENDATIONS
DPT	222	A	fails	Lose indication of LAr level	Safe	Other devices give LAr level in CC.
EI	223	A	fails	Lose indication of LAr level	Safe	Other devices give LAr level in CC.
mv	224	A	Open	Bypasses DPT-222A	Safe	See DPT-222A fails
			Closed	Normal	Safe	
PV	225	V	Fails to open	Isolates VP246V	Safe	Insulating vacuum would be on order 10E-4 torr instead 10E-6 torr
			close unexpect.	Isolates VP246V	Safe	Insulating vacuum would be on order 10E-4 torr instead 10E-6 torr
			Fails to close	Backstreaming into insu. vac. poss.	Safe	No danger involved [2 level failure case]
			open unexpect.	Backstreaming into insu. vac. poss.	Safe	No danger involved [2 level failure case]
TG	226	V	fails	Lose indication of D.P. inlet pressure	Safe	
CC	227	V	fails	Lose indication of D.P. inlet pressure	Safe	
PV	228	A	Fails to open	Isolates the venting of PSV-213A	Safe	If PV-228A doesn't open by operating procedures we will not fill the CC.
			close unexpect.	Isolates the venting of PSV-213A	Safe	PV-228A will be mechanically locked open. [2 level failure case]
			Fails to close	Leak thru relief in CC P&P sequence	Safe	
			open unexpect.	Leak thru relief in CC P&P sequence	Safe	
EV	228	I	fails	Lose control of PV-228A	Safe	See PV-228A failure mode effect analysis
EI	229	E	fails	Lose RD outlet temp. indication	Safe	
PT	230	A	fails	Lose CC pressure indication	Safe	PV-214A will not control correctly. PT-204A indicates CC pressure.
CC	231	V	fails	Lose CC insul. vac. pressure ind.	Safe	
TS	232	E	fails	Lose temp. ind. of condenser outlet	Safe	May waste some LN2 without this temperature switch.
PT	233	A	fails	Lose VPT pressure indication	Safe	
PT	234	A	fails	Lose VPT pressure indication	Safe	
DPT	235	A	fails	Lose LAr temp. gradient information	Safe	
RO	236	N	gets clogged	Lose exhaust purge flow	Safe	Will have possibility of Ar freezing in exhaust line.
MV	237	A	Open	Bypasses DPS238A	Safe	Lose ind. of LAr flowrate at CC. FM671A indicates flowrate at LAr dewar.
			Closed	Normal	Safe	
DPS	238	A	fails	Lose CC LAr flow rate information	Safe	FM671A indicates flowrate at LAr dewar
FM	239	A	fails	Lose CC LAr flow rate information	Safe	FM671A indicates flowrate at LAr dewar
PT	240	A	fails	Lose VPT pressure indication	Safe	
mv	241	A	Open	A cap looks at CC GAr	ODH	
			Closed	Normal	Safe	
TG	242	V	fails	Lose D.P. inlet press. indication	Safe	Some vacuum valves will close on interlocks from TG242V signal.
mv	243	A	Open	A cap looks at CC LAr	ODH	Due to heat leak, LAr can't be delivered thru this 1/4" tube.
			Closed	Normal	Safe	
mv	244	A	Open	A cap looks at CC GAr	ODH	
			Closed	Normal	Safe	

COMPONENT			FAILURE OR ERROR MODE	HAZARD OR EFFECT	HAZARD CLASS	REMARKS OR RECOMENDATIONS
mv	245	A	Open	Normal	Safe	
			Closed	PT-230A blocked	Safe	CC pressure is indicated by PT-204A also.
VP	246	V	fails	Lose D.P. on CC insul. vacuum	Safe	PV-225V and PV-221V close by interlock to isolate VP246V.
mv	247	V	Open	Normal	Safe	
			Closed	CC-231V blocked	Safe	Lose CC insulating vacuum pressure indication.
mv	248	V	Open	Normal	Safe	
			Closed	CC-227V blocked	Safe	Lose indication of D.P. inlet pressure.
mv	249	V	Open	Normal	Safe	
			Closed	TG-242V blocked	Safe	Lose D.P. inlet pressure indication.
EI	250	A	fails	Lose indication of LAr level	Safe	Other devices give LAr level in CC.
PS	251	A	fails	Doesn't sense LAr spill	Safe	Other ODH devices sense LAr spill and turn on fans.
PS	252	A	fails	Doesn't sense LAr spill	Safe	Other ODH devices sense LAr spill and turn on fans.
mv	253	A	Open	Contaimate VPT charge	Safe	Valve handle removed and tagged after charging VPT
			Closed	Normal	Safe	
mv	254	A	Open	Contaimate VPT charge	Safe	Valve handle removed and tagged after charging VPT
			Closed	Normal	Safe	
mv	255	A	Open	Contaimate VPT charge	Safe	Valve handle removed and tagged after charging VPT
			Closed	Normal	Safe	
PSV	256	A	Fails to relieve	Overpressure piping	Mech. damage	Failure rate: Fail to open 1 in 100,000 demands
			open unexpect.	Vents argon	ODH	Vents inside building.
mv	257	A	Open	Bypasses DPT-235A	Safe	Lose indication from DPT-235A
			Closed	Normal	Safe	
RO	336	N	gets clogged	Lose exhaust purge flow	Safe	Will have possibility of Ar freezing in exhaust line.
PSV	402	A	Fails to relieve	Overpressure piping	Mech. damage	Failure rate: Fail to open 1 in 100,000 demands
			open unexpect.	Vents argon	ODH	Vents inside building.
PI	432	N	fails	Wrong press. ind. behind bayonet cap.	Safe	mv-439N is used to make sure no pressure is behind bayonet cap.
mv	433	E	Open	Capped after outlet	ODH	
			Closed	Normal	Safe	
PI	434	E	fails	Wrong press. ind. behind bayonet cap.	Safe	mv-433E is used to make sure no pressure is behind bayonet cap.
mv	435	A	Open	Capped after outlet	ODH	
			Closed	Normal	Safe	
PI	436	A	fails	Wrong press. ind. behind bayonet cap.	Safe	mv-435A is used to make sure no pressure is behind bayonet cap.
mv	437	A	Open	Capped after outlet	ODH	
			Closed	Normal	Safe	
PI	438	A	fails	Wrong press. ind. behind bayonet cap.	Safe	mv-437A is used to make sure no pressure is behind bayonet cap.

COMPONENT			FAILURE OR ERROR MODE	HAZARD OR EFFECT	HAZARD CLASS	REMARKS OR RECOMENDATIONS
mv	439	N	Open	Capped after outlet	ODH	
			Closed	Normal	Safe	
mv	453	V	Open	Normal	Safe	
			Closed	Isolates vac. pumps from cryostats	Safe	Cryostat insul. vac. could get soft before this is discovered.
MV	454	UV	Open	Normal	Safe	
			Closed	Isolates vac. pumps from cryostats	Safe	Would be discovered during P&P of cryostats.
PS	471	N	fails	Lose pressure indication	Safe	Lose confirmation of warm GN2 purge of exhaust piping.
MV	474	A	Open	Normal	Safe	
			Closed	Stops GAr flow to cryostats	Safe	Blocks direct GAr feed from LAr dewar.
PSV	475	A	Fails to relieve	Overpressure piping	Mech. damage	Failure rate: Fail to open 1 in 100,000 demands
			open unexpect.	Vents argon	ODH	Vents inside building.
MV	476	A	Open	Normal	Safe	
			Closed	Stops LAr fill to cryostats	Safe	
MV	477	N	Open	Normal	Safe	Permits LN2 to condensers
			Closed	Stops LN2 to condensers	Safe	Loss of liquid nitrogen, see "What if" analysis
FM	478	N	fails	Lose LN2 cooldown flowrate info.	Safe	
FM	479	N	fails	Lose LN2 s.s. flowrate info.	Safe	
EV	480	N	fails	Can't switch between flowmeters	Safe	Would lose FM-478N or FM-479N.
mv	481	N	Open	Bypasses DPT-482N	Safe	Lose indication from DPT-482N.
			Closed	Normal	Safe	
DPT	482	N	fails	Lose LN2 flowrate information	Safe	Can't tell LN2 flowrate to cryostat condensers.
mv	483	A	Open	Capped after outlet	ODH	
			Closed	Normal	Safe	
F	484	N	gets clogged	Stops LN2 to condensers	Safe	Loss of liquid nitrogen, see "What if" analysis
mv	485	N	Open	Bypasses DPT-486N	Safe	Lose indication from DPT-486N.
			Closed	Normal	Safe	
DPT	486	N	fails	Lose press. drop info.	Safe	Won't be able to tell if filter F-484N is getting dirty.
EV	487	N	fails	Can't switch between flowmeters	Safe	Would lose FM-478N or FM-479N.
MV	491	N	Open	Normal	Safe	Permits LN2 to condensors
			Closed	Stops LN2 to condensers	Safe	Loss of liquid nitrogen, see "What if" analysis
PSV	492	N	Fails to relieve	Overpressure piping	Mech. damage	Failure rate: Fail to open 1 in 100,000 demands
			open unexpect.	Vents nitrogen	ODH	Vents inside building.
mv	493	N	Open	Capped after outlet	ODH	
			Closed	Normal	Safe	

COMPONENT			FAILURE OR ERROR MODE	HAZARD OR EFFECT	HAZARD CLASS	REMARKS OR RECOMENDATIONS
mv	494	A	Open	Capped after outlet	ODH	
			Closed	Normal	Safe	
PV	1403	N	Fails to open	No subcooling of LN2 to condensers	Safe	Lower LN2 quality to cryostat condensers.
			close unexpect.	Lose subcooling of LN2 to condensers	Safe	Lower LN2 quality to cryostat condensers.
			Fails to close	LN2 flows into exhaust pipe	Safe	Will waste some LN2, little or no effect on cryostat conder sers.
			open unexpect.	LN2 flows into exhaust pipe	Safe	Will waste some LN2, little or no effect on cryostat conder sers.
CV	1404	N	Sticks open	Allow backflow	Safe	Exhaust line purged by N2 gas under normal operation.
			Sticks closed	Lose LN2 manifold subcooling	Safe	See PV-1403N closed.
MV	801	H	Open	Normal	Safe	
			Closed	Lose GB-814H as He gas source	Safe	GB-815H, GB-816H, and GB-219H backup GB-814H.
MV	802	H	Open	Normal	Safe	
			Closed	Lose GB-815H as He gas source	Safe	GB-814H, GB-816H, and GB-219H backup GB-815H.
MV	803	H	Open	Normal	Safe	
			Closed	Lose GB-816H as He gas source	Safe	GB-814H, GB-815H, and GB-219H backup GB-816H.
MV	804	H	Open	Normal	Safe	
			Closed	Isolates GB-814H and GB-815H	Safe	GB-816H and GB-219H provide He gas to PV-219A.
MV	805	H	Open	Normal	Safe	
			Closed	Isolates GB-816H	Safe	GB-814H, GB-815H, and GB-219H provide He gas to PV-219A.
PSV	807	H	Fails to relieve	Overpressure piping	Mech. damage	Failure rate: Fail to open 1 in 100,000 demands
			open unexpect.	Vents gaseous helium	ODH	Vents inside building.
PRV	808	H	Set too high	PSV-807H on GHe line relieves	Safe	
			Closed	Isolates GB-814H and GB-815H	Safe	GB-816H and GB-219H provide He gas to PV-219A.
PRV	809	H	Set too high	PSV-807H on GHe line relieves	Safe	
			Closed	Isolates GB-816H	Safe	GB-814H, GB-815H, and GB-219H provide He gas to PV-219A.
PI	810	H	fails	Wrong ind. of He gas bottle press,	Safe	Valves of gas bottles will be closed prior to disconnecting them.
PI	811	H	fails	Wrong ind. of He gas bottle press,	Safe	Valves of GB-816H will be closed prior to disconnecting it.
PS	812	H	fails	False indication of low GHe press.	Safe	Can use PI-810H to check GHe pressure.
PS	813	H	fails	False indication of low GHe press.	Safe	Can use PI-811H to check GHe pressure.
				Components below are added as		
				revision 1, 1/29/91		
TG	258	A	fails	Wrong or no vacuum reading	Safe	Other vacuum TG's are provided on UV to read CC vacuum.
FM	270	A	fails	Lose GAr venting flow rate	Safe	Small GAr flow. Not installed as of 1/29/91.
PI	271	A	fails	Wrong or no ind. of pressure	Safe	Max. source pressure is CC PV press. at 13 psig.
mv	272	A	Open	Vents CC sample	Safe	Useful for purge of CC sample panel.
			Closed	Normal	Safe	

COMPONENT			FAILURE OR ERROR MODE	HAZARD OR EFFECT	HAZARD CLASS	REMARKS OR RECOMENDATIONS
mv	273	A	Open	Lose a GAr sample	Safe	Port for taking a remote GAr sample.
			Closed	Normal	Safe	
mv	274	A	Open	Connects vacuum to CC sample panel	Safe	Pumping port for CC sample panel.
			Closed	Normal	Safe	
mv	275	A	Open	Allows sample to CC sample panel	Safe	mv241A is in series to CC press. vessel.
			Closed	Normal	Safe	
mv	276	A	Open	Allows sample to CC sample panel	Safe	mv243A is in series to CC press. vessel.
			Closed	Normal	Safe	
TG	277	A	fails	Wrong or no vacuum reading	Safe	The CC sample panel will be purged out and is isolated from the CC.
PS	826	H	fails	Lose alarm signal to control system	Safe	Will lose one of the two cold valve helium supply alarms.
mv	825	H	Open	Normal	Safe	
			Closed	Isolates PS813H	Safe	See PS813H fails

R. Rucinski 11/15/90

D-ZERO CENTRAL CALORIMETER

"WHAT IF" ANALYSIS

This "What If" analysis was done in accordance with the Fermilab safety manual section 5032TA appendix B.

"WHAT - IF"	CONSEQUENCE / HAZARD	CONCLUSION / RECOMMENDATIONS
Leaks occur?	Oxygen Deficiency Hazard may occur due to	Leaks of reasonable size have been anticipated by the ODH analysis and
	cryogens leaking into the building.	appropriate provisions made so they present no personnel or
		equipment danger (i.e. the ODH class is 0).
The vacuum of the CC is spoiled?	Loss of vacuum.	The loss of vacuum of the cryostat is a relief case looked at in D0 engineering
		note 6. A heat leak of approx. 3.5 KW will occur causing an additional loading
		of the nitrogen condensors. The required relief capacity for LOV is 139 scfm.
		The relief valve and piping on the CC has a capacity of 942 scfm
		plus an additional rupture disc.
There is a loss of vacuum on a	Increased heat load, lower quality of transferred	There is no safety hazard if this occurred. The problem would be discovered by
transfer line?	liquid, would frost up the effected piping.	either a visual inspection of frost and/or questionable operational behavior.
There is a fire under or around	The CC could relieve and possible loss of	Fire exposure of the CC is looked at in D0 Engineering Note 6.
the CC?	signal or valve operators could occur.	The required relief capacity for fire is 264 scfm. The relief valve and
		piping on the CC has a capacity of 942 scfm plus an additional rupture disc.
		See also the "What if" there is a loss of signals or valve operators occurs?
There is a fire in the cryocorner?	Could lose electrical signals to and from the CC.	See the "What if" there is a loss of signals or valve operators occurs?
	Some of the o-rings on bayonets could fail.	and "What if" a leak occurs?
There is a fire in the Ar dewar	Could lose electrical signals to and from the CC.	See the "What if" there is a loss of signals or valve operators occurs?
room?	Some of the o-rings on bayonets could fail.	and "What if" a leak occurs?
There is a loss of signals or valve	We would lose the ability to control valves.	All control valves fail in the closed positions. All reliefs and rupture discs
operators?		remain operational. After some time trapped volume reliefs could relieve.
		The CC could relieve also after a long period of time.
A cap on an EC rotating bayonet is	Would not be able to successfully pass pump and	It is written into the CC procedures pump and purge section 7.3.0 that
missing or is not clamped on?	purge part of the CC procedures.	the caps are to be installed. If a cap is missing we would not successfully
		be able to pull a vacuum on that line. If a cap was in place but not clamped,
		then it would become unseated after the first backfill to positive pressure
		and the subsequent pumpdown would fail. In either case, the problem
		would be discovered before cryogens entered the line.

"WHAT - IF"	CONSEQUENCE / HAZARD	CONCLUSION / RECOMMENDATIONS
There is an earthquake?	Damage to the piping system could occur.	The ANSI B31.1-1986 piping code under par. 101.5.3 states that
		"The effect of earthquakes, where applicable, shall be considered in the
		design of piping, piping supports..." The effect of earthquakes are not
		applicable to the region of Illinois where Fermilab is located. The
		Uniform Building Code shows that Fermilab is in a Class 0
		seismic zone which means no design provisions for earthquakes are
		required.
There is a loss of electrical	Backup power will be required to maintain	Sustained loss of electrical power will result in critical equipment
power?	operation of the system.	running on the Emergency Power Generator. The instrument air,
		vacuum pumps and controls are (will) all be EPG powered. Should
		the EPG fail before the return of commercial power the equipment
		is lost, see below.
There is a loss of Instrument	Valves will close.	Safe. The primary system is backed up for several hours with a tube trailer.
air?		All valves are failsafe, i.e. they close on the loss of instrument
		air. Reference the failure mode and effects analysis.
There is a loss of cooling	The main cooling water supply might be	The vacuum and Instrument air equipment have a primary, emergency
water?	in jeopardy if a system was not designed	powered, immediate start, closed loop, fan blown radiator, redundant
	properly.	pump, glycol stream to put the heat load on the building system and
		provide lower summertime coolant temperatures. Loss of the secondary
		system, or commercial power if the emergency generator functions,
		does not effect the cooling provided to the rotary equipment.
There is a loss of Liquid	Cooling will be lost and will cause the	The loss of liquid nitrogen denies the detector its necessary coooling
nitrogen?	Vessels to warm, boil off, and vent.	and it will pressurize and vent. The rate of loss is calculated to be
		only 0.45 gpm of liquid argon on average, which is very slow.
		The loss of liquid nitrogen does not provide a personnel or equipment
		danger.
Some kind of contamination	The contamination could restrict flows.	Continued or serious one-time contamination of the coolant stream
occurs?		with frozen solids will result in a loss of liquid nitrogen, see above.

"WHAT - IF"	CONSEQUENCE / HAZARD	CONCLUSION / RECOMMENDATIONS
There is some kind of	A piece of equipment will stop working.	100% redundancy in mechanical forepumps provide for vacuum
equipment failure?		equipment failure in the operating mode. The insulating vacuum can
		function with either the cryostat diffusion pump or the blower.
		Instrument air is backed up by 8 or more hours of high pressure
		gaseous nitrogen. All valves close on air failure. Expected equipment
		modes do not provide a personnel or equipment danger.
An operator makes a	Upset of the system may occur.	Any one operator procedural or console error can cause any one
procedural error?		component to act improperly which is comparable to a component
		failure. Failure of equipment is covered above and failure of valves
		was covered in the FMEA. A single operator error cannot cause a safety
		problem.