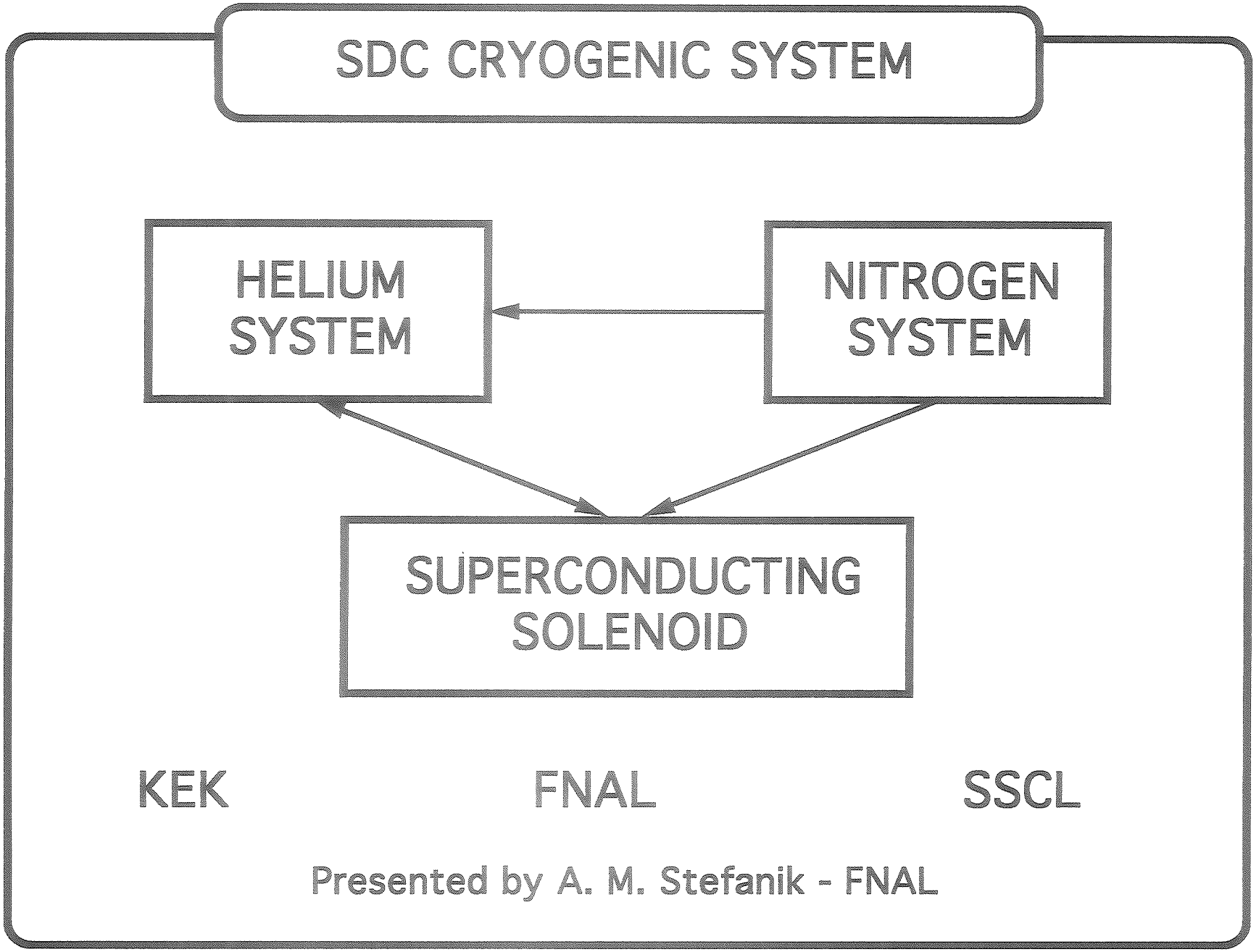

SDC CRYOGENIC SYSTEM
HELIUM SYSTEM
NITROGEN SYSTEM
SUPERCONDUCTING SOLENOID
KEK
FNAL
SSCL
Presented by A. M. Stefanik - FNAL

SDC CRYOGENIC SYSTEM

WORK PLAN

1. ESTABLISH DESIGN REQUIREMENTS
2. SUPPLY (DESIGN -> DELIVERY)
3. INSTALLATION
4. COMMISSIONING
5. OPERATION
6. MAINTENANCE

SDC CRYOGENIC SYSTEM

WORK PLAN: EQUIPMENT/SYSTEM SUPPLY

SOLENOID MAGNET, CHIMNEY, SERVICE PORT	- KEK
SOLENOID POWER SUPPLY CIRCUIT	- FNAL/SSCL
VLPC SYSTEM FOR FIBER TRACKER	- TRK GRP
CONTROL DEWAR	- FNAL
TRANSFER LINES	- SSCL
HELIUM REFRIGERATOR/LIQUEFIER	- SSCL
NITROGEN SYSTEM	- SSCL
CONTROL SYSTEM	- SSCL

SDC CRYOGENIC SYSTEM

DESIGN PHILOSOPHY

1. SAFETY: GOAL IS TO OPERATE IN RISK ZONE 3 ON SSCL RISK ASSESSMENT MATRIX.

2. RELIABILITY: GOAL IS TO MAXIMIZE SYSTEM AVAILABILITY -> SIMPLE YET ROBUST SYSTEM, MTBF DATA, SAFETY ANALYSIS, ACCESS FOR REPAIR, SHORT TERM OPERATION WITH COLDBOX SHUTDOWN.

3. MINIMIZE THE RADIATION AND ABSORPTION LENGTHS OF COMPONENTS IN FRONT OF THE EM CALORIMETER.

4. ENGINEERING ANALYSIS AND TESTING (PREDICTABILITY).

SDC CRYOGENIC SYSTEM

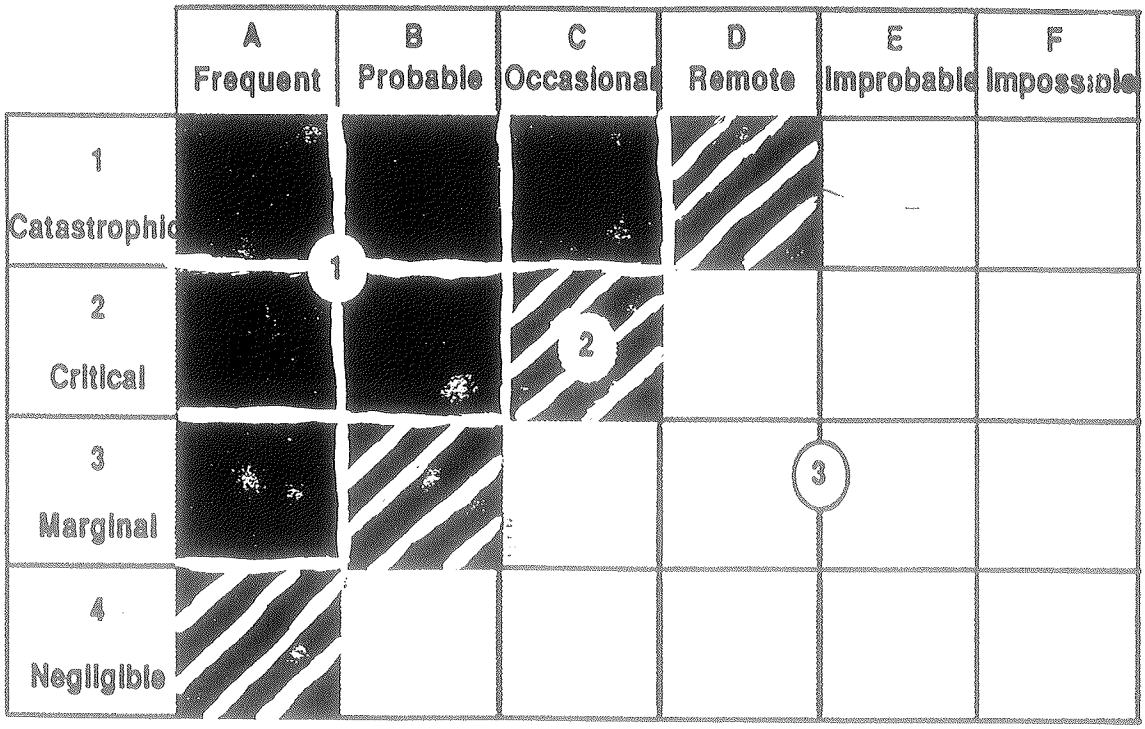
DESIGN PHILOSOPHY

5. ESTABLISH QUALITY ASSURANCE REQUIREMENTS.

6. COMPLIANCE WITH DOE ORDERS, CODES AND STANDARDS.

7. MINIMIZE OPERATING EQUIPMENT IN THE DETECTOR HALL.

APPENDIX B. RISK ASSESSMENT MATRIX



Severity of Consequences

	Descriptive Word	Personal Illness/ Injury	Equipment Loss(s)	Test Unit Downtime	Data Compromise	Environmental Effect
1	Catastrophic	Death	>500K	> 4 months	Data never recoverable or primary program objectives lost	Long-Term (5yrs or greater) environmental damage or requiring $500K or more to correct and/or in penalties
2	Critical	Severe injury or severe occupational illness	100K to 500K	2 weeks to 4 months	Repeat of last program	Medium-term (1-5 yrs) environmental damage or requiring $100K-500K to correct and/or in penalties
3	Marginal	Minor injury or mimor occupational illness	1K to 100K	1 day to 2 weeks	Repeat of last period	Short-term (less than 1 yr) environmental damage or requiring $1K-100K to correct and/or in penalties
4	Negligible	No injury or illness	< 1 K	< 1day	Repeat data point or data requires minor manipulation or computer rerun	Minor environmental damage that readily can be repaired or requiring less than $ 1K to correct and/or in penalties

Probability of Mishap

Level	Descriptive Word	Definition
A	Frequent	Likely to occur repeatedly during life cycle of syst.
B	Probable	Likely to occur several times in life cycle of syst.
C	Occasional	Likely to occur sometime in life of system.
D	Remote	Not likely to occur in life cycle of system.
E	Improbable	Possi. of occurance cannot be distinguished from 0.
F	Impossible	Physically impossible to occur

Risk Zones

Code		Action
1	High	Imperative to suppress risk to lower level
2	Med	Operation requires written, time-ltd waiver endorsed by Mgmt.
3	Low	Operation permissible

Note: PERSONNEL must not be exposed to hazards in Risk Zones 1 and 2

* Adapted from MIL-STD-882B

SDC CRYOGENIC SYSTEM

SOLENOID SYSTEM

RISK ASSESSMENT AFTER ABATEMENT

1. PERSONNEL AND THE ENVIRONMENT ARE NOT EXPOSED TO HAZARDS IN RISK ZONES 1 AND 2.

2. EQUIPMENT (EQUIPMENT LOSS, TEST UNIT DOWNTIME AND DATA COMPROMISE) ARE NOT EXPOSED TO HAZARDS IN RISK ZONES 1 AND 2 IN MOST CASES.

SDC CRYOGENIC SYSTEM

SOLENOID SYSTEM

RISK ASSESSMENT AFTER ABATEMENT

3. EXAMPLES OF EQUIPMENT EXPOSED TO HAZARDS IN RISK ZONES 1 AND 2:

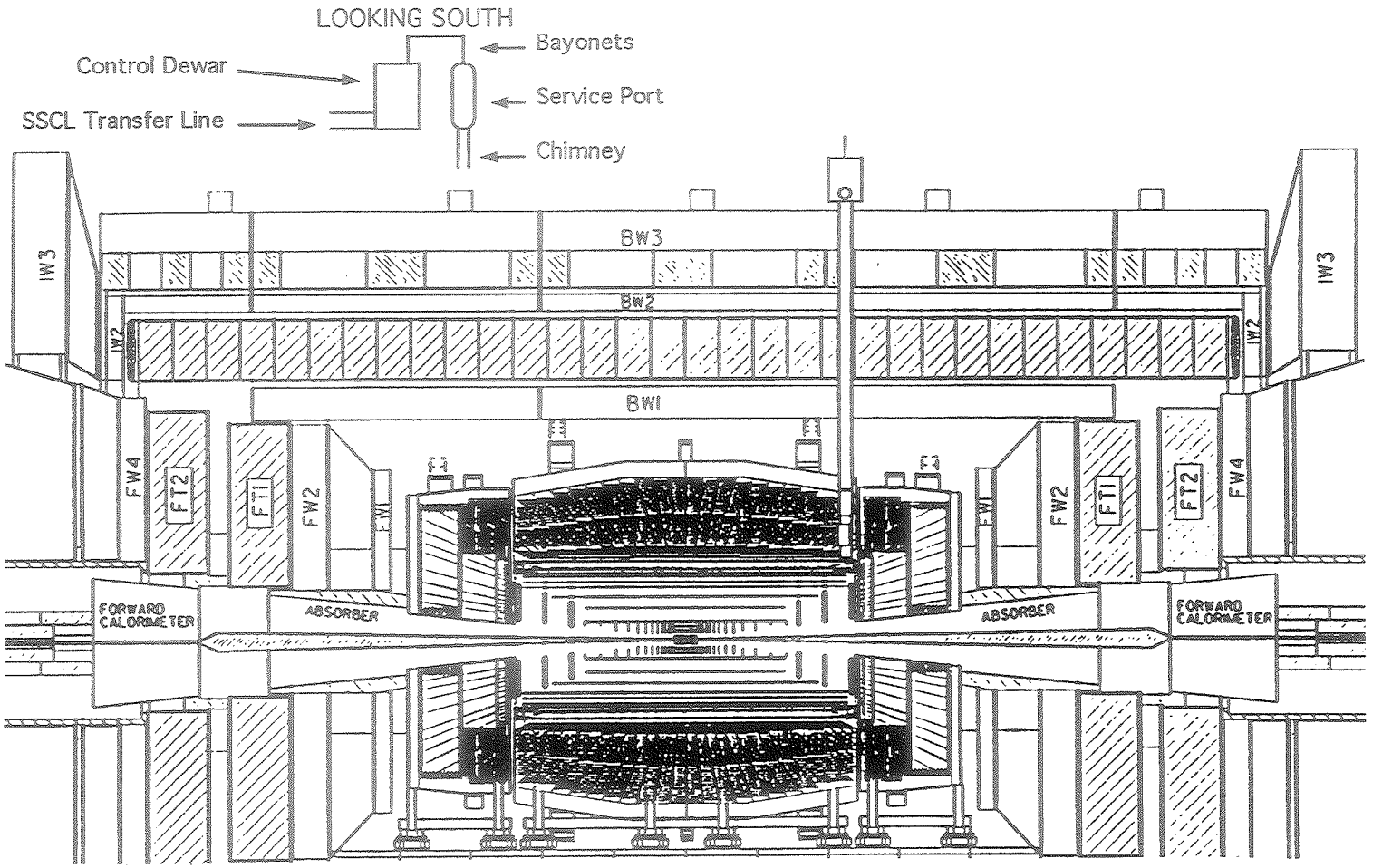
   - LOSS OF THERMAL INSULATION VACUUM, 1-C-1

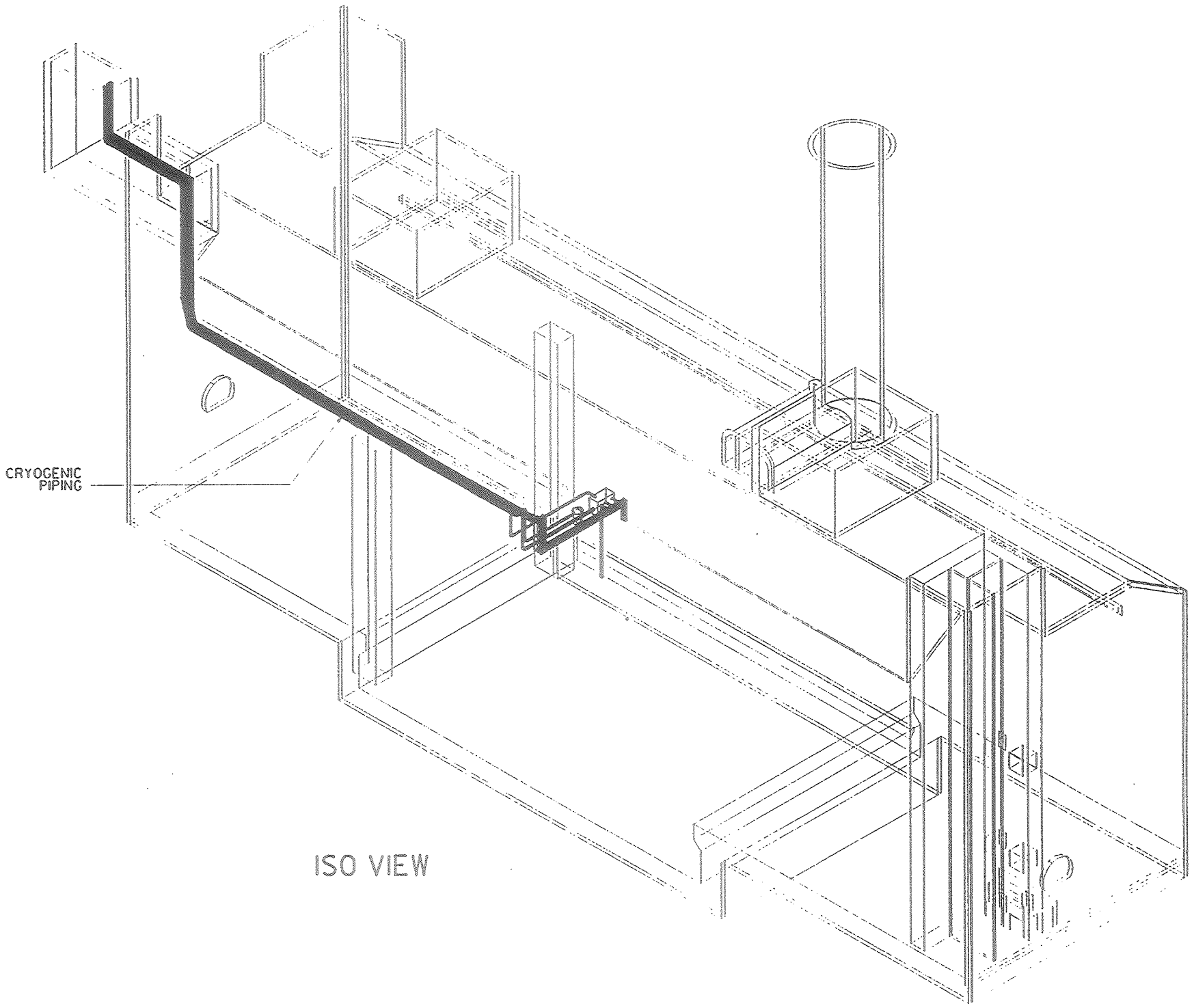
   - THERMAL SHORT AFTER FINAL ASSEMBLY, 1-D-2

   - ISOGRID OR HONEYCOMB OUTER VACUUM SHELL IS UNACCEPTABLE AFTER IT IS BUILT, 1-D-2. REPLACE WITH NEW ISOGRID OR HONEYCOMB SHELL (1-D-2) OR SOLID PLATE (1-E-3).

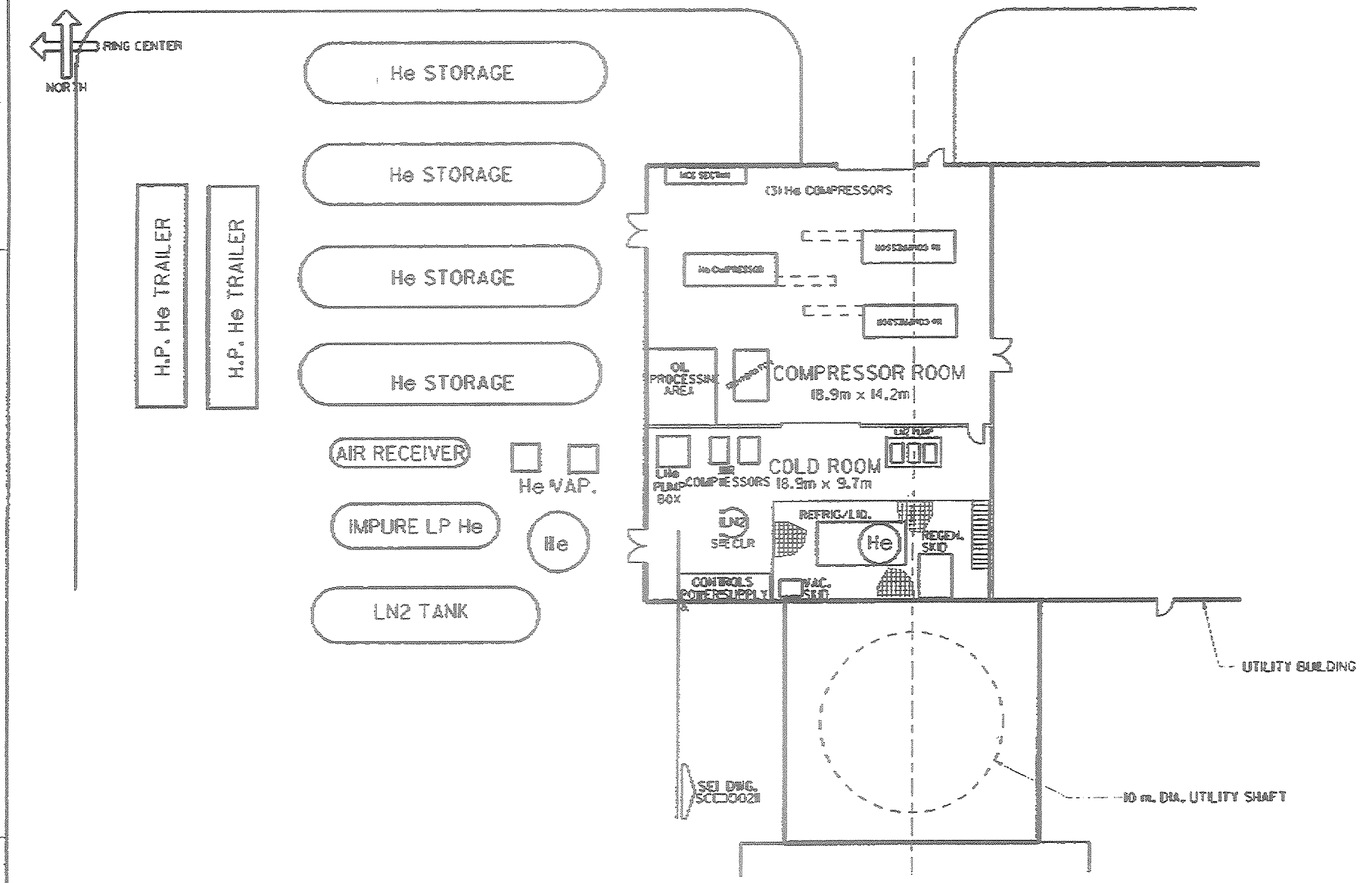
SDC CRYOGENIC SYSTEM

LOCATION OF SOLENOID SYSTEM





ISO VIEW



UTILITY BUILDING - COLD ROOM AND COMPRESSOR ROOM FLOOR PLAN

THIS IS A CAD GENERATED DRAWING. DO NOT MAKE MANUAL REVISIONS OR ALTERATIONS.

DIMENSIONS ARE SHOWN IN METERS UNLESS NOTED OTHERWISE.

PHYSICS RESEARCH DIVISION

SSC

SDC EXPERIMENTAL FACILITIES

SDC UTILITY BUILDING FIRST FLOOR PLAN OF CRYOGENIC COLD ROOM AND COMPRESSOR ROOM

SCD 0001T4A

FIGURE 9-3

SDC CRYOGENIC SYSTEM

COOLING OF COIL/OUTER SUPPORT CYLINDER

THE COIL AND OUTER SUPPORT CYLINDER ARE COOLED WITH FORCED FLOW, TWO-PHASE HELIUM IN A SINGLE PASS COOLING TUBE WHICH IS ATTACHED TO THE OUTER SUPPORT CYLINDER (OSC).

OTHER METHODS CONSIDERED:

1. SINGLE PHASE LIQUID HELIUM - LOWER HEAT TRANSFER COMPARED TO TWO-PHASE HELIUM.

2. THERMOSIPHON - RADIAL SPACE REQUIRED FOR SUPPLY AND RETURN MANIFOLDS

SDC CRYOGENIC SYSTEM

COOLING OF SOLENOID THERMAL RADIATION SHIELD

1. FORCED FLOW, TWO-PHASE NITROGEN

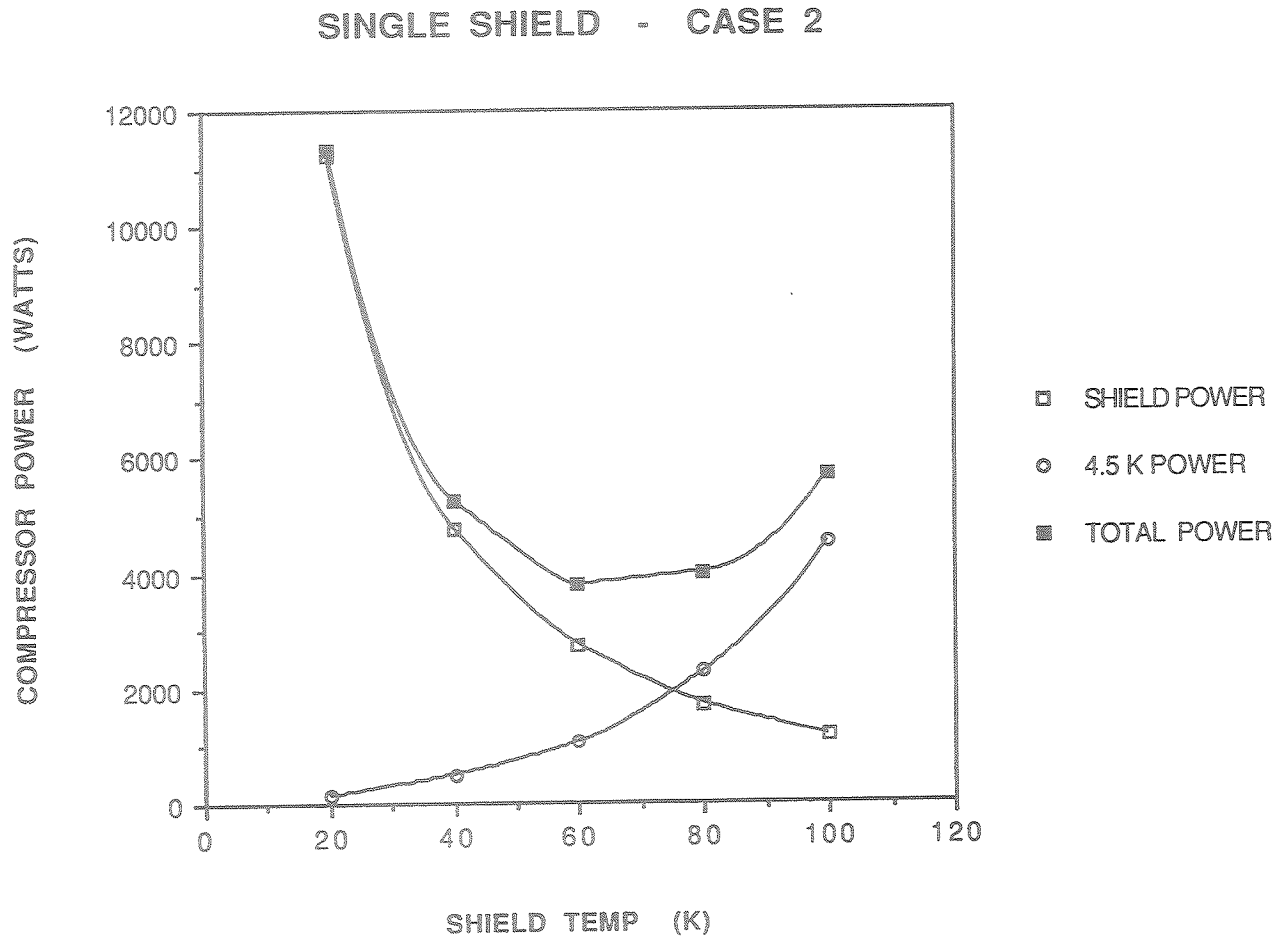
   ADVANTAGES: MAINTAIN SHIELD COOLING DURING SHORT DURATION COLDBOX SHUTDOWNS, AIR SEPARATION PLANT ON THE SITE.

2. HELIUM GAS FROM INTERMEDIATE STAGE IN THE R/L

   ADVANTAGES: SINGLE CRYOGEN SIMPLIFIES THE SYSTEM, REDUCES LIQUID NITROGEN ODH IN THE DETECTOR HALL.

SDC CRYOGENIC SYSTEM

COOLING OF SOLENOID THERMAL RADIATION SHIELD



SDC CRYOGENIC SYSTEM

HELIUM COOLING TUBE ON OUTER SUPPORT CYLINDER

1. DESIGN PRESSURE IS BASED ON PRESSURE GENERATED DURING SOLENOID QUENCH - 6.5 MPa -A (945 PSIA) CURRENTLY (250 METER LENGTH, ONE-WAY VENTING).

2. CONSIDER ANSI B31.3 - 302.2.4, "ALLOWANCES FOR PRESSURE AND TEMPERATURE VARIATIONS, METALLIC PIPING", IN SETTING THE DESIGN PRESSURE.

SDC CRYOGENIC SYSTEM

HELIUM COOLING TUBE: MAXIMUM PRESSURE AND HELIUM VENTING RATE DURING A QUENCH

1. CALCULATE SUPPORT CYLINDER HEATING RATE ASSUMING ADIABATIC EDDY CURRENT HEATING (NO QUENCH-BACK).

2. CALCULATE PEAK PRESSURE WITH EQUATION DEVELOPED BY MILLER ET AL (ORNL) USING MAXIMUM HEATING RATE CALCULATED IN #1. CHECK APPLICABILITY.

3. CALCULATE HELIUM VENTING RATE FROM COOLING TUBE DURING EDDY CURRENT HEATING TO SIZE THE RELIEF VALVES.

4. WILL INCLUDE QUENCH-BACK FROM THE OUTER SUPPORT CYLINDER.

SDC CRYOGENIC SYSTEM

CHIMNEY

1. PASSAGE FOR CRYOGEN LINES & SUPERCONDUCTING LEADS
2. FLOW CHANNEL FOR PRESSURE RELIEF & VACUUM PUMPING
3. PROVIDE ACCESS TO THE FIELD JOINTS
4. INSTRUMENTATION CONNECTOR BOX
5. ACCOMMODATE DIFFERENTIAL MOVEMENTS
6. SPACE LIMITATIONS

SDC CRYOGENIC SYSTEM

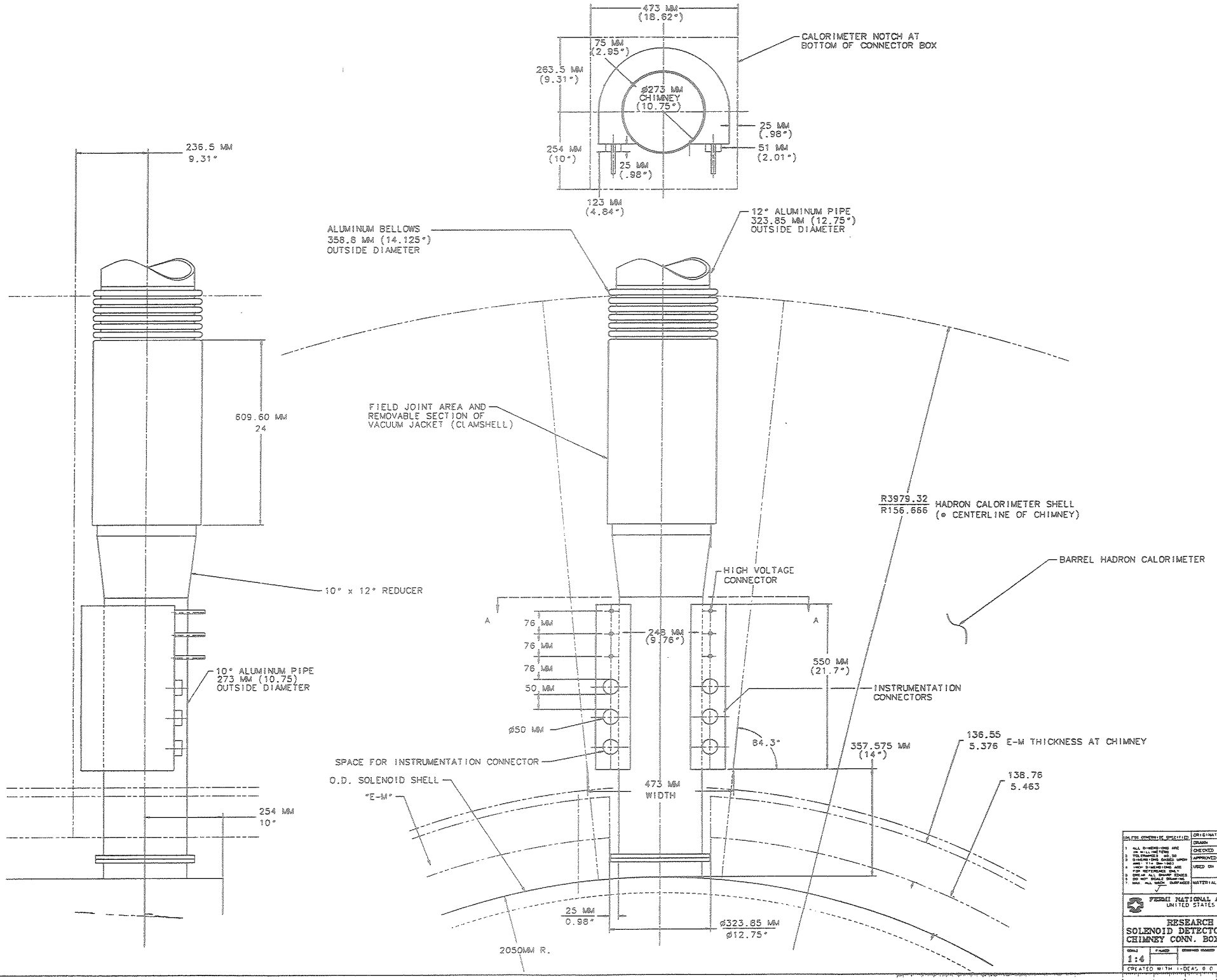
CHIMNEY - CURRENT DESIGN

1. VACUUM VESSEL RELIEVING PRESSURE IS 0.15 PSIG.

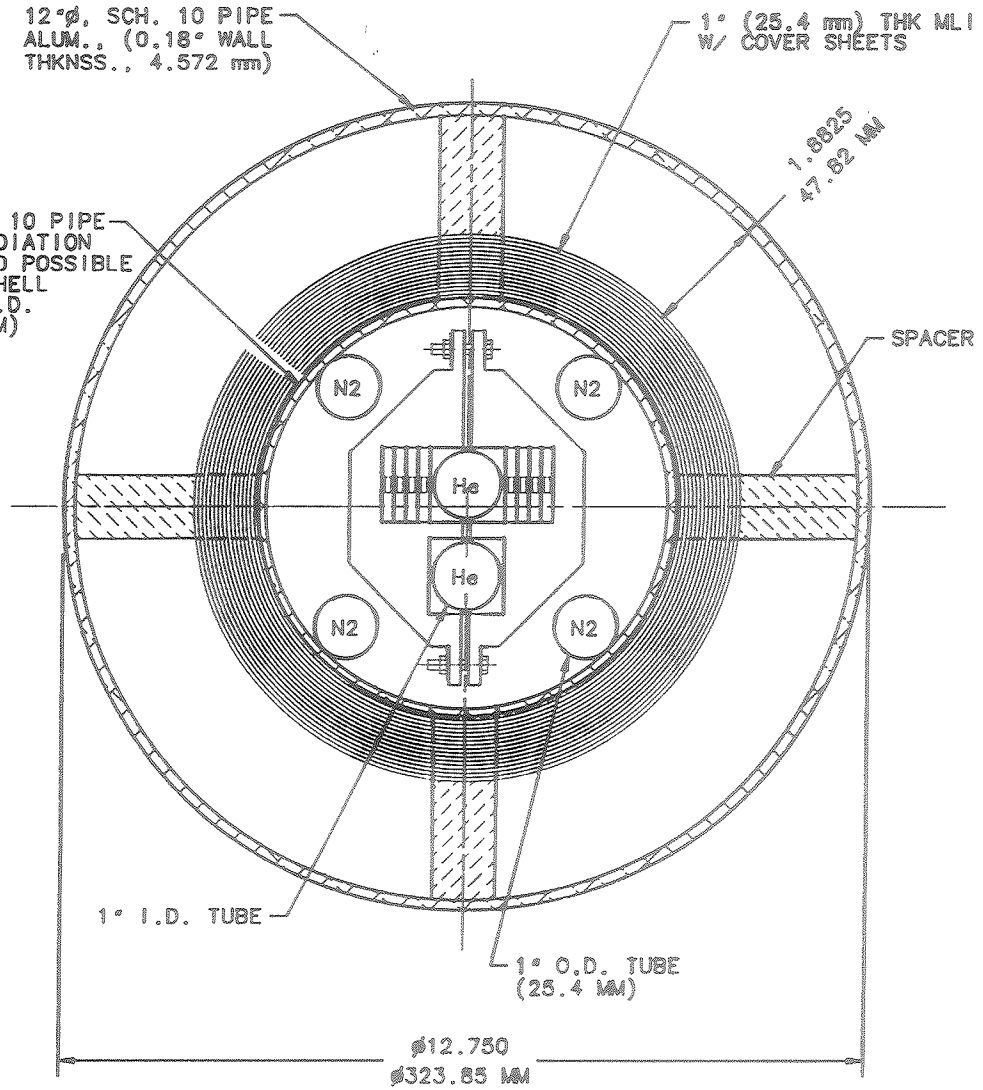
   VACUUM VESSEL DESIGN PRESSURE IS 0.6 PSIG.

2. VACUUM PUMPING THROUGHPUT IS 2 x10^-3 ATM-CC/SEC AT 2.2 x10^-5 TORR (CDF SOLENOID TRIP POINT).

   CDF LEAK RATE WITH LIQUID HELIUM WAS DETERMINED TO BE ABOUT 1.5 x10^-7 ATM-CC/SEC.


473 MM
(18.62")
75 MM
(2.95")
263.5 MM
(9.31")
CALORIMETER NOTCH AT
BOTTOM OF CONNECTOR BOX
ø273 MM
CHIMNEY
(10.75")
25 MM
(.98")
254 MM
(10")
51 MM
(2.01")
25 MM
(.98")
123 MM
(4.84")
236.5 MM
9.31"
ALUMINUM BELLOWS
358.8 MM (14.125")
OUTSIDE DIAMETER
12" ALUMINUM PIPE
323.85 MM (12.75")
OUTSIDE DIAMETER
609.60 MM
24
FIELD JOINT AREA AND
REMOVABLE SECTION OF
VACUUM JACKET (CLAMSHELL)
R3979.32
R156.666
HADRON CALORIMETER SHELL
(⊕ CENTERLINE OF CHIMNEY)
BARREL HADRON CALORIMETER
HIGH VOLTAGE
CONNECTOR
10" x 12" REDUCER
A
A
76 MM
76 MM
76 MM
50 MM
248 MM
(9.76")
550 MM
(21.7")
INSTRUMENTATION
CONNECTORS
10" ALUMINUM PIPE
273 MM (10.75)
OUTSIDE DIAMETER
ø50 MM
84.3°
357.575 MM
(14")
136.55
5.376
E-M THICKNESS AT CHIMNEY
SPACE FOR INSTRUMENTATION CONNECTOR
O.D. SOLENOID SHELL
"E-M"
473 MM
WIDTH
138.76
5.463
254 MM
10"
25 MM
0.98"
ø323.85 MM
ø12.75"
2050MM R.
ORIGINATOR
A. STEFANIK
DRAWN
RGH
CHECKED
APPROVED
USED ON
MATERIAL
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
SSC
RESEARCH DIVISION
SOLENOID DETECTOR COLLABORATION
CHIMNEY CONN. BOX AND FIELD JOINT
1:4
CREATED WITH I-DEAS 6.0
USER NAME FRIEND

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	A. STEFANIK	2/91
FRACTIONS	DECIMALS	ANGLES	DRAWN	D. FRIEND	2/12/91
±	±	±	CHECKED		
1. BREAK ALL SHARP EDGES 1/64 MAX. 2. DO NOT SCALE DRWG. 3. DIMENSIONING IN ACCORD WITH ANSI Y14.5 STD'e.			APPROVED		
			USED ON		
√ MAX. ALL MACHINED SURFACES			MATERIAL		B

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

SOLENOIDAL DETECTOR COLLABORATION
SUPERCONDUCTING SOLENOID; TYPE I
CHIMMNEY CROSSSECTION; 12" NOM.

SCALE	DRAWING NUMBER	SHEET NO.	REV.
HALF		1	

A B

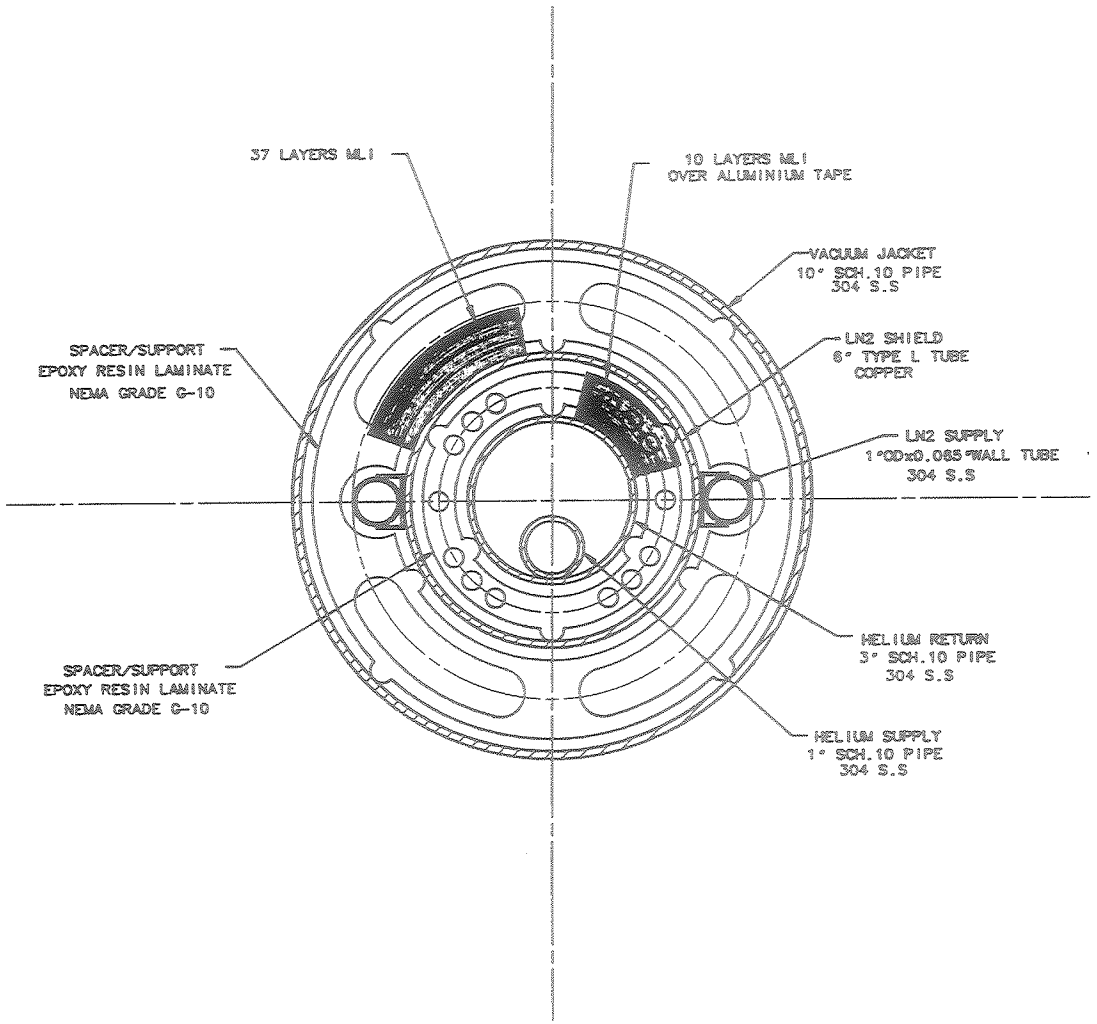
1 2 3 4

SDC CRYOGENIC SYSTEM

TRANSFER LINES - ALL LINES FOLLOW THE SAME ROUTE

1. 10" CRYOGENIC TRANSFER LINE: LIQUID HELIUM SUPPLY AND RETURN, AND EITHER HELIUM GAS OR LIQUID NITROGEN SUPPLY AND RETURN.
2. CURRENT LEAD FLOW RETURN (ONE LINE FOR EACH LEAD)
3. COOLDOWN
4. NITROGEN GAS SUPPLY
5. PROCESS NITROGEN RETURN
6. WATER COOLED ELECTRICAL BUS
7. VLPC SYSTEM

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



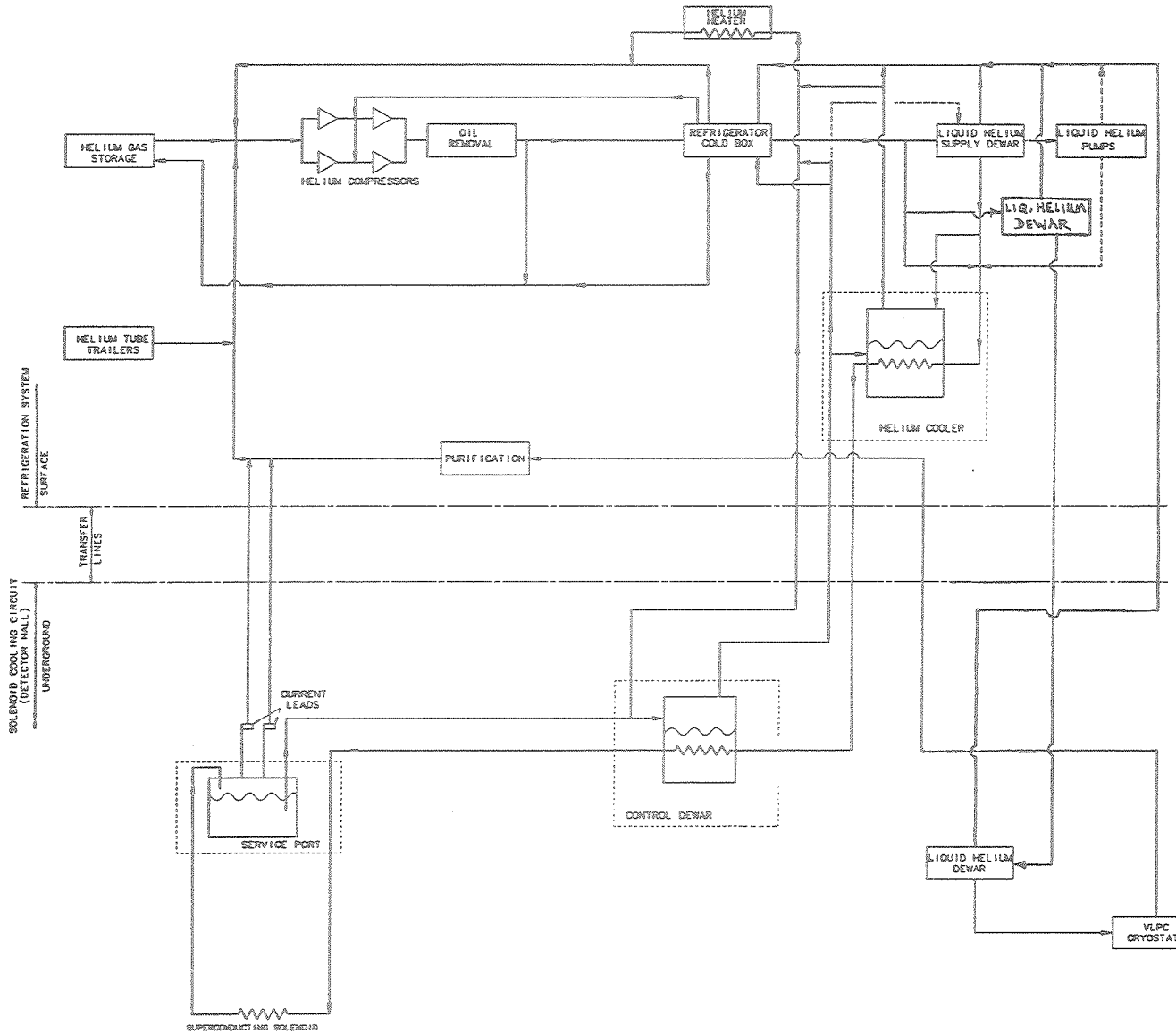
ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.
	PARTS LIST		

UNLESS OTHERWISE SPECIFIED	ORIGINATOR	A.STEFANIK	
FRACTIONS / DECIMALS / ANGLES	DRAWN	N.CADENA	8/13/91
± / ± / ±	CHECKED		
1. BREAK ALL SHARP EDGES 1/64 MAX. 2. DO NOT SCALE DRWG. 3. DIMENSIONING IN ACCORD WITH ANSI Y14.5 STD's.	APPROVED		
	USED ON		
√ MAX. ALL MACHINED SURFACES	MATERIAL		C

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

SOLENOIDAL DETECTOR COLLABORATION
CRYOGENIC TRANSFER LINE, CROSS SECTION
SUPERCONDUCTING SOLENOID

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/2-1"	MC-267004	1	



NOTE 1: THE OPTIONAL PUMP SYSTEM IS DRAWN WITH DASHED LINES.
2: REDRAWN AND REVISED SUPERCEDES MD-267001
3: VLPC SYSTEM IS VERY PRELIMINARY

UTILITIES PROVIDED BY SDC
1. ELECTRIC POWER
2. COOLING WATER
3. LIQUID NITROGEN

AUXILIARY EQUIPMENT PROVIDED BY RSC
1. COMPRESSOR LUBRICANT PROCESSING UNIT
2. INSTRUMENT AIR

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

SOLENOIDAL DETECTOR COLLABORATION
SUPERCONDUCTING SOLENOID
HELIUM SYSTEM: FLOW DIAGRAM

SCALE: NONE

SDC CRYOGENIC SYSTEM

STEADY STATE 4.35 K LIQUID HELIUM REFRIGERATION LOADS

	ESTIMATED
1. SOLENOID SYSTEM	37 WATTS
2. CONTROL DEWAR	13
3. TRANSFER LINE	50
4. 10,000 LITER LHe DEWAR	4
5. VLPC SYSTEM - DISTRIBUTION	200 (BUDGET-?)
TOTAL	304 WATTS

SDC CRYOGENIC SYSTEM

STEADY STATE HELIUM LIQUEFACTION LOADS

	ESTIMATED
1. VAPOR COOLED CURRENT LEADS	1 GRAM/SEC
2. VLPC SYSTEM - CASSETTES	0.2
TOTAL	1.2 GRAMS/SEC

SDC CRYOGENIC SYSTEM

MINIMUM 4.35 K COOLING POWER REQUIREMENT FOR THE REFRIGERATOR/LIQUEFIER

1. STEADY STATE: 304 WATTS PLUS 1.2 G/S RETURNING AT 300 K -> 425 WATTS

2. CHARGING: (35 MINUTES) 88 + 425 = 513 WATTS

3. COOLDOWN: (14 DAYS) 700 WATTS

4. QUENCH RECOVERY: (4 HOURS) 2500 WATTS AT 4.5 K

SDC CRYOGENIC SYSTEM

SOLENOID QUENCH RECOVERY

1. 3300 LITERS OF LIQUID HELIUM REQUIRED.

2. 10,000 LITER STORAGE DEWAR - ENOUGH LIQUID IS AVAILABLE TO RECOVER FROM 2 BACK-TO-BACK QUENCHES.

3. COMPRESS AND STORE THE GAS. RELIQUEFY DURING STEADY STATE OPERATION -> 12 HOURS/QUENCH WITH 1500 WATT REFRIGERATOR/LIQUEFIER.

4. A PRESSURE OF 0.31 MPa (45 PSIG) IS NEEDED IN THE LIQUID HELIUM SUPPLY DEWAR AT THE START OF QUENCH RECOVERY TO DELIVER THE REQUIRED FLOW RATE OF 28.5 GRAMS/SEC (3300 LITERS IN 4 HOURS). DEWAR NORMAL OPERATING PRESSURE IS 0.07 MPa (10 PSIG).

SDC CRYOGENIC SYSTEM

REFRIGERATOR/LIQUEFIER SIZE - CURRENT ESTIMATE

FULL REFRIGERATION CAPACITY OF 1500 WATTS AT 4.35 K IS REQUIRED BASED ON THE STEADY STATE, CHARGING, COOLDOWN AND QUENCH RECOVERY REQUIREMENTS.

SDC CRYOGENIC SYSTEM

EFFECT OF TWO-PHASE HELIUM IN THE RETURN LINE FROM THE SOLENOID - 40 METER ELEVATION CHANGE

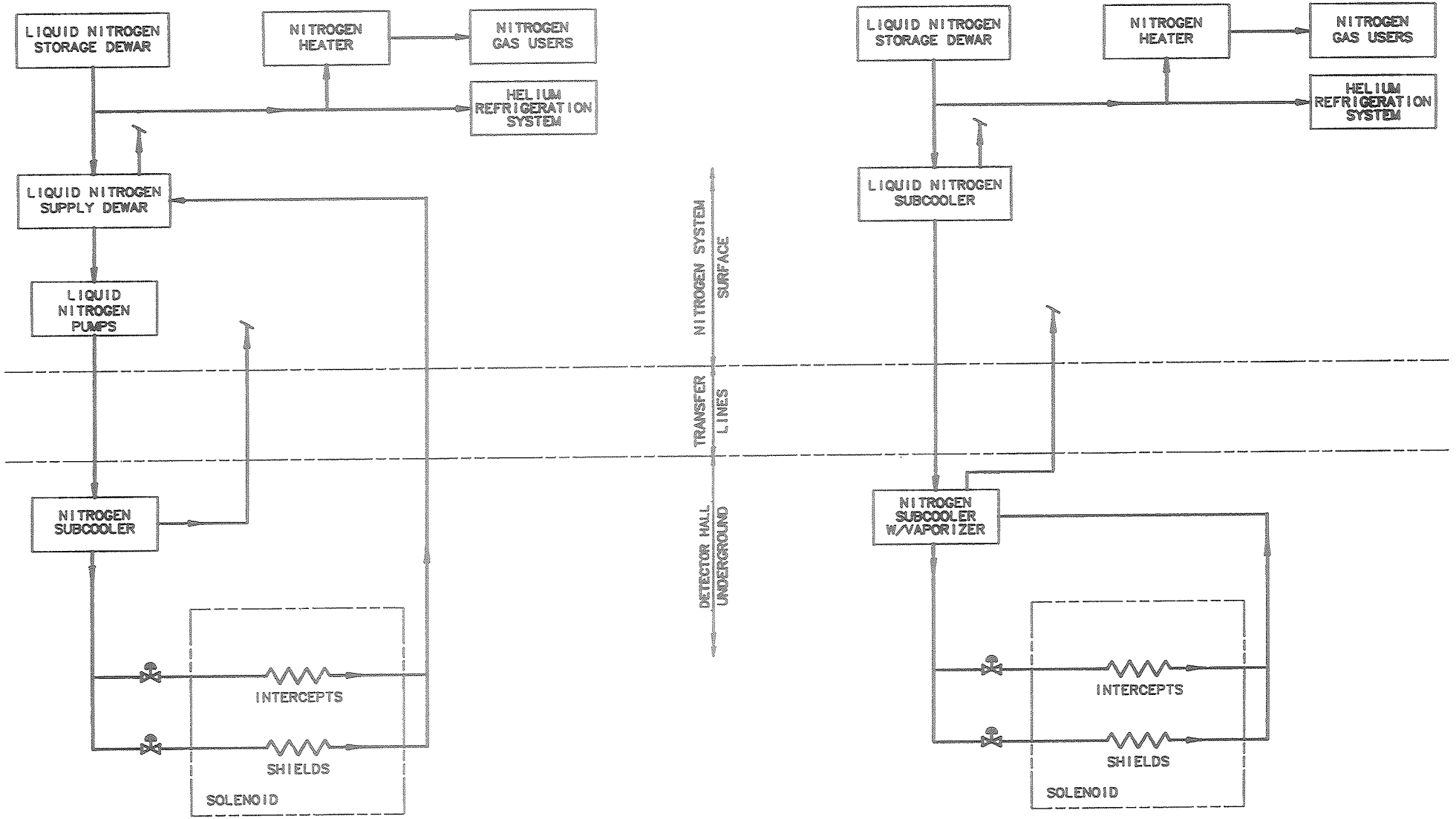
BOTH CASES ASSUME A FLOW RATE OF 23 G/S AND A RETURN TEMPERATURE TO THE R/L OF 4.35 K.

1. QUALITY = 0.5 AT SOLENOID EXIT -

   OPERATING CONDITIONS AT SOLENOID EXIT:
   0.128 MPa-A, 4.48 K.

2. QUALITY= 0 AT SOLENOID EXIT (WORSE CASE) -

   OPERATING CONDITIONS AT SOLENOID EXIT:
   0.15 MPa-A, 4.68 K.



ORIGIN'R	A. STEFANIK	4/92	DRAWING		
DRAWN	D. FRIEND	4/30/92	APP'D		

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

SOLENOIDAL DETECTOR COLLABORATION
SUPERCONDUCTING SOLENOID
NITROGEN SYSTEM FLOW OPTIONS

SCALE	DRAWING NUMBER	SHEET NO.
NONE		1

SDC CRYOGENIC SYSTEM

STEADY STATE LIQUID NITROGEN SYSTEM LOADS

	ESTIMATED
1. SOLENOID SYSTEM	363+ WATTS
2. CONTROL DEWAR	125
3. TRANSFER LINE	165
4. 75,000 LITER LN2 DEWAR	340
5. PIPING & EQUIPMENT	325
TOTAL	1318+ WATTS

SDC CRYOGENIC SYSTEM

HELIUM STORAGE ESTIMATE

1. LIQUID

   10,000 LITER NOMINAL CAPACITY

   2.5 METER DIAMETER BY 5.5 METER OAL

   QUANTITY: 1

2. GAS

   7100 Nm^3

   3.35 METER DIAMETER BY 16.5 METER OAL

   QUANTITY: 4

SDC CRYOGENIC SYSTEM

NITROGEN STORAGE ESTIMATE

1. LIQUID

   75,000 LITER NOMINAL CAPACITY

   3 METER DIAMETER BY 16.5 METER OAL

   QUANTITY: 1

2. GAS

   NONE