**Summary of Warm-up after Draining
for the
the D-Zero LAr Calorimeters**

D-ZERO ENGINEERING NOTE # 3740.512 EN-442

March 14, 1996

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RD/DØ Mechanical

Approved:

A handwritten signature in black ink, appearing to read 'Russ Rucinski', written over a horizontal line.

Abstract

After a very successful physics run, the D-Zero detector Liquid Argon Calorimeters were drained in preparation of the detector roll out. During the roll out process, the calorimeters were without cooling. Information regarding the temperatures, estimated heat transfer, and pressure maintenance are documented in this engineering note.

Timeline

The ECS, CC, and ECN were drained February 28, 29, and March 1, 1996 respectively. The three calorimeters were kept individually isolated and cooled with LN2 to maintain pressure at 20.0 psia from the time they were emptied until the morning of March 11. On March 11 the detector was readied for the move from the collision to the assembly hall. The gas argon lines for the three calorimeters were physically blocked open and a temporary umbilical connected this line to the liquid argon dewar. The liquid nitrogen flow ceased sometime before 08:00 when the building to platform u-tubes were removed. From approx. 08:00, 3/11 until 14:00, 3/12 the pressure in the calorimeters was maintained by the connection to the Lar dewar. From 14:00 until approximately 20:00 the calorimeters were isolated from the Lar dewar while u-tube installation in the assembly hall position took place. Cooling by liquid nitrogen of the calorimeters commenced shortly thereafter to maintain pressure.

Temperature Data

Table 1: Temperature data for emptied Calorimeters

DATE	ECS			ECS	CC	ECN	ECN	COMMENT
	OH, MH, IH			AVG.		AVG.	OH, MH, IH	
3/5 17:04	93.68,	91.49,	100.42	93.89	94.33	91.68	89.89, 91.89, 96.93	Cooling
3/11 9:43	93.16,	91.29,	103.70	94.05	96.08	98.26	93.38, 95.81, 119.98	Cooling stopped
DIFF. 137 hrs.				+0.16	+1.75	+6.58		
3/12 17:12	97.54,	96.28,	120.54	100.53	97.65	100.87	94.53, 98.74, 126.50	Still no Cooling
DIFF. 32 hrs.				+6.48	+1.57	+2.61		

DT/dt ECS = 0.2025 K/hr, During uncooled 32 hours

DT/dt CC = 0.0491 K/hr, " "

DT/dt ECN = 0.0768 K/hr, " "

The temperature data was provided through the LAREXAM.DAQ program. From raw temperatures, averages were taken for a group of modules in the EC's. Then a whole calorimeter average was made weighted by mass. The CC raw temperature data was not mapped well enough to know where the

temperatures applied. A large number of data points were averaged together for the 3/11 and 3/12 data. A suitable subgroup that matched the average was used to get the 3/5 temperature.

Heat Transfer

The average heat load to the calorimeters was determined based on the 32 hour temperature rise and knowledge of the calorimeter thermal masses.

Table 2: Average heat load to empty uncooled calorimeters

ECS	CC	ECN
2468 watts	651 watts	995 watts

Design calculations for the steady state operating heat loads for the calorimeters estimated that the heat load to each calorimeter is approximately the same. Actual measurements indicate that the total heat load for the three calorimeters was 5300 watts or 1767 watts for each. Breaking down the steady state heat load into specifics it is estimated that:

Cables at 80% of total	= 1414 watts
Radiation/vacuum at 10% of total	= 177 watts
Other at 10% of total	= <u>177 watts</u>
Total	= 1767 watts

One would expect that the heat loads to the empty calorimeters would be on the order of what was shown by the CC. The thermal length of the cables is increased thereby reducing the major source of heat load. Poor insulating vacuums explain the higher heat load/warm ups of the EC's.

Table 3: Insulating Vacuum levels for the calorimeters

DATE	ECS	CC	ECN
3/11, 10:00	10 microns	6 microns	9 microns
3/12, 17:00	68 microns	6 microns	32 microns
3/12, 19:40	72 microns	6 microns	33 microns

The mean apparent thermal conductivity versus vacuum level for a 60 layer blanket between 300 K and 90 K is given in "Cryogenic Systems" by Barron. At 6 microns k_t is 0.2 mW/m-K. At 32 microns k_t is 0.7 mW/m-K. At 68 microns k_t is 1.2 mW/m-K. Using this information, the steady state information, and the CC as a baseline for the signal cable heat load when empty, we would expect:

Table 4: Illustration of the effect of poor vacuum on EC's

	ECS	CC	ECN
Cables	297 watts	297 watts	297 watts
Radiation/vacuum	$177(1+1.2/.2)/2=1239$ watts	177 watts	$177(1+.7/.2)/2=398$ watts
Other	177 watts	177 watts	177 watts
Total	1713 watts	651 watts	872 watts

Which is the general trend seen. One can see that it is very important that we pump on the EC vacuum jackets for longer duration moves.

With good vacuum levels in the EC's and the CC the expected heat load would be $3 \times 650 \text{ watts} = 1950 \text{ watts}$. This number is consistent with current data based on our liquid nitrogen consumption. After the move the vacuum jackets were pumped down, the modules cooled back down and a steady state was reached. From historical trending, the total liquid nitrogen consumption is 25 gal/hr. 12 gal/hr is estimated to be used for the liquid argon storage dewar. That leaves 13 gal/hr for the three calorimeters. If the heat is assumed to be taken out through heat of vaporization, this equates to a heat load of 2160 watts.

Pressure Maintenance

The three GAR valves tag number PV*14A were blocked open and the gas line was connected to the liquid argon storage dewar. The early CC pressure trend indicated that it was not communicating to the dewar and so an additional pathway to the storage dewar via the top CC sample port was added. Later investigation showed that the mechanical block failed and the valve was indeed closed. During u-tube installation (3/12 14:00 to 20:00) the umbilical was isolated and no cooling was yet in place. I assume that the EC's were in communication with each other and the CC was isolated by itself. From the pressure rise seen I can predict the amount of gas flow required to maintain pressure of the calorimeters.

Actual combined EC pressure rise = $21.9 - 20.2 = 1.7 \text{ psi}$ in 6 hours

Actual CC pressure rise = $22.05 - 21.68 = 0.37 \text{ psi}$ in 6 hours

Knowing the dT/dt , module temperature rise of the calorimeters, if the gas warmed by that amount one would have expected a smaller pressure rise;

$$\Delta P \text{ expected} = P_{\text{final}} - P_{\text{initial}} = P_{\text{initial}} * \{(T_{\text{final}}/T_{\text{initial}}) - 1\}$$

$$\text{where: } T_{\text{final}} = T_{\text{initial}} + DT/dt * 6 \text{ hours}$$

$$\text{For the CC; } \Delta P \text{ expected} = 21.68 \{(97.94 \text{ K})/ 97.65 \text{ K})-1\}= 0.06 \text{ psi}$$

In estimating the EC pressure rise I took into account the higher than averaged heat load and adjusted the DT/dt accordingly. The expected pressure rise for the two connected EC's was 0.225 psi. The delta P observed divided by the delta P expected was 6.2 for the CC and 7.6 for the EC. The observed larger pressure rise must be due to some residual liquid argon changing to the gas phase.

Using the actual pressure rise number, I calculated that to maintain a steady pressure during an uncooled warm up we need to siphon off argon at a rate of approximately 8.2 scfh from the CC. No numbers were generated for the EC's because in the future we will maintain their vacuum. If the vacuums are maintained they should behave exactly like the CC.

APPENDIX

The pages that follow comprise the appendix of this engineering note. It needs to be noted that the calculations were not altered to make them look pretty, this engineering note was for that purpose. The reason they are included is to show the reader more detail in the way things were calculated. Also the applicable temperature data and groups of sensors is included so that future data can be compared effectively.

REFERENCES

G.T. Mulholland, K. J. Krempetz et. al, "Cryogenic Design of the D-Zero Liquid Argon Collider Calorimeter" D-Zero Note #583, July 10, 1987.

R. A. Rucinski et. al, "Thermal Information Regarding the Cooldown and operation of the D-Zero Liquid Argon Calorimeters", D-Zero Engineering note 3740.512-EN-377, July 14, 1993.

R. F. Barron, "Cryogenic Systems", 2nd ed., Oxford University Press, 1985.

2.) DETECTOR WARM-UPS:

3-11-96 @ 9:42 COOLANT STOPPED.

A) ECS 3-12 34ms

OH = 93.16	MH = 91.29	IH = 123.31
OH = 97.54	MH = 96.28	IH = 120.54
$\Delta T_{OH} = 4.38$	$\Delta T_{MH} = 4.99$	$\Delta T_{IH} = 16.84$

NEED TO AVERAGE SO I CAN USE GENERALITIES.
IE THERMAL MASS & S.

EC MODULES

1 ~ IH @ $\approx 60,600$ ea. FROM
16 ~ MH @ $\approx 9,270$ ea. DO NOT
16 ~ OH @ $\approx 12,200$ ea. 794

$$\Delta T_{\text{WEIGHT AVG.}} = \frac{\Delta T_{OH} \cdot M_{OH} + \Delta T_{MH} \cdot M_{MH} + \Delta T_{IH} \cdot M_{IH}}{M_{OH} + M_{MH} + M_{IH}}$$

$$\Delta T_{\text{WT. AVG.}} = \frac{(4.38)(16)(12.2) + (4.99)(16)(9.27) + (16.84)(60.6)}{16(12.2 + 9.27) + 60.6}$$

$$\Delta T_{\text{WT. AVG.}} = 8.77725 \text{ KELVIN.}$$

UPON FURTHER REVIEW
IH DATA IS SUSPECT.
9 OF THE 16 DATA PTS.
WERE 10 TO 40 WARMER
THAN LAT TEMP.THERMAL MASS 293 TO 90 K = 12.88×10^9 JOULES

$$C_{P, \text{AVG}} = \frac{C_{\text{LOW}} + C_{\text{HIGH}}}{2} \quad \# \quad 2C_{\text{LOW}} = C_{\text{HIGH}}$$

$$C_{P, \text{AVG}} = \frac{3}{2} C_{P, \text{LOW}}$$

$$\Delta E_{\text{TH}} = m C_{P, \text{AVG}} \Delta T_{\text{TH}}$$

$$\Delta E_{34 \text{ ms}} = m C_{P, \text{LOW}} \Delta T_{\text{WT. AVG.}}$$

$$C_{P, \text{LOW}} = \frac{2}{3} C_{P, \text{AVG}} = \frac{2}{3} \frac{\Delta E_{\text{TOTAL}}}{m \Delta T_{\text{TOTAL}}}$$

$$\Delta E_{34 \text{ ms}} = \frac{2}{3} \cdot \frac{12.88 \times 10^9 \text{ J}}{(203 \text{ K})} \times (8.7772 \text{ K}) = 2.79 \times 10^8 \text{ J}$$

FROM
DO E
377

$$Q_{\text{AVG TO EC MODULES}} = \frac{2.335 \times 10^8 \text{ J}}{32 \text{ HRS}} \times \frac{1 \text{ HR}}{3600 \text{ s}} = \underline{2335 \text{ WATTS}}$$

CONCLUSION: WARMUP OF EC WAS AT LEAST AS MUCH IF NOT A LITTLE MORE THAN EXPECTED. IF IT WAS A DRY DETECTOR,

IF SOGGY DETECTOR THEORY WAS RIGHT, WOULD HAVE EXPECTED SMALLER AMOUNT OF TEMP. RISE IN MODULES BECAUSE SOME OF THE HEAT LEAK WOULD GO TO VAPORIZE LAT. EC IS NOT A SOGGY DETECTOR.

B.) ACC?

DON'T HAVE CLEAR UNDERSTANDING OF WHAT TEMP. SENSORS ARE WHERE.

USE CARD 1 FIRST 10 VALUES

$$T_{\text{AVG}} = 96.13 \quad \text{EMPTY JUST BEFORE COOLING WAS STOPPED.}$$

$$T_{\text{AVG}} = 97.59 \quad \text{AFTER 34 HRS OF NO COOLING.}$$

$$\Delta T = 1.46 \text{ K} \quad \text{— NOT AS LARGE AS I WOULD HAVE EXPECTED.}$$

AVERAGE MORE VALUES, PICK TEMPS ≈ 90.5 WHEN FULL
NEGLECT SHELL TEMPS.

$$\Delta T\text{'S} \quad 1.46, 1.70, 1.83, 1.75, 1.32, 1.36$$

$$\Delta T_{\text{AVG}} = 1.57 \text{ K}$$

CC:

$$\Delta E_{34 \text{ HRS}} = \frac{2}{3} \cdot \frac{13.068 \times 10^9 \text{ J}}{203 \text{ K}} (1.57 \text{ K}) = 6.738 \times 10^7 \text{ J} \quad \text{TO MODULES}$$

$$Q_{\text{AVG TO CC MODULES}} = \frac{6.738 \times 10^7 \text{ J}}{32 \text{ HRS}} \times \frac{1 \text{ HR}}{3600 \text{ s}} = \underline{585 \text{ WATTS}}$$

DOESN'T APPEAR WARM UP OF CC IS AS MUCH AS IT SHOULD BE IF IT WAS A "DRY" DETECTOR.

PART 3) CONSOLIDATION.

USING DATA OF PRESSURE RISE OF VESSELS WHEN GAS VENTING WAS BLOCKED.

FROM 3/12/96

14:00 UNTIL 20:00; 6 HRS VESSELS WERE ISOLATED DURING JUMPER INSTALLATION

$$\Delta P_{CC} = 22.05 - 21.68 = 0.37 \text{ psi}$$

$$\Delta P_{EC} = 21.9 - 20.2 = 1.7 \text{ psi}$$

$$\Delta T_{\text{EXPECTED CC}} = 1.57 \times \frac{6}{32} = 0.294 \text{ K} \quad \left\{ \begin{array}{l} \text{GAS SHOULD FOLLOW} \\ \text{MODULE } \frac{dT}{dt} \end{array} \right.$$

$$\Delta T_{\text{EXPECTED EC}} = 6.472 \times \frac{6}{32} = 1.2135 \text{ K}$$

IF CALORIMETERS WERE DRY; FINAL PRESSURE RISE WOULD BE

$$\Delta P_{\text{DRY CC}} = 21.68 \times \frac{98.2 + 98.277}{98} = 21.74 \text{ psia}$$

$$\text{ACTUAL } P_F = 22.05 \text{ psia}$$

$$P_{\text{F DRY EC}} = 20.2 \times \frac{96.91 + 1.142}{96.91} = 20.44 \text{ psia}$$

$$\text{ACTUAL WAS } 21.9 \text{ psia}$$

CONCLUSION IS THAT PRESSURE RISE ACTUALLY SEEN IS HIGHER THAN THAT EXPECTED BASED ON $\frac{dT}{dt}$ MODULES & PURE GAS

∴ OUTGASSING/ EVAPORATION OF LAR FROM G-10 OR MODULES IS A FACTOR.

SOME COMPLICATION IS ADDED BY THE UNCERTAINTY OF THE GAS CONNECTION BETWEEN EC'S & CC.

HOW MUCH EXTRA GAS WAS EVOLVED?

CC: * FINAL 22.05% $\Rightarrow Q_F = \frac{22.05}{14.7}$

$$Q_F = \frac{22.05}{14.7} \times 5000 \text{ gal} \times \frac{288.7 \text{ K}}{98.277} \times \frac{21.74 \text{ ft}^3}{17.48 \text{ ft}^3} = 2945 \text{ SCF ARGON}$$

$$Q_F = 2945 \text{ SCF ARGON}$$

$$Q_i = \frac{21.68}{22.05} \times \frac{98.277}{98.277} (2945) = 2904.5 \text{ SCF ARGON}$$

$$\frac{dQ}{dt} = \frac{2945 - 2904}{6 \text{ HRS}} = 6.83 \text{ scfh ARGON}$$

$$Q_{\text{expected}} = \frac{21.74}{22.05} \times 2945 = 2904 \checkmark \text{ same as } Q_i$$

6.83 scf WAS EVOLVED FROM VAPORIZED LAT.
IN 6 HRS.

$$Q_{\text{VAPORIZATION (HEAT)}} = \frac{6.83 \text{ scf}}{6 \text{ HRS}} \times \frac{.1034 \text{ * Ar}}{1 \text{ scf gas}} \times \frac{70.2 \text{ BTU}}{\text{scf}} \times \frac{1 \text{ WATT}}{3.413 \text{ BTU/hr}} = 2.4 \text{ WATTS}$$

$$Q = 2.4 \text{ WATTS} \quad \text{— INSIGNIFICANT AMOUNT.}$$

HOW MUCH GM NEEDS TO BE SIPHONED OFF TO MAINTAIN PRESSURE?

← SAME PRESSURE

$$Q_F' = \frac{21.68}{14.7} \times 5000 \text{ gal.} \times \frac{288.7 \text{ K}}{98.277} \times \frac{1}{7.48} = 2896 \text{ SCF.}$$

TEMP. RISE INCLUDED

SIPHON
FLOW RATE

$$q = \frac{2945 - 2896}{6 \text{ HRS}} = 8.17 \text{ scfh Argon.}$$

PRESSURE RISE OF CC, ECS, ECN WHEN JAWED OFF

3/12/96 14:00

REFINEMENT OF HEAT LOAD'S
BY LOOKING CLOSER @ C_p .

	100 K	200 K	300 K
URANIUM, C_p	$94 \frac{J}{kg \cdot K}$	$108 \frac{J}{kg \cdot K}$	$116 \frac{J}{kg \cdot K}$
STAINLESS STEEL	272	$402 \frac{J}{kg \cdot K}$	$477 \frac{J}{kg \cdot K}$
COPPER	252	356	$385 \frac{J}{kg \cdot K}$

ABOVE FROM "FUNDAMENTALS OF HEAT & MASS TRANSFER"
2nd EDITION INCROPERA & DEWITT

FIRST CALCS. ESTIMATED THAT; $\frac{C_{p,low}}{C_{p,avg}} = \frac{2}{3}$

THIS NEEDS TO BE REFINED:

$$CC: \frac{M_{Cu}}{M_{TOTAL}} = \frac{7292 \text{ MJ}}{13,068 \text{ MJ}} = .558$$

$$\frac{M_{SS}}{M_{TOTAL}} = \frac{1453 + 799}{13,068} = .172 \quad .964$$

$$\frac{M_{ur}}{M_{TOTAL}} = \frac{3056}{13,068} = .234$$

$$\frac{C_{p,low}}{C_{p,avg}} \Big|_{Cu} = \frac{.558 \left(\frac{252}{356} \right) + .172 \left(\frac{272}{402} \right) + .234 \left(\frac{94}{108} \right)}{.558 + .172 + .234}$$

$$= .7417 \quad \leftarrow \text{NOT TOO BAD COMPARED TO } \frac{2}{3}.$$

$$EC \quad \frac{M_{SS}}{M_{TOTAL}} = \frac{10436 + 997}{12880 \text{ MJ}} = .8877$$

$$\frac{M_{ur}}{M_{TOTAL}} = \frac{1089}{12880} = .08455$$

$$\frac{C_{p,low}}{C_{p,avg}} = \frac{.887 \left(\frac{272}{402} \right) + .08455 \left(\frac{94}{108} \right)}{.8877 + .08455} = 0.693$$

↑
NOT
BAD.
EITHER.

$$Q_{ECS \text{ REFINED}} = 2375 \text{ W} \times \frac{.693}{.667} = 2468 \text{ W}$$

$$Q_{CC \text{ REFINED}} = 585 \times \frac{.7417}{.667} = 651 \text{ W}$$

DELTA P EXPECTED FOR THE EC'S ;

ECS; $P_{INITIAL} = 20.2 \text{ psia.}$

$$\Delta T \propto Q$$

$$\Delta T_{3/12} = \Delta T_{AVG} \times \frac{Q_{FINAL}}{Q_{AVG}}$$

$$Q_{AVG} = \frac{Q_i + Q_f}{2} \quad \text{ESSENTIALLY LINEAR}$$

$$Q_f = 2Q_{AVG} - Q_i$$

$$Q_{AVG \text{ ECS}} = 2468 \text{ WATTS.}$$

$$\Delta T_{ECS \text{ FOR } \Delta P} = \left(.2025 \frac{K}{hr} \right) (6 \text{ HRS}) \frac{(2(1713) - 651)}{1713}$$

$$\Delta T_{ECS \text{ FOR } \Delta P} = 1.62 \text{ K}$$

$$\Delta P_{EXP. \text{ ECS}} = \frac{100.53 + 1.62}{100.53} (20.2) - (20.2) = 0.3255 \text{ psi}$$

$$ECN; \Delta T_{ECN \text{ FOR } \Delta P} = \left(.0768 \frac{K}{hr} \right) (6) \frac{(2(995) - 691)}{995} = 0.62 \text{ K}$$

$$\Delta P_{EXP. \text{ ECN}} = \frac{100.87 + .62}{100.87} (20.2) - 20.2 = 0.124 \text{ psi}$$

$$\Delta P_{BOTH \text{ CONNECTED}} = \frac{.3255 + .124}{2} = 0.225 \text{ psi}$$

$$\frac{\Delta P_{OBSERVED}}{\Delta P_{EXT}} = \frac{.37}{.06} = 6.17 \text{ FOR CC}$$

$$\frac{1.7}{.225} = 7.56 \text{ FOR EC}$$

SUBJECT

MEASURE LN_2 consumption for Dφ

NAME

K. KREMPETZ

DATE

3/28/96

REVISION DATE

Number pulled by D. Markley from Historical trending Database.

Around Feb. 1, 1996 → STEADY STATE OPERATION - ECS, CC, ECN
full of LN₂, LN₂ storage dewar 2000 gallons
consumption ≈ 971 gals/day → 40.46 gal/hr → this checks with
old #'s which were
44 gal/hr

Around March 5, 1996 → Calorimeters are empty, but kept cold
LN₂ storage dewar → 15000 gallons
consumption = 600 gals/day → 25 gal/hr

Old data indicated that LN₂ storage dewar consumption = 12 gal/hr

∴ Calorimeter consumption when cold, but emptied = 25 - 12 = 13 gal/hr

Check Table 4 shows calculated heat leak from Calorimeters
with a good vacuum ≈ 651 watts

∴ 650 × 3 = 1950 watts total calc. heat leak

$Q = \dot{m} \Delta h_{fg}$ $\Delta h_{fg} = 85.3 \text{ BTU/lbm}$ assume heat taken out only
through heat of vaporization

$1950 \text{ W} = \dot{m} \cdot 85.3 \frac{\text{BTU}}{\text{lbm}} \cdot \frac{1054 \text{ W}}{1326} \quad \dot{m} = .022 \text{ lbm/s}$

In gals/hr $\dot{m} = .022 \text{ lbm/s} \cdot \frac{173}{50.6 \text{ lbm}} \cdot \frac{7.48 \text{ gals}}{\text{ft}^3} \cdot \frac{3600 \text{ s}}{\text{hr}} = 11.71 \text{ gals/hr}$
Roughly checks
with measured
value.

or

$\frac{13 \frac{\text{gal}}{\text{hr}}}{11.71 \frac{\text{gal}}{\text{hr}}} \times 1950 \text{ WATTS} = 2164 \text{ WATTS}$

MARCH 12, 1996

ECS EMPTY,
NO COOLING FOR
34 HOURS

DUMP OF TV2P

CRYOSTAT, YEAR, MONTH: ES 1996. 3.
DAY, HOUR, MINUTE : 12. 17. 12.
CARD: 0

CAL RESISTOR ONE:	228.8				
104.4	103.9	103.6	109.8	108.9	OH
108.9	110.7	109.2	109.1	106.2	
105.5	-999.0	100.5	99.9	99.8	
CAL RESISTOR TWO:	112.3				
101.7	109.6	101.1	100.9	100.5	MH
100.3	99.7	98.8	98.7	118.6	
-999.0	-999.0	-999.0	-999.0	-999.0	

CARD: 1

CAL RESISTOR ONE:	221.9				
100.3	100.4	100.4	99.2	98.4	OH * 97.54 (+4.38)
98.5	96.9	96.0	97.4	94.6	
93.9	94.5	99.6	99.0	99.5	
CAL RESISTOR TWO:	108.5				
98.6	97.4	98.3	97.1	95.6	MH
96.6	95.3	94.0	94.3	-999.0	
-999.0	-999.0	-999.0	-999.0	-999.0	

CARD: 2

CAL RESISTOR ONE:	228.9				
93.6	91.8	92.3	90.2	90.0	OH
90.1	97.5	90.0	90.0	92.1	
91.4	91.6	94.9	94.3	94.7	
CAL RESISTOR TWO:	112.0				
93.9	93.6	93.5	94.5	94.0	MH
94.1	95.6	94.6	95.0	-999.0	
-999.0	-999.0	-999.0	-999.0	-999.0	

CARD: 3

CAL RESISTOR ONE:	227.2				
95.5	93.5	94.7	96.7	96.0	OH
96.8	98.2	98.0	97.7	98.9	
98.8	98.8	96.8	95.9	96.0	
CAL RESISTOR TWO:	110.3				
98.1	97.3	-999.0	98.5	98.2	MH
98.5	98.9	98.8	98.7	-999.0	
-999.0	-999.0	-999.0	-999.0	-999.0	

CARD: 4

CAL RESISTOR ONE:	224.3				
97.5	98.5	97.3	97.3	97.1	OH
97.9	96.6	98.7	-999.0	98.5	
98.9	98.6	97.6	98.1	96.2	
CAL RESISTOR TWO:	109.7				
96.5	96.2	95.9	95.7	95.7	MH * 96.28 (+4.99)
94.0	95.7	96.1	97.6	96.4	
97.6	97.4	96.8	95.6	96.7	

CARD: 5

CAL RESISTOR ONE:	223.5				
122.6	128.7	126.6	106.4	118.4	* 120.54 (+16.84)
-999.0	139.6	167.3	140.2	165.1	
139.8	187.8	166.8	139.1	128.4	
CAL RESISTOR TWO:	109.6				
162.5	140.1	163.8	137.3	178.0	IH +
-999.0	-999.0	-999.0	-999.0	-999.0	
-999.0	-999.0	-999.0	-999.0	-999.0	

CARD: 6

CAL RESISTOR ONE:	229.8				
97.6	98.3	91.6	91.5	95.7	VESSEL
96.9	97.3	100.4	99.4	97.7	
90.3	90.3	90.5	90.5	-999.0	
CAL RESISTOR TWO:	111.8				
90.1	93.3	91.3	95.7	97.4	VESSEL
97.4	100.3	100.7	-999.0	92.5	
93.7	91.6	97.6	91.6	97.7	

CARD: 7

CAL RESISTOR ONE: 227.6

14

CC EMPTY

NO COOLING FOR
34 HRS.

DUMP OF TV2P

CRYO, YR, MO, DY, HR, MN: 2.0 1996.0 3.0 12.0 17.0 11.0

CARD: 0

CAL RESISTOR ONE:	224.9				
114.5	103.3	98.0	96.3	95.3	
94.5	94.4	94.5	94.6	96.4	
96.6	98.4	104.6	115.5	120.4	

CAL RESISTOR TWO:	112.3				
115.4	96.7	95.1	94.6	95.7	
97.7	107.2	115.3	99.0	96.3	
94.6	94.6	96.6	101.7	118.8	

CARD: 1

CAL RESISTOR ONE:	233.8				
114.2	107.8	96.3	95.4	94.1	
93.9	92.6	92.4	94.1	95.1	
96.9	97.8	102.4	103.2	102.7	

CAL RESISTOR TWO:	117.8				
106.9	99.1	95.8	94.6	95.6	
97.9	104.9	99.9	96.8	95.5	
94.8	95.5	96.2	99.1	102.9	

CARD: 2

CAL RESISTOR ONE:	237.0				
103.4	99.2	-999.0	95.1	95.0	
96.9	99.4	103.6	97.3	95.5	
-999.0	94.3	95.7	-999.0	105.6	

CAL RESISTOR TWO:	118.1				
94.8	95.5	95.8	95.8	95.5	
96.7	97.2	96.9	97.2	97.8	
97.7	98.7	103.1	99.3	100.3	

CARD: 3

CAL RESISTOR ONE:	233.0				
100.0	99.1	97.2	99.0	97.9	
97.2	-999.0	96.3	95.7	95.8	
96.0	95.7	95.6	95.7	95.6	

CAL RESISTOR TWO:	116.1				
99.8	98.4	-999.0	95.7	94.8	
95.7	96.1	98.2	94.3	101.8	
96.2	174.3	215.6	194.3	241.5	

CARD: 4

CAL RESISTOR ONE:	233.9				
119.0	114.6	103.1	97.4	95.8	
95.0	93.8	92.4	93.8	95.9	
95.9	98.2	104.1	115.3	120.4	

CAL RESISTOR TWO:	117.5				
115.2	103.2	96.2	95.0	93.6	
95.3	97.0	105.9	115.2	95.7	
93.3	93.7	95.9	100.7	117.2	

CARD: 5

CAL RESISTOR ONE:	235.0				
111.6	106.2	99.9	-999.0	95.4	
94.8	93.7	93.3	93.2	94.1	
95.6	97.9	102.2	108.2	111.1	

CAL RESISTOR TWO:	117.7				
106.8	99.2	95.8	94.9	94.4	
95.6	97.8	104.6	100.5	97.0	
95.5	95.4	96.5	98.8	102.8	

CARD: 6

CAL RESISTOR ONE:	234.2				
107.1	101.4	-999.0	95.3	95.0	
96.7	97.5	109.8	100.9	97.4	
95.7	94.5	96.6	98.9	101.2	

CAL RESISTOR TWO:	116.5				
95.7	96.1	95.7	-999.0	97.6	
98.1	96.9	97.7	97.2	97.4	
98.4	99.0	99.3	100.5	101.2	

CARD: 7

CAL RESISTOR ONE:	232.8				
100.7	100.5	99.2	-999.0	100.0	

NEGLECT
BASED ON CC FULL

- 97.59 (+1.46)

- 98.37 (+1.70)

- 98.42 (1.83)

- 97.49 (+1.75)

- 96.91 (+1.32)

- 97.01 (1.22)

SHEU

- 102.31 (2.8) - POSSIBLY
SHEU

- 98.37 (1.36)

T_{AVG}

97.65

15

ECN EMPTY

NO COOLING FOR
34 HOURS

DUMP OF TV2P

CRYOSTAT, YEAR, MONTH:	EN	1996.	3.
DAY, HOUR, MINUTE :	12.	17.	10.

CARD: 0

CAL RESISTOR ONE:	228.5			
113.6	112.4	112.7	104.5	104.4
104.5	98.7	98.4	98.5	96.2
96.2	96.1	103.1	102.6	102.7
CAL RESISTOR TWO:	112.8			
99.5	99.4	99.4	97.8	96.8
97.4	96.2	96.0	96.1	-999.0
-999.0	-999.0	-999.0	-999.0	-999.0

CARD: 1

CAL RESISTOR ONE:	230.2			
95.7	95.4	95.6	95.1	94.9
95.3	93.9	93.9	93.8	93.6
94.0	93.2	95.6	95.4	95.6

CAL RESISTOR TWO:	113.5			
95.4	95.3	95.3	95.3	95.2
95.2	-999.0	95.1	95.3	-999.0
-999.0	-999.0	-999.0	-999.0	-999.0

CARD: 2

CAL RESISTOR ONE:	230.0			
95.2	95.3	95.2	95.9	95.8
95.7	96.5	96.0	96.0	98.6
98.3	98.3	95.7	95.7	95.9

CAL RESISTOR TWO:	114.0			
96.1	95.9	96.0	98.0	97.1
97.7	99.4	99.0	99.2	-999.0
-999.0	-999.0	-999.0	-999.0	-999.0

CARD: 3

CAL RESISTOR ONE:	231.4			
103.6	103.7	103.7	112.0	111.2
111.5	117.8	116.1	116.0	120.0
118.2	119.1	103.9	107.9	101.8

CAL RESISTOR TWO:	113.5			
-999.0	104.7	105.4	108.0	107.0
107.2	106.5	105.8	106.0	124.4
125.8	-999.0	-999.0	-999.0	-999.0

CARD: 4

CAL RESISTOR ONE:	231.3			
98.0	99.2	98.0	97.8	97.5
98.3	97.4	97.1	97.1	97.1
96.8	96.7	-999.0	95.9	97.6

CAL RESISTOR TWO:	113.7			
97.7	100.1	99.8	99.6	101.0
99.5	98.5	99.3	98.3	97.6
98.1	97.9	98.1	95.9	97.5

CARD: 5

CAL RESISTOR ONE:	230.3			
-999.0	134.3	131.1	116.7	123.9
128.3	148.1	174.6	148.6	174.9
143.1	188.6	147.1	173.6	164.8

CAL RESISTOR TWO:	113.7			
200.0	144.1	171.3	142.4	188.9
96.9	96.9	91.3	90.7	91.7
92.0	96.6	97.1	-999.0	-999.0

CARD: 6

CAL RESISTOR ONE:	233.0			
98.4	100.1	95.5	95.0	96.0
97.8	98.2	-999.0	100.5	98.5
91.6	91.6	92.7	91.8	94.9

CAL RESISTOR TWO:	114.5			
-999.0	95.1	95.3	95.9	97.8
98.3	102.1	102.4	98.3	95.3
95.6	95.5	98.0	97.5	95.5

CARD: 7

CAL RESISTOR ONE:	230.0
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OH 94.53 (+1.15)

MH 98.74 (2.93)

14. 126.5 (+6.53)

MARCH 11, 1996

ECS EMPTY, JUST
STOPPED COOLING

DUMP OF TV2P

CRYOSTAT, YEAR, MONTH: ES 1996. 3.
DAY, HOUR, MINUTE : 11. 9. 43.
CARD: 0

CAL RESISTOR ONE: 228.8

97.9	97.4	97.8	98.8	98.0
98.2	99.2	98.1	97.7	98.0
97.7	-999.0	96.6	96.3	94.4

CAL RESISTOR TWO: 112.3

96.8	103.4	95.7	96.9	96.0
94.7	96.2	95.9	94.4	103.2
-999.0	-999.0	-999.0	-999.0	-999.0

CARD: 1

CAL RESISTOR ONE: 221.8

95.0	94.7	94.5	93.3	93.1
93.0	92.6	92.5	92.8	92.3
92.2	91.9	93.4	93.5	92.8

CAL RESISTOR TWO: 108.5

92.8	92.7	92.5	92.6	92.2
92.0	92.1	92.0	91.7	-999.0
-999.0	-999.0	-999.0	-999.0	-999.0

CARD: 2

CAL RESISTOR ONE: 229.0

90.7	90.4	90.1	89.8	89.8
89.6	97.5	89.9	89.8	90.3
89.8	89.9	91.0	90.7	90.7

CAL RESISTOR TWO: 112.0

90.6	90.1	90.3	90.9	90.3
90.2	91.8	90.9	90.5	-999.0
-999.0	-999.0	-999.0	-999.0	-999.0

CARD: 3

CAL RESISTOR ONE: 227.1

91.9	91.5	91.1	92.4	92.5
92.3	93.3	92.9	93.1	95.6
95.4	95.2	92.3	91.7	91.2

CAL RESISTOR TWO: 110.5

93.0	92.4	-999.0	93.3	93.2
92.9	95.0	94.6	92.5	-999.0
-999.0	-999.0	-999.0	-999.0	-999.0

CARD: 4

CAL RESISTOR ONE: 224.3

92.4	92.6	92.4	92.1	91.5
91.3	91.2	92.7	-999.0	92.7
92.9	92.8	91.4	91.3	91.8

CAL RESISTOR TWO: 109.6

92.1	91.8	91.1	91.4	90.7
90.5	90.3	90.8	92.3	91.3
92.1	91.6	91.7	90.7	90.7

CARD: 5

CAL RESISTOR ONE: 223.4

103.0	103.8	104.3	99.4	108.0
-999.0	130.8	159.4	130.5	156.2
127.5	176.9	158.0	129.2	117.0

CAL RESISTOR TWO: 109.7

152.6	130.8	154.5	124.7	166.7
-999.0	-999.0	-999.0	-999.0	-999.0
-999.0	-999.0	-999.0	-999.0	-999.0

CARD: 6

CAL RESISTOR ONE: 229.8

93.7	94.6	89.9	90.0	92.0
94.5	95.4	97.6	97.0	96.5
89.7	89.9	90.2	89.9	-999.0

CAL RESISTOR TWO: 111.9

89.7	91.0	89.9	92.5	96.1
96.2	97.4	97.5	-999.0	89.6
90.0	89.6	94.7	89.7	94.9

CARD: 7

CAL RESISTOR ONE: 227.6

* ALL 12 PTS, 93.16

* 13 DATA PTS, 91.

* TOP 5, 103.7

IH

VESSEL

17

CC EMPTY, JUST
STOPPED COOLING

DUMP OF TV2P

CRYO, YR, MO, DY, HR, MN: 2.0 1996.0 3.0 11.0 9.0 43.0

CARD: 0

CAL RESISTOR ONE: 224.7

108.8	100.8	96.4	95.1	94.6
94.4	93.6	93.9	94.4	95.0
95.5	96.9	102.4	108.9	111.1

CAL RESISTOR TWO: 112.3

108.7	95.6	94.5	94.3	94.8
96.4	103.1	108.9	97.5	94.8
94.1	94.4	95.5	98.9	110.5

NEGLECT
BASED ON CC FULL

CARD: 1

CAL RESISTOR ONE: 233.9

109.9	104.2	95.3	94.3	93.0
92.9	92.3	92.0	93.0	94.4
96.1	96.3	100.2	99.7	100.2

96.13

use as
Avg.

CAL RESISTOR TWO: 117.8

102.8	97.2	94.9	93.2	94.8
96.4	101.5	98.8	95.4	94.6
93.1	94.7	95.2	97.2	100.2

96.67

CARD: 2

CAL RESISTOR ONE: 236.9

100.9	97.2	-999.0	94.1	93.8
95.7	96.1	100.9	95.5	94.5
-999.0	93.3	94.9	-999.0	102.2

96.59

CAL RESISTOR TWO: 118.0

92.4	94.1	94.7	94.9	94.2
95.1	95.7	95.1	95.3	95.8
95.2	95.6	100.8	98.3	98.9

- 95.74

CARD: 3

CAL RESISTOR ONE: 233.1

98.1	97.7	96.6	97.5	96.8
96.5	-999.0	95.2	95.0	94.6
94.5	94.9	93.5	94.2	93.1

- 95.59

CAL RESISTOR TWO: 116.0

98.1	96.9	-999.0	94.9	93.0
94.9	95.5	96.4	93.7	99.9
95.5	171.3	213.7	191.3	239.6

- 95.93

CARD: 4

CAL RESISTOR ONE: 234.0

111.3	108.5	100.6	96.1	95.2
94.1	93.1	91.7	93.2	95.3
95.3	96.6	101.7	108.6	111.4

- 99.51

CAL RESISTOR TWO: 117.5

108.0	100.5	95.5	93.9	92.5
94.4	95.7	102.6	108.1	95.0
92.3	93.1	95.3	99.3	109.3

CARD: 5

CAL RESISTOR ONE: 235.3

107.9	103.3	98.5	-999.0	94.7
94.1	93.2	92.3	92.5	93.5
94.7	96.7	100.4	104.0	103.7

CAL RESISTOR TWO: 117.6

103.1	98.1	95.2	93.9	93.5
95.1	96.5	101.7	99.0	95.8
94.9	94.9	95.4	97.4	100.7

- 97.01

CARD: 6

CAL RESISTOR ONE: 234.2

103.5	99.5	-999.0	94.6	92.9
96.0	96.6	107.2	99.7	96.5
94.6	93.3	95.6	96.8	98.2

CAL RESISTOR TWO: 116.5

92.9	94.9	94.6	-999.0	96.7
97.1	96.0	96.5	96.4	96.3
96.2	96.3	97.4	98.0	99.1

CARD: 7

CAL RESISTOR ONE: 232.8

98.7	98.5	97.4	-999.0	98.2
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MARCH 11, 1996

ECN EMPTY JUST 18
STOPPED COOLING

DUMP OF TV2P

CRYOSTAT, YEAR, MONTH: EN 1996. 3.
 DAY, HOUR, MINUTE : 11. 9. 42.
 CARD: 0

CAL RESISTOR ONE: 228.6
 108.4 107.3 107.8 100.2 100.0
 100.1 95.9 95.7 95.9 95.3
 95.3 95.1 98.9 98.5 98.6
 CAL RESISTOR TWO: 113.0
 95.9 96.0 96.0 95.7 95.4
 95.6 95.2 95.1 95.3 -999.0
 -999.0 -999.0 -999.0 -999.0 -999.0

CARD: 1

CAL RESISTOR ONE: 230.2
 95.3 94.9 95.2 94.1 94.0
 93.8 92.9 92.3 92.5 92.2
 91.9 91.5 95.1 94.8 95.2

CAL RESISTOR TWO: 113.5
 94.8 94.8 94.7 94.3 94.6
 94.6 -999.0 94.5 94.5 -999.0
 -999.0 -999.0 -999.0 -999.0 -999.0

CARD: 2

CAL RESISTOR ONE: 230.1
 94.3 94.3 94.1 95.2 95.4
 95.2 95.7 95.4 95.7 96.1
 96.0 96.0 95.5 95.2 95.2

CAL RESISTOR TWO: 114.0
 95.3 95.3 95.3 95.9 95.7
 95.9 96.1 96.1 96.0 -999.0
 -999.0 -999.0 -999.0 -999.0 -999.0

CARD: 3

CAL RESISTOR ONE: 231.5
 99.5 99.8 99.9 107.7 106.6
 106.9 112.1 111.6 110.9 114.1
 112.9 113.7 100.1 104.4 98.1

CAL RESISTOR TWO: 113.5
 -999.0 100.9 101.5 104.0 103.1
 103.2 102.4 102.0 102.0 116.8
 117.9 -999.0 -999.0 -999.0 -999.0

CARD: 4

CAL RESISTOR ONE: 231.2
 95.6 95.7 95.5 95.4 95.3
 95.5 95.4 95.2 95.2 95.2
 95.3 95.1 -999.0 95.1 95.3

CAL RESISTOR TWO: 113.8
 95.2 96.4 96.3 95.9 97.4
 95.9 95.6 95.7 95.5 95.4
 95.4 95.4 95.4 95.0 95.3

CARD: 5

CAL RESISTOR ONE: 230.4
 -999.0 127.8 122.4 111.7 118.0
 120.2 144.0 171.6 144.2 170.9
 137.3 183.9 143.2 171.3 161.1

CAL RESISTOR TWO: 113.8
 197.0 139.1 166.9 136.4 184.3
 95.3 95.3 90.4 90.0 89.8
 90.3 95.1 95.2 -999.0 -999.0

CARD: 6

CAL RESISTOR ONE: 232.9
 95.7 95.9 94.1 93.4 95.3
 95.7 96.1 -999.0 97.9 95.8
 91.1 90.8 91.7 91.2 93.4

CAL RESISTOR TWO: 114.6
 -999.0 93.8 94.1 95.2 95.7
 96.3 99.7 99.6 95.5 93.9
 93.7 94.4 95.5 95.4 93.7

CARD: 7

CAL RESISTOR ONE: 230.0

- 04 93.38

- MH 95.01

I- 119.975

MARCH 5, 1996

SEC EMPTY

19

DUMP OF TV2P

CRYOSTAT, YEAR, MONTH: ES 1996. 3.

DAY, HOUR, MINUTE : 5. 17. 4.

CARD: 0

CAL RESISTOR ONE:		229.1			
98.0	97.9		97.8	98.5	97.5
98.1	98.8		97.8	95.9	98.0
97.8	-999.0		97.0	96.5	95.4
CAL RESISTOR TWO:		112.4			
97.2	103.8		96.4	96.7	96.7
94.0	96.2		96.4	93.8	101.0
-999.0	-999.0		-999.0	-999.0	-999.0

CARD: 1

CAL RESISTOR ONE:		221.9			
95.8	95.9		94.9	93.6	93.3
93.5	92.8		92.7	93.1	92.6
92.3	92.2		93.8	93.7	93.3
CAL RESISTOR TWO:		108.5			
93.3	93.0		92.8	92.9	92.5
92.5	92.4		92.2	92.0	-999.0
-999.0	-999.0		-999.0	-999.0	-999.0

OH 93.68

CARD: 2

CAL RESISTOR ONE:		229.2			
91.2	90.7		90.4	89.8	89.8
89.7	97.6		89.7	89.8	90.6
90.0	89.8		91.4	91.2	91.0
CAL RESISTOR TWO:		112.0			
90.8	90.7		90.8	91.2	90.7
90.7	91.8		91.3	90.7	-999.0
-999.0	-999.0		-999.0	-999.0	-999.0

CARD: 3

CAL RESISTOR ONE:		227.1			
92.2	91.9		91.4	92.8	92.6
92.4	93.7		93.6	93.3	96.4
96.0	95.3		92.7	92.1	91.3
CAL RESISTOR TWO:		110.4			
93.5	92.8		-999.0	94.1	93.6
93.3	95.7		95.2	92.9	-999.0
-999.0	-999.0		-999.0	-999.0	-999.0

CARD: 4

CAL RESISTOR ONE:		224.4			
92.4	92.8		92.5	92.4	92.0
91.4	91.5		92.9	-999.0	92.7
93.0	93.0		91.6	91.5	92.1
CAL RESISTOR TWO:		109.7			
92.2	92.1		91.4	91.6	90.7
90.7	90.5		90.8	92.5	91.8
92.4	91.8		91.9	90.9	90.8

M 91.49

CARD: 5

CAL RESISTOR ONE:		223.5			
102.2	89.8		101.6	99.4	109.1
-999.0	132.2		161.9	132.1	158.5
127.5	177.6		160.7	131.3	117.9
CAL RESISTOR TWO:		109.7			
153.6	132.4		157.6	124.9	167.1
-999.0	-999.0		-999.0	-999.0	-999.0
-999.0	-999.0		-999.0	-999.0	-999.0

109.42

CARD: 6

CAL RESISTOR ONE:		229.8			
94.3	94.8		90.1	90.2	92.5
94.9	95.7		97.7	97.0	96.4
89.7	89.8		90.1	90.1	-999.0
CAL RESISTOR TWO:		111.8			
89.6	91.1		90.2	93.1	96.2
96.2	97.6		97.6	-999.0	90.1
90.4	89.9		94.8	89.9	94.8

CARD: 7

CAL RESISTOR ONE:		227.7			
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MAR 5

NORTH

EMPTY

20

DUMP OF TV2P

CRYOSTAT, YEAR, MONTH: EN 1996. 3.

DAY, HOUR, MINUTE : 5. 17. 3.

CARD: 0

CAL RESISTOR ONE:	228.5			
96.0	96.0	95.9	93.1	92.9
93.8	91.6	90.7	91.0	90.8
90.6	90.8	93.2	92.6	93.0

CAL RESISTOR TWO:	112.6			
92.1	90.9	92.6	91.5	90.7
91.4	91.1	90.3	90.8	-999.0
-999.0	-999.0	-999.0	-999.0	-999.0

CARD: 1

CAL RESISTOR ONE:	230.1			
90.8	89.9	90.5	89.7	89.6
89.8	89.6	89.6	89.8	89.8
89.7	89.5	90.3	89.8	90.1

CAL RESISTOR TWO:	113.5			
89.9	89.6	89.8	89.6	89.6
89.6	-999.0	89.5	89.8	-999.0
-999.0	-999.0	-999.0	-999.0	-999.0

CARD: 2

CAL RESISTOR ONE:	230.1			
90.1	90.1	90.1	91.6	90.1
90.8	91.9	90.6	91.1	92.8
91.4	91.6	90.7	89.9	90.3

CAL RESISTOR TWO:	114.0			
91.3	90.3	90.7	92.6	90.8
91.7	93.2	91.0	92.5	-999.0
-999.0	-999.0	-999.0	-999.0	-999.0

CARD: 3

CAL RESISTOR ONE:	231.5			
93.4	92.5	93.6	95.2	94.9
94.9	95.8	92.5	90.5	97.5
95.7	96.1	94.9	97.1	92.8

CAL RESISTOR TWO:	113.5			
-999.0	89.9	92.4	94.7	93.7
93.7	94.0	93.9	92.9	99.0
99.8	-999.0	-999.0	-999.0	-999.0

CARD: 4

CAL RESISTOR ONE:	231.3			
92.1	92.6	92.3	91.9	91.6
92.1	90.3	91.9	90.1	91.4
90.4	91.4	-999.0	90.4	91.7

CAL RESISTOR TWO:	113.7			
91.7	93.1	91.0	92.0	93.2
93.2	91.7	91.9	92.7	90.1
91.6	90.6	92.4	90.4	91.5

CARD: 5

CAL RESISTOR ONE:	230.3			
-999.0	89.8	100.2	95.8	101.9
100.1	132.5	162.0	133.6	162.8
122.3	173.6	131.7	162.2	147.5

CAL RESISTOR TWO:	113.7			
187.1	128.1	158.4	121.1	174.0
92.7	93.4	89.9	89.8	89.8
89.8	92.3	93.2	-999.0	-999.0

CARD: 6

CAL RESISTOR ONE:	232.9			
93.6	93.7	91.2	90.5	92.9
94.3	95.3	-999.0	95.5	94.6
90.4	90.4	90.6	91.2	90.6

CAL RESISTOR TWO:	114.6			
-999.0	91.5	90.9	92.6	94.7
94.9	96.9	96.4	94.6	92.0
92.7	92.9	94.1	93.5	92.9

CARD: 7

CAL RESISTOR ONE: 230.0

OH

89.89

MH

91.89

IH

96.93