CRYOGENIC AND SAFETY CONSIDERATIONS
FOR MOVING THE SOUTH END CAP
CALORIMETER TO THE SIDEWALK

D-ZERO ENGINEERING NOTE # 3823.115 EN-459

September 25, 1996

Approved: [Signature]
RD/D-Zero Mechanical Group Leader
INTRODUCTION
The southern end cap calorimeter (ECS) will need to be moved off of the detector platform to allow for the installation of new central tracking components. This engineering note documents the cryogenic and safety issues associated with the planned move. Because of the difficulty involved in building a temporary vent line out of the building, we plan to vent the ECS condenser flow, 6 scfm N2 into the assembly hall atmosphere. Information contained herein proves that this is safe even for failure/relief conditions.

CRYOGENIC ISSUES
The ECS was drained of liquid argon on 2/28/96 and is currently kept cold (95 Kelvin) and isolated on the detector platform. We plan on keeping the ECS in this condition through out the multi-year upgrade project. The planned move will involve the following:
1.) Swap out of cryogenic control cables with extension cables. (Done)
2.) Installation of a bridge between the main beam and the south sidewalk.
3.) Isolation and capping of cryogenic services to the ECS.
4.) Move of the ECS directly southward approximately 25 feet.
5.) Reconnection of some cryogenic services.

The cryogenic and associated services to the calorimeters are listed below:
1.) 1 1/2" x 3" LN2 supply
2.) 6" Insulating vacuum header
3.) 4" Utility vacuum
4.) 1 1/2" x 3" GAr line
5.) 4" x 6" Vent line
6.) 1 1/2" x 3" LAr drain line
7.) Instrument air
8.) GN2 purge line for vent
9.) GHe for Cold valve, PV319A
10.) LAr Spill trough (already disconnected-all calorimeters empty)
11.) Cooling water for diffusion pump (disconnect at any time)

Just before the move, each line will be taken out of service in an orderly manner. The tentative order will be as follows:
1.) LAr drain line: Isolated dewar. Pull ECS rotating u-tubes. Cap platform side. P&P platform side. ECS side cap has small P&P valve to clean between cap and PV318A. Remove air supply to PV318A. PV318A will be in a closed position.
2.) GHe for Cold valve, PV319A: Cap both sides. PV319A will be in a 50% open position.
3.) Utility vacuum: Remove air supply to PV315UV after verifying closed.
Pull ECS rotating u-tubes. Cap both sides.
4.) GAr line: Pull ECS rotating u-tubes. Cap platform side. P&P platform side. ECS side cap has small P&P valve to clean between cap and PV314A.
5.) LN2 supply: Several days ahead of time we will lower the ECS pressure to 18 psia. Isolate liquid nitrogen line between MV491N and PVX01N, PVX02N at the calorimeters. Warm line by doing a few P&P. Pull ECS rotating u-tubes. Cap platform side. P&P platform side but do not bring back on line. Attach VI flex hose to ECS side in anticipation of connection when moved to sidewalk.
7.) GN2 purge line for vent: Cap both sides of connection to ECS. Establish cooling and steady state operating conditions to the CC and ECN.
8.) Insulating vacuum: Pull ECS rotating u-tubes. Cap platform side. Attach additional piping to bring ECS side to sidewalk level for a ready connection of a portable vacuum pump to maintain ECS vacuum. (Note: ECS vacuum ROR=1.9 microns per hour when isolated.)
9.) Disconnect instrument air to ECS.

During the move it is anticipated that the ECS pressure will rise 0.1 to 0.3 psi per hour. The average module temperature will rise 0.1 to 0.2 Kelvin per hour. It is expected that the ECS cryogenics will be disconnected for no more than two days.

After the ECS is moved to the sidewalk:
1.) Connect instrument air.
2.) Turn on ECS vent heater.
3.) Purge out the LN2 source and connect it to the ECS supply line. Establish liquid nitrogen flow through the ECS cooling coils and steady state pressure maintenance.

SAFETY ISSUES
The main safety issue that needs to be addressed is the ODH consideration of venting the nitrogen exhaust gas into the building. ODH calculations are included as an appendix. Three cases are considered. The first case is for the normal steady state operation of the ECS. The second case is a failure case where the control valve fails open and a maximum liquid nitrogen flowrate is dumped into the building. (This second case also happens to be equivalent to the maximum flow required for a pressure vessel main relief blowing due to a condenser rupture.) The third case is a failure case where the vacuum jacketed flex hose supplying the ECS with liquid nitrogen is severed. The calculations show that the ODH classification of the building stays class 0.
Additional control features that were not taken into account make the analysis conservative. These features are:

1. A flow switch that will automatically shut off flow at the liquid nitrogen dewar in an overflow condition.
2. A liquid sensor in the ECS vent that will automatically shut off flow at the ECS condenser inlet valves if liquid is sensed.
3. ODH heads in the assembly hall remain active.
4. Building ventilation, natural and forced, was neglected. Only the cryogenic system exhaust fan which is monitored and tested daily was used.

### Table 1. Summary of ODH analysis

<table>
<thead>
<tr>
<th>CASE</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to get O₂ = 18%</td>
<td>Never</td>
<td>269 minutes</td>
<td>216 minutes</td>
</tr>
<tr>
<td>Fatality factor @ t-infinity</td>
<td>0.0</td>
<td>3.13 E-5</td>
<td>1.93 E-4</td>
</tr>
<tr>
<td>Probability factor</td>
<td>1.0</td>
<td>1.0 E-8</td>
<td>3.0 E-6</td>
</tr>
<tr>
<td>$\phi = P_1 \Phi_1$</td>
<td>0.0</td>
<td>3.1 E-13</td>
<td>5.8 E-10</td>
</tr>
</tbody>
</table>

The current assembly hall ODH analysis presented in D-Zero engineering note 3740.510-EN-258 has a summed total $\phi = 5.96 E-9$. Adding the individual $\phi$'s of the above cases does not change the conclusion that $\phi < 1.0 E-7$ which is the criteria for a class 0 ODH classification.

An additional item that needs to be addressed is the warm up heater that is going to be installed in the 4 x 6 rotating bayonet. A design sketch, pertinent calculations and circuit diagram are attached as appendix B. The 2 kW circulation heater and associated controls are existing equipment purchased for the D-Zero test beam. It was for a similar cryogenic application. The warm up heater will be set to bring the nitrogen exhaust gas up to room temperature by applying approximately 800 watts of heat. If the heater fails with no power, some frosting will occur locally without any safety risk. If the heater fails at full power, an over temperature cut-out switch will shut off it's power.

The heater can be considered to be a check valve in the vent pipe. It will rest in the female bayonet making a gas seal at the top by it's own weight (8 lbs). The normal flow path will be through the 3/4" pipe size heater and then exhausted out a standard Fermilab cryogenic check valve (Drg. 1650-MB-258040). The pressure drop at steady state flow is less than 0.01 psi. If the flow rate was increased significantly, (such as for a relieving case ) the heater/check valve assembly will lift. At 0.4 psid (> eight times the normal flow rate), the plate making the gas seal would lift. At that point an
additional flow path between the 3 1/4" dia. heater sheath and the 4 1/4" inside diameter pipe would be created. The heater may pop up and down during a relieving case. For a maximum flow relieving case, the heater/check valve assembly would either pop out of the bayonet port entirely or lift such that the pressure drop across the 3 1/4" x 4 1/4" annular path equals 1.0 psi. This pressure reacting on the 3 1/4" diameter bottom of the heater will balance the 8 lbs. weight of the heater.

In the ECS pressure vessel engineering note (D0 EN-329), it was calculated that the pressure drop through the normal vent line from the cryo corner to the vent pipe outside would be 2.13 psi at maximum flow capacity conditions. Since the maximum back pressure of 1.0 psi that the warm up heater could create is less, it does not decrease the relief valve capacity calculations in the engineering note.

**CLOSING REMARKS**

The details regarding the cryogenic and safety aspects of the ECS move have been thought out and planned. The cryogenic operation of the ECS calorimeter will be limited to maintaining it's pressure by keeping it cold and isolated while it is in it's temporary position off the platform. The 4 gph liquid nitrogen flow required for this operation is easily absorbed into the D-Zero assembly building atmosphere without any safety concerns. Emergency or failure scenarios have been addressed on a conservative basis and also pose little threat. Other safety features built into the system such as the liquid nitrogen excess flow switch, vent line liquid sensor, and monitored ODH heads provide additional assurance that an unexpected hazard would be identified and contained.
VENTING N₂ EXHAUST INSIDE DAB ODH CONSIDERATIONS

- MAXIMUM POSSIBLE FLOW RATE:
  I WILL CALCULATE THE MAXIMUM POSSIBLE FLOW RATE BASED ON PHYSICAL PIPING AND 100% OPEN VALVES.

MASS FLOW RATE IS GIVEN BY:

\[ W = \sqrt{\frac{\Delta P \cdot \phi \cdot d^4}{2.8 \times 10^{-7} \cdot (\Sigma K)}} \]

FOR VALUES, (Eq 3-16) \( K = \frac{891 \cdot d^4}{(C_v)^2} \)
FOR PIPING, (Eq 3-15) \( K = \frac{f \cdot L}{D} \)

TO CONVERTING K'S OF DIFFERENT PIPE SIZES, \( K_1 = K_2 \left( \frac{d_1}{d_2} \right)^4 \) [Eqn. 2.5]
K'S WILL BE FIGURED ON THE BASIS OF 1½" SCH.10 PIPE, \( d = 1.682 \text{ in.} \)

\[ \Sigma K = \left( K_{CV} \right)_{24} + K_{PIPE} + K_{PIPE}^1 + K_{6,3} + \left[ \frac{K_{9} \cdot K_{1,25}}{K_{9} + K_{1,25}} \right] + K_{CV} \]

\[ K_{CV} = \frac{891 \cdot (1.682)^4}{34^2} = 6.17 \]
\[ K_{PIPE} = \frac{(0.023 \cdot 100 \text{ ft})}{1.682 \text{ ft}} = 16.4 \]
\[ K_{PIPE}^1 = \frac{(0.0275 \times 300)}{622} = 159.2 \text{ BASED ON } \frac{1}{2} \text{" PIPE} \]
\[ K_{PIPE} = 159.2 \left( \frac{1.682^4}{0.622^4} \right) = 8513 \]

NOTE: \( f = 0.023 \# 0.0275 \)
FOR 1½" & ½" PIPE ECSP.
FROM CALLS IN EN 435 APPENDIX D, PG. 1 & 2
K_{cv} = 204.9 \quad K_{cv} = 11,143 \quad K_{cv} = 4564 \quad K_{cv} = 36.4

S + K = (6.17)2 + 16.4 + 8513 + 204.9 + \frac{((11,143)(4564))}{15,707} = 36.4

S = 0.8066 S_{cc} (62.427869 \text{ lbm/ft}^3) = 50.353 \text{ lbm/ft}^3 \quad (\text{sat. liquid})

\text{SUBSTITUTING INTO EQN. 3-16;}

W = \sqrt{\frac{(35 \text{ psi})(50.353 \text{ lbm/ft}^3)(1.6824 \text{ ft})}{(2.8 \times 10^{-7})(12,021)}} = 2047 \text{ lbm/hr}

= 2047 \frac{\text{ lbm}}{\text{ hr}} \times \frac{1 \text{ ft}^3}{50.353 \text{ lbm}} \times \frac{7.48052 \text{ gal}}{\text{ ft}^3} = 304 \text{ gal/hr}

- \text{NORMAL ECS FLOW RATE: WITH THE CALORIMETERS}

\text{COLD AND EMPTY, IT HAS BEEN MEASURED THAT}

\text{TOTAL LN}_2 \text{ CONSUMPTION IS 25 gal/hr.}

12 \text{ gal/hr is estimated to be used for the}

\text{LAr STORAGE Dewar.}

\therefore \text{ ECS FLOW RATE} \times \frac{13 \text{ gal/hr}}{3} = 4.33 \text{ gal/hr}

- \text{MAX. FLOW IF FLEX HOSE IS BROKEN}

S + K = (6.17)2 + 16.4 + 8513 + 204.9 = 8747

W = 2047 \frac{\text{ lbm}}{\text{ hr}} \times \sqrt{\frac{12,021}{8747}} = 2400 \frac{\text{ lbm}}{\text{ hr}} = 357 \text{ gal/hr}
I will calculate the assembly hall volume.

\[ V = (225)(24)(75) + (70)(75)(37) = 599,250 \text{ ft}^3 \]

**ODH Calculation**

Ref. ES#H Chapter 5064TA

\[ \phi = \sum P_i F_i \]

3 cases need to be addressed:

- Case I: Normal Operation
- Case II: Max. \( N_2 \) flow into DAB thru piping system
- Case III: Flex hose broken

**Common information:**

\[ V = 599,250 \text{ ft}^3 \]

\[ Q = 1500 \text{ scfm} \] minimum exhaust ventilation rate assured by cryo exhaust fans

\[ R = \text{spill rate in scfm} \]

Note: Building air handling system nominally provides 4440 scfm fresh air make-up. Ref. DJ: EN-25B Ass'y hall platform ODH analysis.

\[ C_r = \text{oxygen concentration during release} \]
VENTING N₂ EXHAUST INSIDE DAB
ODH CONSIDERATIONS

CASE I

$$R = 4.33 \text{ gal/hr} \times \frac{1 \text{ hr}}{60 \text{ min}} \times 86.4 \text{ ft}^3/\text{gal} \times \frac{1 \text{ gal LN₂}}{16 \text{ ft}^3} = 6.2 \text{ scfm N₂}$$

From 5064A, the appropriate equation is CASE B, Eq'n 1

$$C_r(t) = 0.21 \left\{ 1 - \frac{R}{Q} \left[ 1 - e^{-\frac{Qt}{V}} \right] \right\}$$

During release, vent fans exhausting out Q > R

I will calculate what the concentration will be during this release after 2 years.

$$t = 2 \text{ yrs} \times \frac{365 \text{ days}}{\text{yr}} \times \frac{24 \text{ hrs}}{\text{day}} \times \frac{60 \text{ min}}{1 \text{ hr}} = 1,051,200 \text{ minutes}$$

$$C_r(t) = 0.21 \left\{ 1 - \frac{6.2}{1500} \left[ 1 - e^{-\frac{1500}{200,000}} \right] \right\}$$

$$= 0.21 \left\{ 1 - 0.004133 \right\} = 0.209 > 18\% \{ F_i = 0 \}$$

Since the oxygen concentration barely changes and is greater than 18%, there is no concern.

CASE II

$$R = 304 \text{ gal/hr} \times \frac{1 \text{ hr}}{60 \text{ min}} \times 86.4 \text{ ft}^3/\text{gal} \times \frac{1 \text{ gal LN₂}}{16 \text{ ft}^3} = 437.8 \text{ scfm N₂}$$

If this happened and went unnoticed, then at $$t = \infty$$

$$C_r(\infty) = 0.21 \left\{ 1 - \frac{R}{Q} \right\} = 0.21 \left\{ 1 - \frac{437.8}{1500} \right\} = 0.1487$$

Partial pressure of oxygen:

$$P_o = 0.1487 \times 740 \text{ mm Hg} = 110 \text{ mm Hg}$$

Fatality factor:

$$F = 10 \left( 0.5 - \frac{P_o}{100} \right) = 3.13 \times 10^{-5}$$
VENTING N₂ EXHAUST INSIDE DAB ODH CONSIDERATIONS

$P_i$ expected rate of failure (HR⁻¹)

From Table 2 in FESHM, failure of an automatically
operated valve to remain open is

$P_i = 1 \times 10^{-8}\text{ HR}^{-1}$  \Rightarrow \text{PV 302N or PV 301N remain open.}$

Assume PV 302N will stay open
to maintain condenser pressure

$\phi_{\text{this case}} = P_iF_i = (1 \times 10^{-8}\text{ HR}^{-1})(3.13 \times 10^{-5}) = 3 \times 10^{-13}$

Folding this into the existing overall ODH analysis
for the assembly hall in DØ EN-258

$\sum \phi_{\text{total}} = \sum \phi_{\text{EN-258}} + \phi_{\text{this case}}$

$= 5.96 \times 10^{-9} + 3 \times 10^{-13} = 5.96 \times 10^{-9}$

ODH classification does not change

$\phi < 10^{-7}$ ODH class 0.

For this case, how long before $C_r(t) = .18$?

$C_r(t) = .18 = .21 \left(1 - \frac{4.37.8}{500} \left[1 - e^{-\frac{1500}{60000}t}\right]\right)$

$t = 269 \text{ minutes} = 4.5 \text{ hours.}$


**CASE III**  
**FLEX HOSE BREAK**

\[ R = 357 \times \frac{941}{400} \times \frac{86.4}{20} = 514 \text{ scfm N}_2 \]

**How long would this have to go unnoticed for it to be a concern? Solve for \( C_f(t) = 0.18 \)**

\[ C_f(t) = 0.18 = 0.21 \left( 1 - \frac{514}{1500} \left[ 1 - e^{- \frac{1500}{5!}} \right] \right) \]

\[ t = 216 \text{ minutes} = 3.6 \text{ hours.} \]

\[ C_f(t=\infty) = 0.21 \left( 1 - \frac{R}{Q} \right) = 0.21 \left( 1 - \frac{514}{1500} \right) = 0.138 \]

\[ P_0 = 0.138 (740 \text{ mm Hg}) = 102 \text{ mm Hg} \]

**Fatality factor:** \( F = 10 \)

\[ (6.5 \times \frac{102}{10}) = 1.93 \times 10^{-4} \]

**P_i, Expected rate of failure \([\text{hr}^{-1}]\)**

**Table 1: 5064TA, CRYOGENIC FLUID LINE LEAK OR RUPTURE \(3 \times 10^{-6} \text{ hr}^{-1}\)**

\[ \phi_{\text{this case}} = P_i F_i = (3 \times 10^{-6} \text{ hr}^{-1}) \left( 1.93 \times 10^{-4} \right) = 5.8 \times 10^{-10} \]

**Folding this into the existing ASS'Y HALL ODH ANALYSIS**

\[ \Sigma \phi_{\text{total, ASS'Y HALL NOW}} = \Sigma \phi_{\text{EN-358, ANALYSIS}} + \phi_{\text{this case}} \]

\[ = 5.96 \times 10^{-9} + 5.8 \times 10^{-10} = 6.5 \times 10^{-9} \]

\[ \phi < 10^{-7} \text{ ODH CLASS 0} \]

**Classification does not change.**
Venting N₂ Exhaust Inside OAB ODH Considerations

Other ODH Related Factors:

A flow venturi, FM558N and a differential pressure switch DPS 560N will sense any abnormal excessive LN₂ flow and will trigger the PLC computer to close off the source at PV513N.

A liquid nitrogen sensor in the ECS condenser exhaust pipe, TS332N will automatically close the condenser inlet values PV301N & PV302N if liquid is sensed. This ensures that only vapor phase nitrogen will make it out the vent.

ODH heads located on the platform and in the cryocorner (and others) will remain active even though not required for ODH reasons.

The ventilation rate used in the analysis is conservative @ 1500 scfm. The building ventilation rate is nominally 4440 scfm. [Ref. ASSY Hall ODH analysis DφEN2587]
Figure 1. Sketch of ECS vent heater.

Parts list: 1) Chromalox circulation heater
GCH15-C20E2, 2 kW
HEATER IN VENT PIPE

- MAX. BACKPRESSURE = \[ \frac{5 \text{ lbs} + 3 \text{ lbs}}{11 (3.25 \text{")}^2} = \frac{0.96 \text{ psi}}{4} \]

\[ \therefore @ 1 \text{ psi} \Delta P \text{ HEATER WILL LIFT.} \]

- EXPECTED \( \Delta P \) UP 3/4" PIPE: Assume room temp. N₂

\[ \frac{W}{d \mu} = 6.31 \]

\[ \frac{(29.2 \text{ lb/hr})}{(0.324 \text{ w})(179/10^6 \text{ poises})} \text{ 100 ep} \text{ 1 poise.} \]

\[ \text{Re} = 12,562 \Rightarrow f = 0.027 \]

\[ \Delta P = 3.36 \times 10^{-6} \frac{f L W^2}{\rho d^5} = 3.36 \times 10^{-6} \frac{0.027 (26 \text{ ft})(29.2 \text{ lb/hr})}{(0.7245 \text{ lb/s})(-0.324 \text{ w})^5} \]

\[ \Delta P = 0.006 \text{ psi} \quad \text{NEGIGIBLE.} \]

- IF SEC RELIEF VALVE BLOWS:

\[ \text{S.P.} = 13 \text{ psi} = 28 \text{ psia.} \]

SEC DESIGN = 30 psid

REFERENCE DO EN-329 ECS PRESSURE VESSEL

NOTE: CRYOCORNER TO OUTSIDE PRESSURE DROP = 2.13 psi LINE 165 PG 114.

- SINCE PRESSURE REQ'D TO LIFT HEATER ASSY OUT IS LESS THAN PRESSURE DROP CRYOCORNER TO OUTSIDE: (DURING RELIEVING COND.) ECS IS STILL SAFE, IN FACT BACKPRESSURE IS LESS OF A CONSIDERATION.

\[ \% \text{ BACKPRESSURE DUE TO "CHECK VALVE" HTL} = \frac{15.96 + 14.7}{15 + 14.7} (100) - 100 = 3.2\% \]
Initial Lift Back Pressure:

\[ \Delta P = \frac{8 \text{ lbs}}{\frac{1}{11} (5.34 \text{ in.})^2} = 0.36 \text{ psi} \]

Then flow paths:

If \( P_1 > 1 \text{ psi} \), heater will lift up additional amounts.

0. Calculate what \( \Delta P \) up 3/4" pipe @ max relieving flow rate; is it 70.4 psi?  

\[ Q = 443 \text{ SCFM air} - \text{condenser coil rupture} \]

From EN 329 ECS pressure vessel engineering note relief calculation summary.

\[ \text{NOTE: This matches 438 SCFM N}_2 \text{ that was calculated in case II of the OPH analysis for a failure of all the valves in the LN}_2 \text{ supply line being wide open.} \]

To bound it, assume warm gas.

\[ Re = 22,700 \frac{9}{d \mu} \quad q = 438 \frac{\text{ft}^3}{\text{min}} \times \frac{1}{60\text{s}} = 7.3 \quad \frac{\text{ft}^3}{\text{s}} \]

\[ \rho = 0.07245 \quad \frac{\text{lb} \cdot \text{ft}^3}{\text{lb}} \]

\[ d = 0.824 \quad \mu = 178 \times 10^{-4} \text{ cp} \]

\[ Re = 22700 \frac{(7.3) (0.07245)}{0.824 (178 \times 10^{-4})} = 8.185 \times 10^5 \]

\[ \varepsilon = 0.002 \quad F = 0.0235 \]

\[ \Delta P = 3.36 \times 10^{-6} \frac{(0.0235) \left( \frac{36}{2047 \text{ in.}} \right)^2 (0.07245)(0.824 \text{ in.})^{5}}{0.87245 \times 0.824 \text{ in.}^{5}} = 240 \text{ psi} \]
Now calc. \( \Delta P \) if gas is at sat. temp.
(More realistic)

\[
Re = 6.31 \frac{W}{d \mu} \quad W = 2047 \text{ lb/hr}
\]
\[
d = 0.824
\]

\[
\mu = 0.0056 \text{ cp @ sat. press. & temp.}
\]

\[
Re = 6.31 \frac{(2047)}{(0.824)(0.0056)} = 2.8 \times 10^6
\]

\[
f = 0.0235
\]

\[
\Delta P = 3.36 \times 10^{-6} \left( \frac{0.0235}{\frac{12}{12}} \right) \left( \frac{2047 \text{ lb}}{\text{hr}} \right)^2
\]
\[
\frac{(0.2754 \frac{\text{lb}}{\text{hr}^2})}{(0.824 \text{ in})^5}
\]

\[
\Delta P = 6.85 \text{ psi}
\]

Heater would lift.
specifications

Customer Specifications

Circulation Heater

PE306-1

Date: MARCH 1, 1989

Prepared By: RUSSELL RUCINSKI

Representative Co.: TOURTELOT CO. INC.

Customer Name: FERMILAB

Sales Engineer: TROY A. COURTNEY

Location: TOURTELOT CO. INC.

Qty. of Heaters: Per Order _____ Per Year _____

Order/Inquiry No. ____________

1. Medium Being Heated NITROGEN

From -300 °F To +140 °F

Sp. Ht. __________ viscosity ________ @ ______ °F

Minimum Flow Rate ______ 0 ______

Maximum Flow Rate 30 lb/hr or 6.7 SCFM

Max. Pressure: Operating 50 PSIG Design 22 PSIG

Max. Temperature: Operating MIN. °F Design 140 °F

MIN. °F Design 130 °F

2. Heater Construction — Catalog Description

Nominal Vessel Size ___ 6", 5", 8", 14", 18", 24", Other ___

150 lb. Construction (150, 300, 400, etc.)*

STAINLESS STEEL

Element Material (Copper, Steel, S.S. Incoloy)*

3/4" - 14

Moisture TIGHT

Inlet & Outlet (Inch, NPT or Flanged)

VERTICAL

Terminal Cover (STD, ER, LT)

Insulation Jacket (STD, Weatherproof, None)

Mounting Position (Vertical or Horizontal)

Section of Code (I, IV, VIII)*

Circulation (Baffled or Unbaffled)

3. Electrical Data

kW 2.0 Voltage 120 Phase 1 No. of Circuits 1

Watt Density* 50 W/in² Overheat Protection

SET 50 INSULATION JACKET

WILL BE < 160°F IF ABBREVE

4. Temperature Control Requirements

Chromalox Model No. TC-3910-1104AS

Range 0 - 999 °F Nema Type STD

(ER, LT, STD)

5. Power Control Requirements

A. CSCR Model No. N/A

B. Step Controller, ISSC ISSU

C. Contactor

6. Other Regulatory or Code Requirements

7. Remarks (Other Requirements) NO INSULATION, 150 psi MWP

*Some parameters may be specified, but factory will advise if design calculations suggest better choice.