TO: **M. Cole**
FROM: **P. L. Goranson**

SUBJECT: **Job 1270 - NCSX Heater Control System Closeout Summary**
08July-08-PG

Scope
This effort covers all Title I, II, and III engineering design for a resistance heating temperature control system to maintain the NCSX inner port extension wall temperatures during standby and bake out operation. It includes monitoring of temperatures of the Vacuum Vessel body and the port extensions during standby and bake out operation. It includes transmission of temperature data to Central I & C for archival and interface to other disciplines.

Work includes engineering design, procurement, fabrication, and installation of leads, thermocouple signal conditioners, processors, heater controllers, racks, wire trays, and associated support hardware. Thermocouples and heater tapes are supplied by WBS 12

Status
At the time of closeout no work was in process.

Interfaces
Vacuum Vessel (12)
Cryostat (WBS 17)

Specifications
No work had begun on a system requirements document or CSPEC.

All work to date was included in the SC Project Review of NCSX, April 8-10, 2008 and a presentation by Gernhardt entitled **"**NCSX Heater and Thermocouple-Instrumentation and Control", updated 10/25/07. (Both Attached).

Schematics
None except in documents listed above.

Models Completed
None required.

Drawings
None started.

Analyses
None required.

Testing
None required. MDL incorporated the design in one of its heating systems for a furnace with good results.

Costs
Cost estimates were updated on the latest WAF and were included in the 08 Lehmann review presentation.

Remaining Work
- The routing of wire trays.
- Locating equipment.
- Drawings and schematics.

R&D was not required.

Conclusion
The work was in a preliminary phase.

Attachments:

NCSX Heater Control System

P. L. Goranson

Work package 1270

Outline

Updated 10/25/07 R. Gernhardt

- Scope
- Requirements
- System Proposed
- Configuration
- Component details
- M&S and Labor cost details
- Total Cost (M&S and Labor)
- Schedule
- Risk and Mitigation

Scope

- Provide resistance heating temperature control system to maintain the NCSX inner port extension wall temperatures during standby and bake out operation.
- Monitor temperatures of the vacuum vessel body and port extensions during standby and bake out operation.
- Send temperature data to Central I & C for archival and interface to other disciplines.

Requirements-1

Criteria

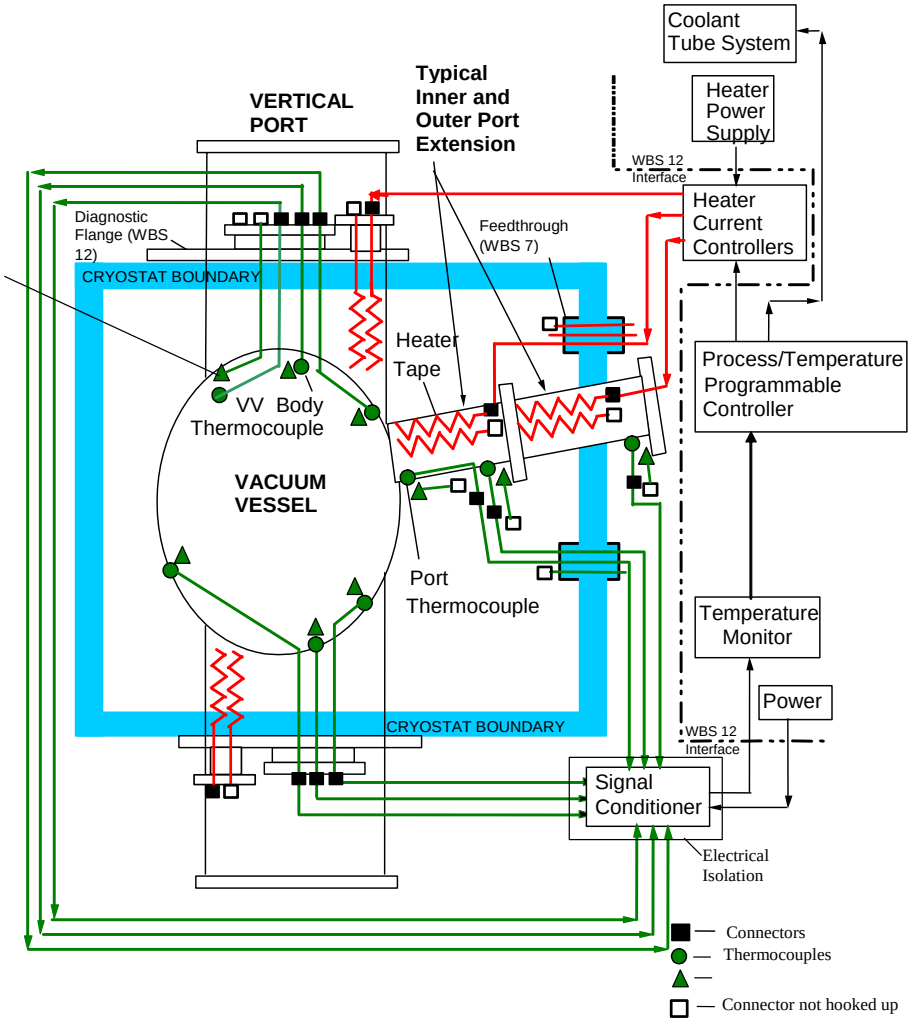
- **Monitor the VV temperature during standby and bake out operation.**
- **Operation range - room temperature to 375 C**
- **The leads must be insulated from all structure including VV and Cryostat.**
- **The signal conditioners must be the isolated type. Additionally, the instrument cabinet will be isolated from ground by insulation and isolation transformers.**
- **Each heater must be capable of continuous variable operation from 0 - 200 watts.**

Interfaces

- **Provisions must be provided by WBS 171 for future hookup of additional thermocouples when outer port extensions are added. The interfacing electrical system must be capable of upgrade to accommodate the upgrade.**
- **WBS 12 will be responsible for overall design of the system including choice and location of components, mounting provisions, lead routing, signal conditioning, and electrical isolation.**
- **WBS 12 will be responsible for coordination of the thermocouple design with the other interfacing disciplines (WBS 171 and WBS 5).**
- **For purpose of assigning interface responsibility, the WBS 4 responsibility shall end at the power panel.**

Requirements-2

Interface Block Diagram:



System Proposed, page 1

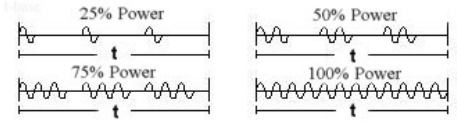
- **Provides for:**
  - **120 Channels of Active Heater Temperature Control Zones**
    - **114 heating control zones (channels) requested.**
  - **282 Channels of Thermocouple monitoring points**
    - **279 (expandable) temperature monitoring points requested.**

System Proposed, page 2

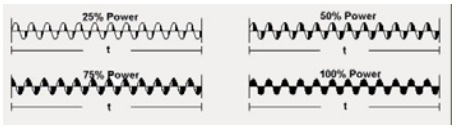
- **PLC based temperature control of heaters:**
  - Rockwell Control Logix Platform
  - Networking
    - Control Net for PLC I/O and Local Programming/Control
    - TCP/IP interface to Central I&C for data exchange. May use Rockwell software.TBD
    - Ethernet/IP network for Remote system control operator interfaces.
  - Software
    - RSLogix 5000 PLC programming software. PC platform
    - RSView32 or SE MMI software---TBD . PC operator interface.

System Proposed, page 3

- **Heater 120VAC control:**
  - Zero crossing Time Pulsed Output (TPO) solid state relay supplies variable 120VAC pulse train to heater.
    - TPO chosen to minimize RFI to diagnostics.



    - Phased output SSR's are noisy (i.e.. Standard lighting dimmers)



  - Heater power limited by Variac.
  - Secondary SSR protects for thermal runaway (shorted TPO control SSR).
  - One or more thermocouples provide feedback for each heating zone PID loop.
    - Failed TC sets alarm, notifies operator and removes TC for heating zone mix allowing conditional heater zone control.

Sensor Specifications

- **Thermocouples:**
  - **Ref: NCSX-PRL-12-003-00**
    - **Type-E, Isolated, electrically floating junction Type-E, Isolated, electrically floating junction.**
  - **Similar to type Omega XCIB-E-4-3-10.**

- **Heaters:**
  - **Manufacture: BriskHeat**
    - **BIH series tapes are constant resistance type.**
  - ***Custom BIH Style Heating Tape:*** **½" W X 10 Ft. L, non-magnetic.**
  - **Heavy Insulated Heating Tape, 520 Total Watts, 24" Leads Same End, Split Plug, 120 Volt.**
  - ***Custom BIH Style Heating Tape:*** **½" W X 6 Ft. L, non-magnetic.**
  - **Heavy Insulated Heating Tape, 310 Total Watts, 24" Leads Same End, Split Plug, 120 Volt**

Control I/O M & S Costs

I/O M&S Total = $211,262

NCSX Heater/TC Instrumentation and Control Component Parts List

Provides for 120 Heaters and 282 Thermocouples

Rev 1: 24 OCT 2007 R.Gernhardt

Item	Description	Mfgr	Model	unit cost	Qty	Item Cost	Comment	Source
	PLC							
1	Logix 5560 processor with 2 M memory. (Is 2M enough??	Allen-Bradley	1756-L61	$5,105.00	1	$5,105.00	memory size???	Rumsey Electric
2	Control Logix Chassis, 10 slot	Allen-Bradley	1756-A10	$542.00	8	$4,336.00	TBD	Rumsey Electric
3	Control Logix Power supply, 10 A	Allen-Bradley	1756-PA 72	$805.00	8	$6,440.00		Rumsey Electric
4	Controlnet interface module	Allen-Bradley	1756-CNB	$1,312.00	8	$10,496.00		Rumsey Electric
5	Control Logix Ethernet interface module	Allen-Bradley	1756-ENBT	$1,760.00	1	$1,760.00		Rumsey Electric
6	MODBUS-TCP/IP communications module for 1756 chassis	ProSoft	MV156-MNET	$2,228.00	1	$2,228.00		Rumsey Electric
7	Control Logix Enhanced Isolated TC module, 6 Channel	Allen-Bradley	1756-IT6I2	$1,915.00	47	$90,005.00		Rumsey Electric
8	Interface module for above 1756-IT6I2	Allen-Bradley	1492-AIFM 6TC-3	$154.00	47	$7,238.00		Rumsey Electric
9	Cable for above 1756-IT6I2	Allen-Bradley	1492-ACABLE 025-Y	$177.00	47	$8,319.00		Rumsey Electric
10	Control Logix Ethernet interface module	Allen-Bradley	1756-ENBT	$1,760.00	1	$1,760.00		Rumsey Electric
11	Control Logix Analog Output, 8 Channel	Allen-Bradley	1756-OFB	$1,787.00	15	$26,805.00		Rumsey Electric
12	Cable for above 1756-IOFB	Allen-Bradley	??????????			$0.00	TBD	Rumsey Electric
13	Control Logix Digital Output, 16 Channel	Allen-Bradley	1756-OB16D	$727.00	8	$5,816.00		Rumsey Electric
14	Controlnet PCI interface card for local PC	Allen-Bradley	1784-PCIC	$1,569.00	1	$1,569.00		Rumsey Electric
15						$0.00		Rumsey Electric
16								
17	**SOFTWARE**							
18	Logic Programming, RSLogix5000, standard, NetWorx edit	Rockwell	9324-RLT300NXENE	$3,350.00	1	$3,350.00	TBD	Rumsey Electric
19	PIDE_AUTOTUNE software for RSLogix5000	Rockwell	9323-ATUNEENE	$490.00	1	$490.00	TBD	Rumsey Electric
20		Rockwell			1			Rumsey Electric
21	RSView SE Server 25 Display w/RSLinx Enterprise	Rockwell	9701-VWSS025LENE	3,960.00	1	$3,960.00	Server-- local?????	Rumsey Electric
22	RSView SE Server 25 Display	Rockwell	9701-VWSS025AENE		1	$0.00	Client-- Remote???/?	Rumsey Electric
23								
24	**CONTROL DISPLAY PC'S**							
25	Test cell PC, display & keybord	TBD		$1,300.00	1	$1,300.00		
26	Control room pc - supplied by CI&C	TBD						
27								
28	**HEATER DRIVE**							
29	Solid State Relay, 4-20ma in, 25 A AC TPO output	Power I/O	DMA-6V25	$99.00	120	$11,880.00		Power I/O
30	Solid State Relay, 4-32 VDC control, 20 A	Crydom	CKRD2420	$31.00	120	$3,720.00		Allied
31	Variac, 120VAC, 5 A	Staco	511	$98.00	120	$11,760.00		Newark
32	Fuse & holder, TBD			$1.00	120	$120.00		
33	Bud Panels for Variac mounting, 5.25" x 19"	Bud	PS-1252	$18.94	30	$568.20		Allied
34	Bud Panels for PLC mounting, 7" x 19"	Bud	PS-1253	$19.06	10	$190.60		Allied
35	DIN Rails, 6' length to mount SSR's and TC interfaces	Various		$5.00	12	$60.00		
36								
37	**FIELD CABLE CONNECTORS**							
38	Heater cable connectors, 16 socket, crimp type MS	Amphenol	MS3126F20-16S	$61.62	16	$985.92		Allied
39	Crimp tool, positioner, Ins/Ext for MS3126F20-163	Amphenol	M22520/1-01	$500.00	1	$500.00		
40	TC cable connectors, socket crimp type - G.Labik to purchase						TBD	
41						$0.00		
42	Misc hardware	various		$500.00	1	$500.00		
					TOTAL:	**$211,261.72**	NOTE: List cost	

AC Power, Field/Rack/Tray Wire M & S Costs

NCSX Resistance heating system field installation by: Frank Jones

Materials total: $42,894

Wire: #2 awg	$600
#4 awg	$180
#10 awg	$1000
2/0	$250
#6 & #8 awg	$140
Multi-conductor shielded (1000ft.), 105c	
Power cable for heaters ($6/ft.)	$6000
Thermo-extension cable (2000ft.):……..	
Type-E shielded-8pr.($4/ft.)	$8000
2-“GE” breakers & enclosure	$2000
42 ckt. “GE” panelboard…….	
3 ph. 4 wire, 150A	$1500
480v, square-D 70a Breaker (250 af)	$700
G-10 sheets…….	
5-1/8” 24” x 36”	$260
2-1/8” 36” x 76”	$364
PVC shed. 40 conduit, 50 ft.	$75
5-2.5kva MGE isolation Transformers	$6000
5-20a plugmold strips	$550
5-emi/rfi filters	$1500
5 fan assemblies	$500
30-25amp 1 pole breakers	$1050
5-20amp 1 pole breakers	$175
Panduit 2” x 2” in rack	$250
4” x 18” fiberglass tray fittings For thermo-wire	$1700
4 x 12” fiberglass tray fittings For heater power	$1200
4” x 18” fiberglass straight tray For thermo-wire	$2000
4 x 12” fiberglass straight tray For heater power	$1200
Aluminum and fiberglass Strut	$200
Isolation transformer 45 kva, 480v to 208/120v…41kvdc iso.	$5500

Instrumentation and Control- Labor Estimate

NCSX RESISTANCE HEATING TEMPERATURE CONTROL SYSTEM						
Instrumentation and Control - R.Gernhardt- 10/24/07						
	Task		Man days			
DESIGN			eng	dsn	sr lab	tech
Documentaion		R.Gernhardt				
Rack layout (1 dwg)					1	
Internal PLC terminal layout drawings (6)					3	
Create Spreadsheet- End to End - Device to PLC wire list					5	
Intra rackCWD's, PLC to Drive components (10)					5	
Control		R Gernhardt, J.Dong, Sichta				
Define temp control algorithms, Associate TC W/Htr zones.					5	
Prepare I&C interface doc. & PLC tag assignment			5		10	
Select/Evaluate Control software packages			1		1	
CI&C interface development			5		2	
		Design Man Days	11	0	32	0
PROCUREMENT			eng	dsn	sr lab	tech
Connectors		R Gernhardt				
Order Heater Field cable connectors (MS type)					0.5	
Hardware						
Order PLC I/O hardware					1	
Order Heater Drive components					0.5	
Software						
Order Control display software					1	
		Procurement Man Days	0	0	3	0

FABRICATION			eng	dsn	sr lab	tech
Prototype		R Gernhardt				
Configure/Evaluate typical htr / TC control channel					5	
Rack		Tech shop				
Fabricate Variac and PLC mounting panels (40)						2
Mount Variacs (120) to panels						2
Mount Drive components (240- SSR's) on DIN rails						2
Control		R Gernhardt				
Configure & program PLC					20	
Program RSView control pages (heater ~6), (TC~6), (System~7)					20	
		Fabrication Man Hours	0	0	45	6
INSTALLATION			eng	dsn	sr lab	tech
Rack		R Gernhardt/ Tech shop				
Install and wire Drive components					1	10
Control		R Gernhardt/Tech shop				
Install / network PLC chassis (8), Wire PLC I/O,					3	3
Test- PLC & Control software					5	
Install / network test cell PC ---- J.Dong			1			
Commission I&C interface, test ----R.Gernhardt/ J.Dong			5		5	
Test Procedure					1	
		Installation Man Days	6	0	15	13
LABOR			**eng**	**dsn**	**sr lab**	**tech**
		TOTAL Man Days	**17**	**0**	**95**	**19**
		Man Hr	136		760	152
		Man Month	0.85		4.75	0.95

AC Power, Field/Rack/Tray Wire- Labor Estimate

NCSX RESISTANCE HEATING TEMPERATURE CONTROL SYSTEM					
AC Power, Field/Rack/Tray Wire- F.Jones--- 10/24/07					
Task		Man days			
DESIGN		eng	dsn	sr lab	tech
Design/drafting & supervision- F.Jones					
Machine elevation & tray details			4		
Tray support fabrication detail			4		
Rack internal layout details			3		
Existing Panel draw rev.			1		
New panel schedule dwg.			1		
Shutdown dwg			1		
AC power CWD for panel/xfmr			1		
5 rack ac power CWDs			3		
Heater power from rack to connector					
Wiring diagrams & termination details			4		
Thermocouple wiring from rack to					
Machine and termination details			4		
Tray test cell plan drawing			3		
JHA, procedure, ECN, work order			3		
Package issue and field walk down			2		
	Design Man Days	**0**	**34**	**0**	**0**
PROCUREMENT		eng	dsn	sr lab	tech
AC Power	F.Jones/tech shop				
Order Breakers, Panels, Pwr cable, field cables, x-formers			1		
Tray/Conduit	F.Jones/tech shop				
Order tray/ conduit			1		
Material research	F.Jones		1		
	Procurement Man Days	**0**	**3**	**0**	**0**
FABRICATION		eng	dsn	sr lab	tech
Tray Conduit prefab	Tech shop				4

INSTALLATION	eng	dsn	sr lab	tech
Construction/Electricians				
Install 70a, 3 pole 480v breaker				
(coordinate panel PP_141 shutdown)				2
Install conduit thru wall to test cell				2
Install 45 kva isolation transformer				
(handling and secure to floor)				4
Install primary & secondary breaker				2
Install new panelboard				
(assemble & install branch breakers)				2
Install conduit between xfmr and breaker Enclosures				2
Install ac power conductors & terminate				6
Install power and instrument dedicated trays				
around top and bottom of machine				16
Fabricate & Install tray support system				4
Install rack power conduit				4
Install 2-trays from machine to racks				8
Install 5 racks insulated to 5KV				8
Install 5 isolation xfmrs at racks				
(install 5 filters and plugmold strips)				7
Hi-pot racks to verify isolation				
(coordinate with TC work)				2
Install rack power wire 1/c #10				2
Install heater power from panel to rack				
(30-120v circuits-fan out at racks)				10
Install/terminate heater power from racks to				
Machine via tray 12				12
Install/terminate thermocouple extension				
Wire from rack to machine				24
Revision/Construction Supervision		5		
		5	**0**	**117**
	eng	**dsn**	**sr lab**	**tech**
TOTAL AC Pwr/Fld Man Days	**0**	**42**	**0**	**121**
Man Hr	0	336	0	968
Man Month	0	2.1	0	6.05

Total Costs- M&S and Labor

NCSX RESISTANCE HEATING TEMPERATURE CONTROL SYSTEM				
MATERIALS & SUPPLY	Quantity	units	unit cst	Total
Ray G estimate				
A-B PLC hardware,Software, I/O modules, term blks				
Control PC/Displays, Network modules,				
Heater Drive components and Field Cable connectors				$211,262
F.Jones estimate				
AC power, breakers, enclosures, panels, x-formers, wiring				
Cable tray, conduit, TC/Htr Field cables				
Rack filters, fans and installation materials				$42,894
TOTAL Materials cost (unloaded)				**$254,156**

TOTAL LABOR ESTIMATE				
Instrumentation & Control	eng	dsn	sr lab	tech
Computer Div. / R.Gernhardt / Electrical Tech				
Includes Design, Procurment, Fabrication and Installation				
Man Days	**17**	**0**	**95**	**19**
AC Power, Field/Rack/Tray Wire				
F.Jones- Design/Drafting / Electrical Tech (Tech Shop)				
Includes Design, Procurment, Fabrication and Installation				
Man Days	**0**	**42**	**0**	**121**
LABOR Totals (I&C + AC PWR)	**eng**	**dsn**	**sr lab**	**tech**
TOTAL Man Days	**17**	**42**	**95**	**140**

ESTIMATE BASED ON:

1) PLC feedback control system to maintain port temperatures during stanby and bakeout operations.
2) 120 zones of ACTIVE heater temperature control.
3) 282 thermocouple channels available for monitoring and feedback control of vacuum vessel and port extension temperatures.
4) Archival of TC temperatures and heater power in central I&C.

ESTIMATE INCLUDES:

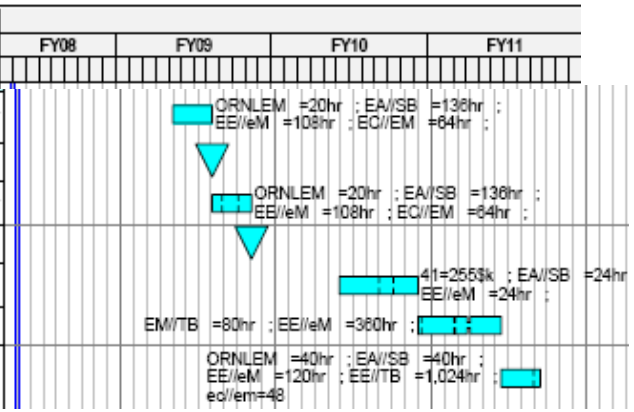
1) AC power labor and M&S costs.
2) PLC programming and M&S costs
3) Rack installations and wiring cost
4) Includes TC/Htr Field cabling and terminination costs from control racks to feedthru ports at vessel.
5) Test and commissioning costs.

COSTS NOT INCLUDED:

1) Control room PCs (2?) computer division

Schedule

Activity ID	MILE -STONE LEVEL	Activity Description	Duration (work days	SHIFTS	Forecast Start	Forecast Finish	Total Float	Cost to Complete
1270-30		Preliminary design	65		*02FEB09**	*01MAY09*	***244***	46,618.64
1270-40		PDR	0			*01MAY09*	***244***	0.00
1270-50		Final Design	65		*04MAY09*	*04AUG09*	***244***	46,618.64
1270-60		FDR	0			*04AUG09*	***244***	0.00
1270-70		Procure Hardware	130		*01MAR10**	*31AUG10*	***107***	348,434.48
1270-80		Fabrication	130		*01SEP10*	*14MAR11*	***107***	72,225.29
1270-90		Installation	65	2	*15MAR11*	*14JUN11*	***107***	127,753.12



Staffing – Resources to be assigned by PPPL

Cost Estimate Risks

Uncertainty of the Estimate

Design Maturity **Medium**

Design Complexity **Low**

The design is straight forward, and uses industry standard components but is a conceptual design at this point.

Risk Mitigation

MDL built a prototype of the Heater and TC controller system (driver and feedback control) and installed it as a furnace controller, with good results.

NCSX Heater and Thermocouple -Instrumentation and Control

Updated 10/25/07

- Task
- Requirements
- System Proposed
- Configuration
- Component details
- AC power requirements
- M&S and Labor cost details
- Total Cost (M&S and Labor)

Tasks

- **Provide resistance heating temperature control system to maintain the NCSX inner port extension wall temperatures during standby and bake out operation.**
  - 114 heating control zones (channels) requested.
  - Type E Thermocouples specified for feedback element (One or more thermocouples used per zone).

- **Monitor temperatures of the Vacuum Vessel body and port extensions during standby and bake out operation.**
  - 279 (expandable) temperature monitoring points requested.
  - Type E Thermocouples specified.

- **Send temperature data to Central I & C for archival and interface to other disciplines.**

Requirements-1

- **Extract from ICD-125-001 "Vacuum Vessel Local Thermocouples"**
  - Thermocouples shall be provided to monitor the VV temperature during standby and bake out operation.
  - Provisions must be provided by WBS 171 and WBS 12 for future hookup of the additional thermocouples, i.e. connectors at the cryostat and expansion capability at the signal conditioner interface.
  - WBS 12 will be responsible for overall design of the system including choice and location of components, mounting provisions, lead routing, signal conditioning, and electrical isolation.
  - WBS 12 will be responsible for coordination of the thermocouple design with the other interfacing disciplines (WBS 171 and WBS 5).

  Criteria

  - Thermocouples will be operated in a range from room temperature to 375 C
- The thermocouple junctions will insulated from the VV.
  - Ray G comment: Need thermocouple Isolation/Standoff specification. TBD
- The leads will be insulated from all structure including the VV and Cryostat.
- The signal conditioners will be of the isolated type to prevent ground loop currents. Additionally, the instrument cabinet will be isolated from ground by insulation and isolation transformers.

Thermocouple Type

- Similar to type Omega XCIB-K-4-3-X
- Inconel Overbraided , Type E, Bolted connection, Insulated junction.

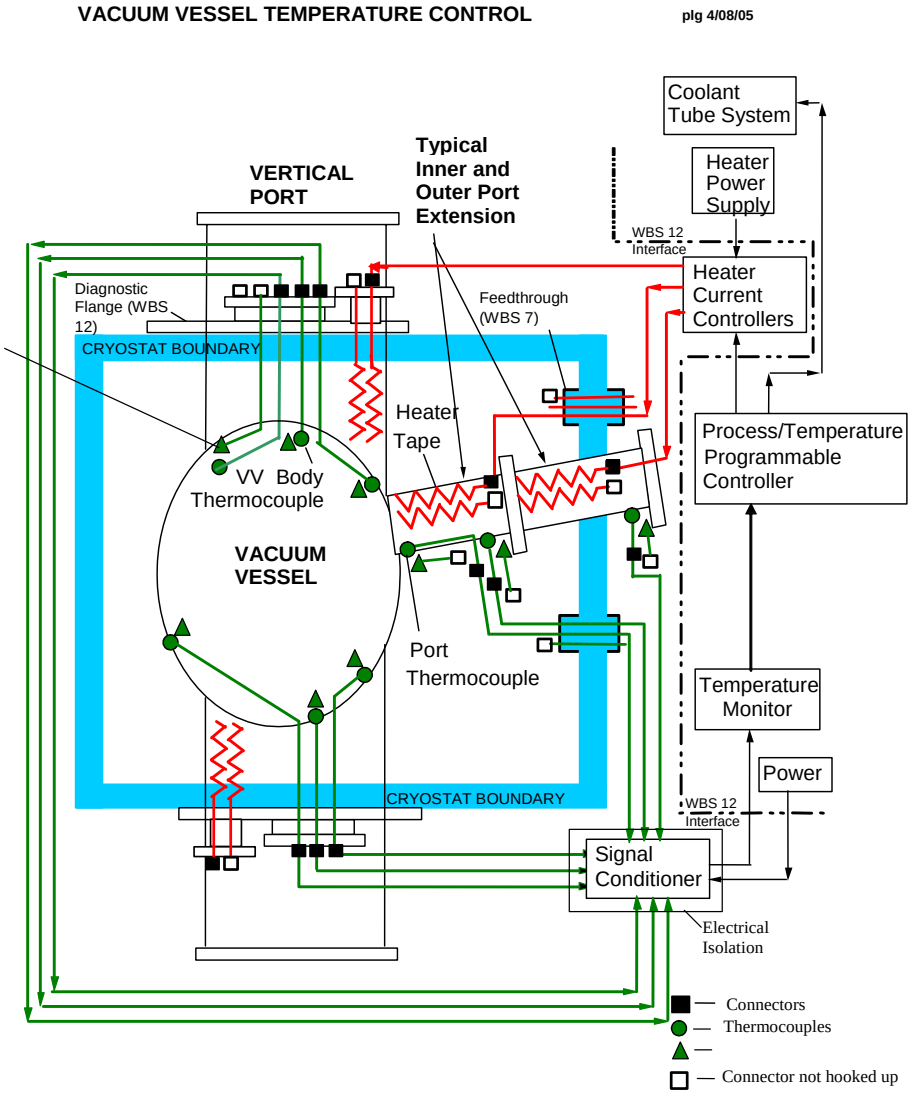
Signal Conditioners

- Isolated type, 93 required per field period (279 total), expandable to 120 per field period.

Requirements-1.1

- **Extract from ICD-125-001 "Vacuum Vessel Local Thermocouples"**

Interface Block Diagrams:



Requirements-2

- **Extract from ICD-123-4-5-0001 "Vacuum Vessel Port Resistance Heaters"**
  - The Vacuum Vessel (VV) utilizes inner and outer port extensions which project through the Modular Coil (MC) shell structure and the Cryostat wall. The port extension walls within the cryostat are electrically heated by resistance heaters which are attached to the port walls and are covered by the port insulation wrap.
  - The leads from the power panel to the heaters shall be the responsibility of WBS 12. WBS 5 shall receive and archive temperature signals from WBS 12.

Installation Information:

- Each of the inner port extensions is provided with a minimum of one primary and one redundant (backup) electrical resistance heater tape mounted to their surface. The vertical ports (port 12) and large non-circular ports (port 4) will each be provided with four sets of heaters (plus backups). The port extension heater tape hookup interfaces shall be located outside the MC structure, at the inner port flanges. The port 12 heater tape hookup interface shall be at the port 12 diagnostic interface flange.
- The interfacing electrical system must be capable of upgrade to provide power to a similar system of heaters on the outer extensions, even though they are not utilized in initial operation. For purpose of assigning interface responsibility, the WBS 4 responsibility shall end at the power panel.
- The heaters must be electrically isolated from the VV and its structure. WBS 121 is responsible for the design of the inner port extension heaters, their mounting provisions, the power controllers, temperature sensors, and signal conditioning. The leads from the power panel to the heaters shall be the responsibility of WBS 12.
  - Ray G comment: Need Heater Isolation/Standoff specification. TBD
- Each heater must be capable of continuous variable operation from zero output to a maximum of 200 watts. The expected nominal operating level is 50-100 watts. The heaters must be capable of continuous operation at 350 C.

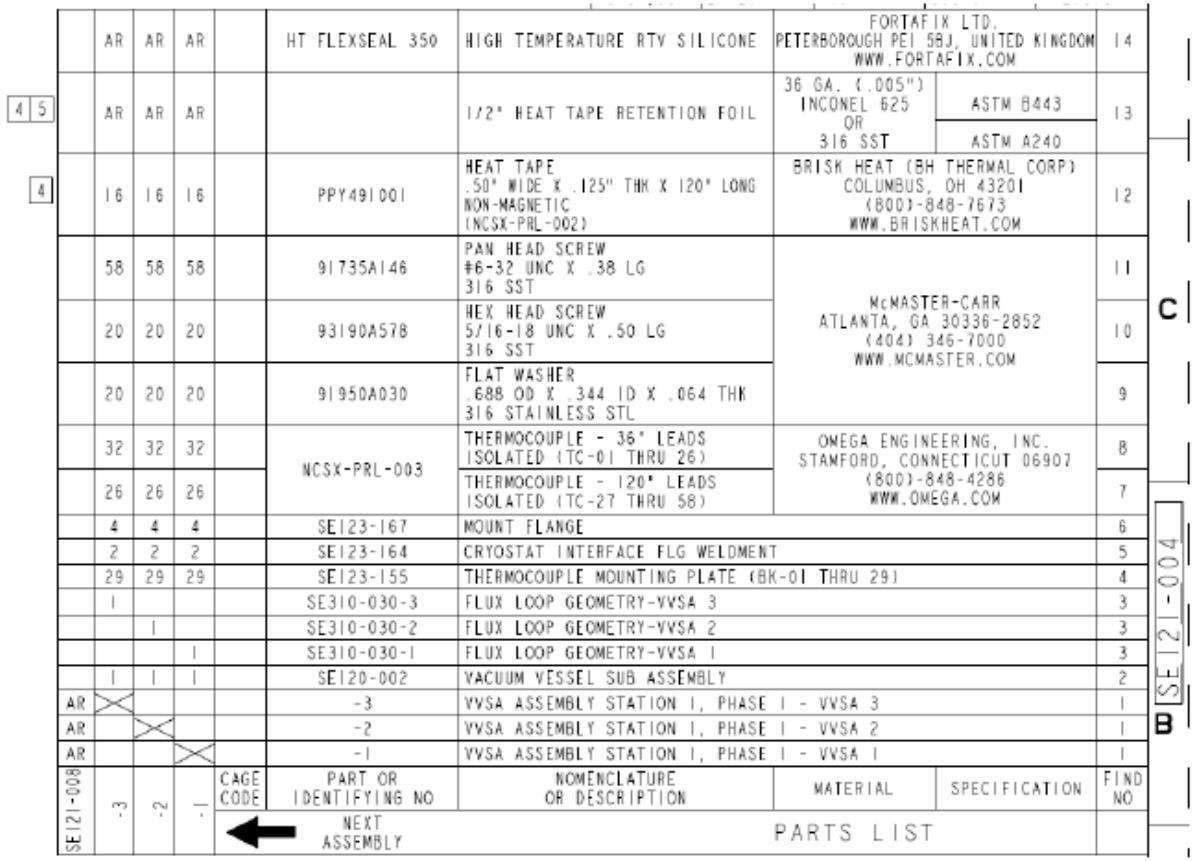
Requirements-3

Heater Count Summary

	SE121-004	SE123-150	SE123-151	SE123-156	Total/FPA	Total NCSX
Heater Tape 120" (non Port 12 extensions)		20	26	16	62	186
Port 12 Heaters	16				16	48
TOTALS					78	**234**

Includes duplicate spares

Total Active Controlled Heater (channels) = 234 / 2 = 117 zones



	AR	AR	AR		HT FLEXSEAL 350	HIGH TEMPERATURE RTV SILICONE	FORTAFIX LTD. PETERBOROUGH PE1 5BJ, UNITED KINGDOM WWW.FORTAFIX.COM		14
4 5	AR	AR	AR			1/2" HEAT TAPE RETENTION FOIL	36 GA. (.005") INCONEL 625 OR 316 SST	ASTM B443 / ASTM A240	13
4	16	16	16		PPY491001	HEAT TAPE .50" WIDE X .125" THK X 120" LONG NON-MAGNETIC (NCSX-PRL-002)	BRISK HEAT (BH THERMAL CORP) COLUMBUS, OH 43201 (800)-848-7673 WWW.BRISKHEAT.COM		12
	58	58	58		91735A146	PAN HEAD SCREW #6-32 UNC X .38 LG 316 SST	McMASTER-CARR ATLANTA, GA 30336-2852 (404) 346-7000 WWW.MCMASTER.COM		11
	20	20	20		93190A578	HEX HEAD SCREW 5/16-18 UNC X .50 LG 316 SST			10
	20	20	20		91950A030	FLAT WASHER .688 OD X .344 ID X .064 THK 316 STAINLESS STL			9
	32	32	32		NCSX-PRL-003	THERMOCOUPLE - 36" LEADS ISOLATED (TC-01 THRU 26)	OMEGA ENGINEERING, INC. STAMFORD, CONNECTICUT 06907 (800)-848-4286 WWW.OMEGA.COM		8
	26	26	26			THERMOCOUPLE - 120" LEADS ISOLATED (TC-27 THRU 58)			7
	4	4	4		SE123-167	MOUNT FLANGE			6
	2	2	2		SE123-164	CRYOSTAT INTERFACE FLG WELDMENT			5
	29	29	29		SE123-155	THERMOCOUPLE MOUNTING PLATE (BK-01 THRU 29)			4
	1				SE310-030-3	FLUX LOOP GEOMETRY-VVSA 3			3
		1			SE310-030-2	FLUX LOOP GEOMETRY-VVSA 2			3
			1		SE310-030-1	FLUX LOOP GEOMETRY-VVSA 1			3
	1	1	1		SE120-002	VACUUM VESSEL SUB ASSEMBLY			2
AR	X				-3	VVSA ASSEMBLY STATION 1, PHASE 1 - VVSA 3			1
AR		X			-2	VVSA ASSEMBLY STATION 1, PHASE 1 - VVSA 2			1
AR			X		-1	VVSA ASSEMBLY STATION 1, PHASE 1 - VVSA 1			1
SE121-008	-3	-2	-1	CAGE CODE	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO
				← NEXT ASSEMBLY		PARTS LIST			

C

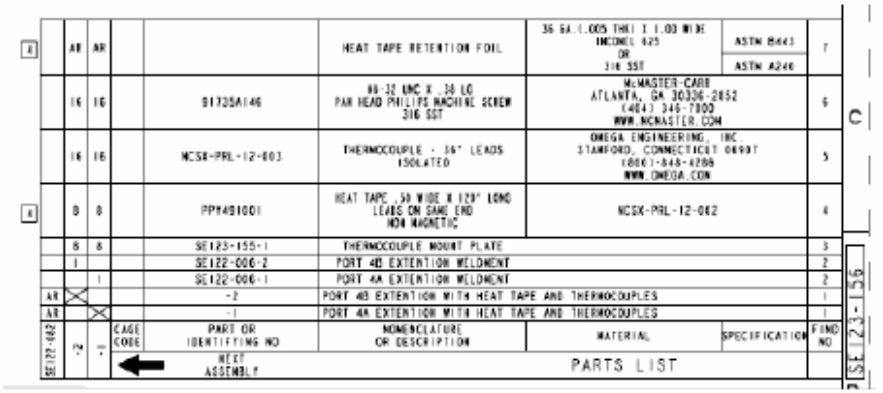
SE121-004

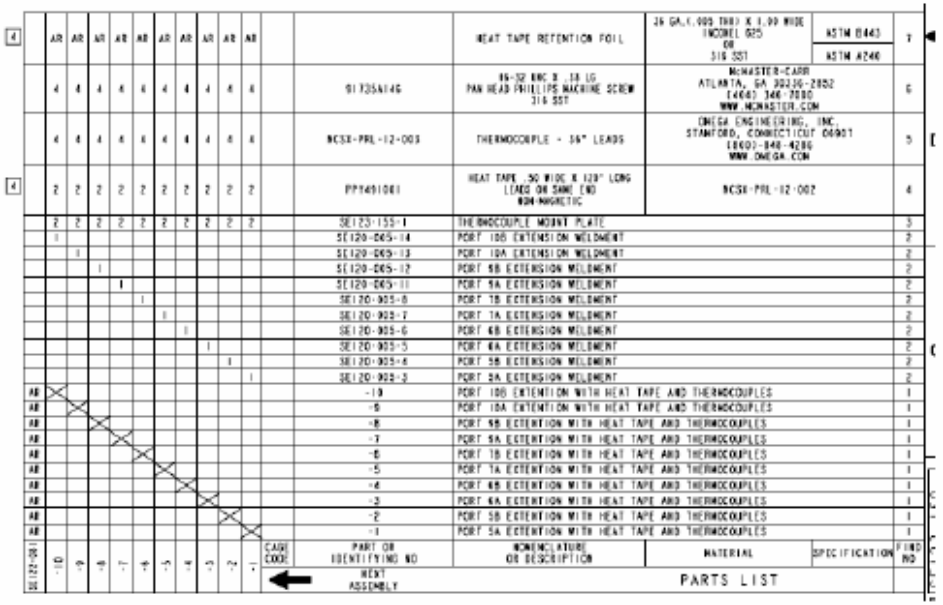
B

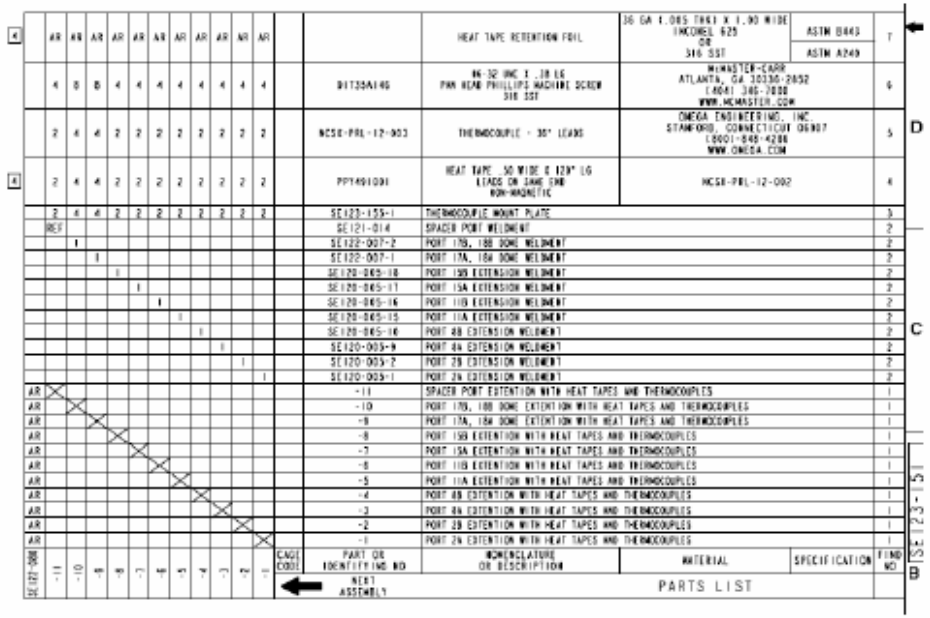
Requirements-3.1

	SE123-150	SE123-151	SE123-156	Total/FPA	Total NCSX	15% Spares	Procure Qty
Thermocouples 36"	40	26	32	98	294	45	339
Heater Tape 120"	20	26	16	62	186	28	214

SE121-004= +48
Heater tape TOTAL=234







Requirements-4

- **Extract from ICD-123-64-0001-00 "Cooling/heating requirements "**
  - **Description of Interface:** The Vacuum Vessel Subassembly (VVSA) exterior surface includes tubes which circulate helium gas to provide heating during bake out of the vacuum vessel and during idle periods when the vacuum vessel is on standby. The helium gas provides cooling of the vessel after operational shots. This ICD defines the operational parameters for the pressurized helium supplied by WBS 64 and defines the requirements for the hookup interface between WBS 123 and WBS 64.

Installation/Operation Information:

- The port extensions are independently heated by resistance heaters during baking and idle operation.

System Proposed 1

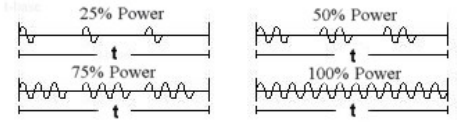
- Provides for:
  - 120 Channels of Active Heater Temperature Control Zones
    - 114 heating control zones (channels) requested.
  - 282 Channels of Thermocouple monitoring points
    - 279 (expandable) temperature monitoring points requested.

System Proposed 2

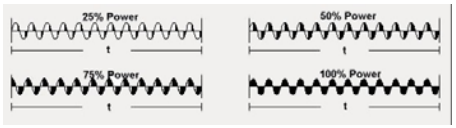
- PLC based temperature control of heaters:
  - Rockwell Control Logix Platform
    - Fully-redundant controller architecture provides bumpless switchover and high availability
      - Available but not proposed for this system
    - Widest range of communication options and analog, digital and specialty I/O.
    - Select ControlLogix products are TUV-certified for use in SIL 2 applications.
    - Isolated differential Thermocouple I/O modules. 282 channels available-expandable.
      - 3250 VDC for 60 sec user to backplane, 1900 VDC for 60 sec channel to channel.
      - DIN rail terminal block interfaces to Thermocouple field wiring
      - Auto-detects T/C failures. PLC logic programming for heater control fault protection.
  - Networking
    - Control Net for PLC I/O and Local Programming/Control
      - Multiple processors can access common I/O.
      - Offers backup control to remote TCP/IP network.
    - TCP/IP interface to Central I&C for data exchange. May use Rockwell software.TBD
    - Ethernet/IP network for Remote system control operator interfaces.
  - Software
    - RSLogix 5000 PLC programming software. PC platform
      - PID temperature control instructions.
    - RSView32 or SE MMI software---TBD . PC operator interface.

System Proposed 3

- Heater 120VAC control:
  - Zero crossing Time Pulsed Output (TPO) solid state relay supplies variable 120VAC pulse train to heater.
    - TPO chosen to minimize RFI to diagnostics.

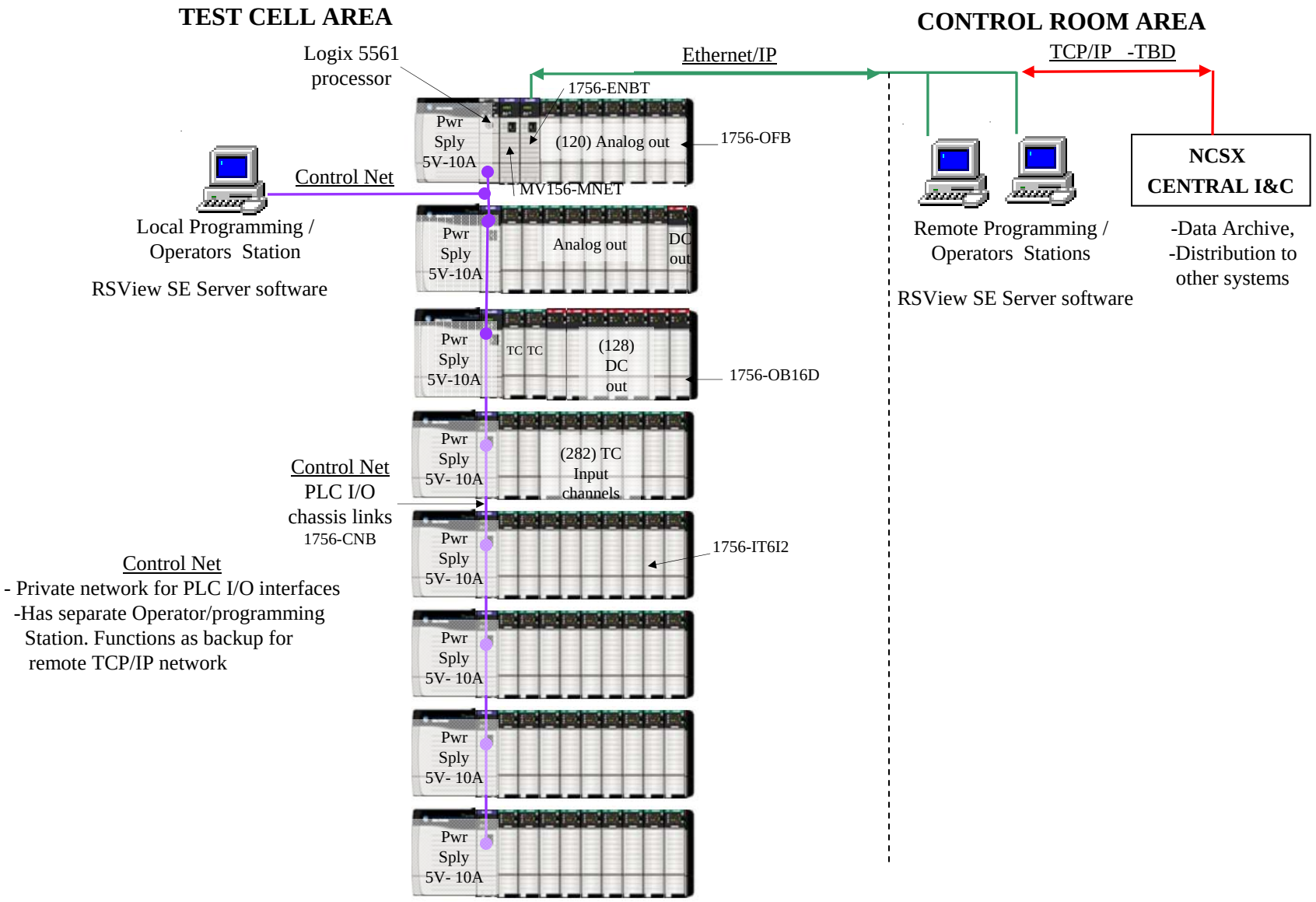


    - Phased output SSR's are noisy (i.e.. Standard lighting dimmers)

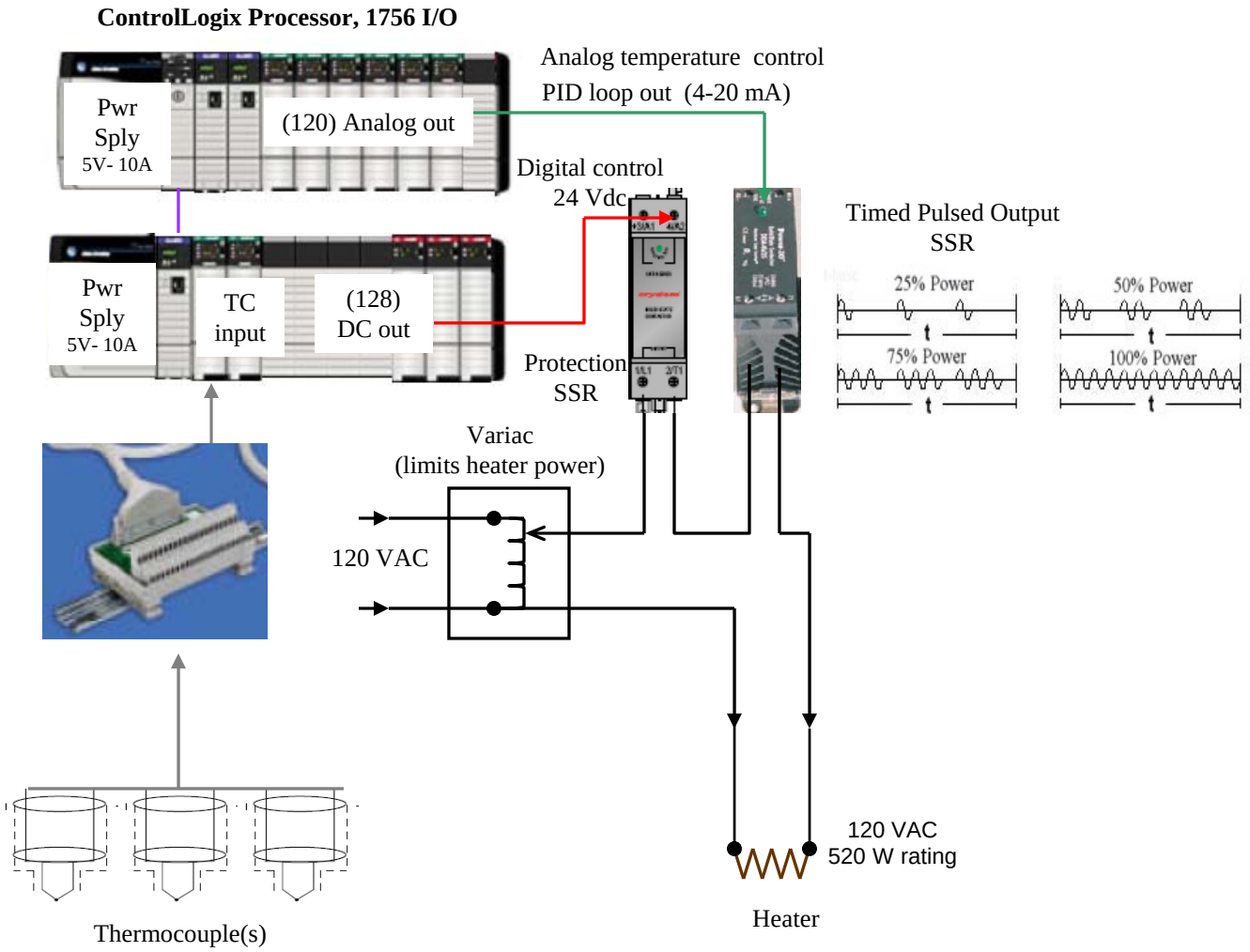


  - Heater power limited by Variac.
  - Secondary SSR protects for thermal runaway (shorted TPO control SSR).
  - One or more thermocouples provide feedback for each heating zone PID loop.
    - Failed TC sets alarm, notifies operator and removes TC for heating zone mix allowing conditional heater zone control.

Network Block Diagram



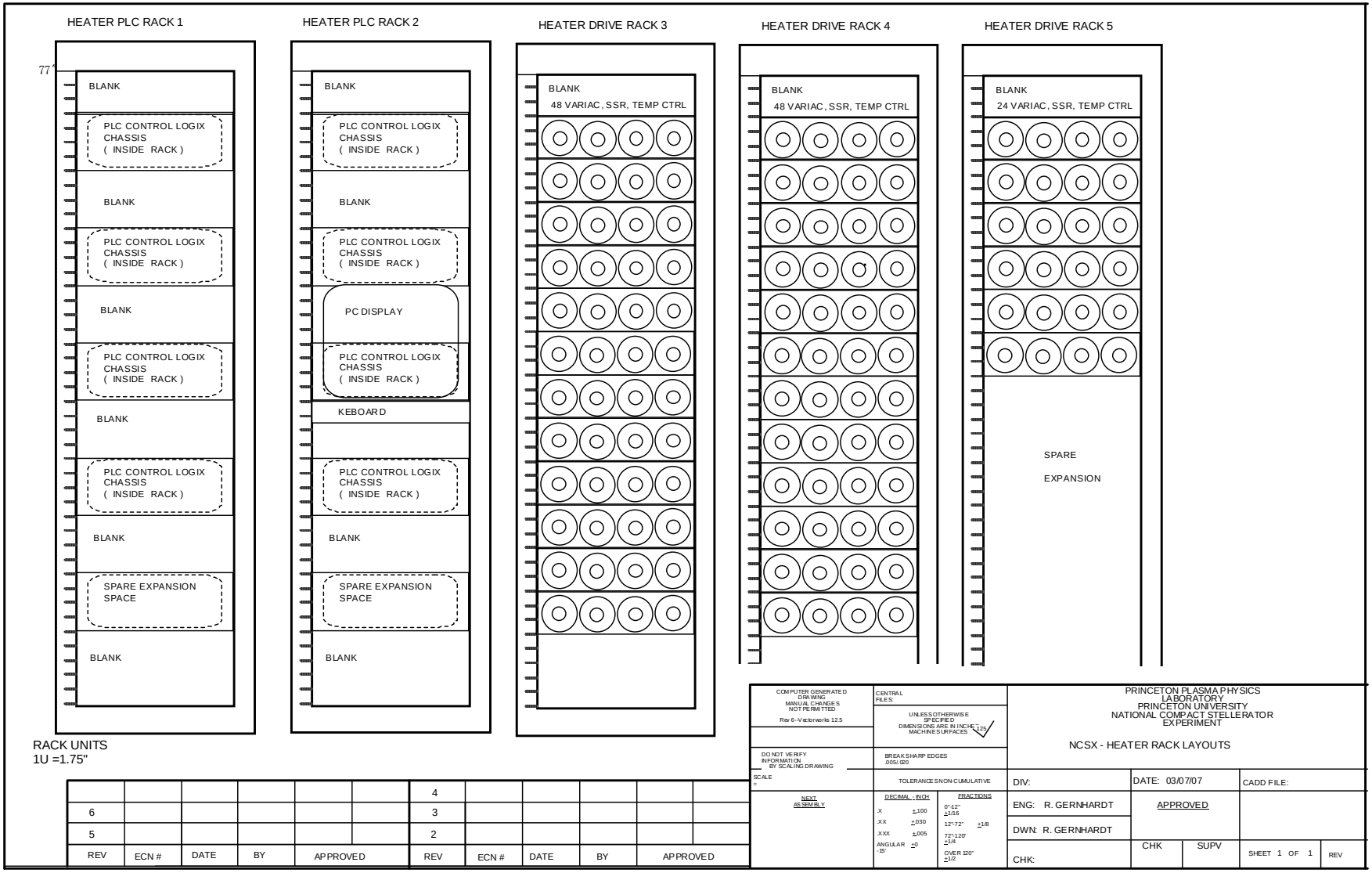
Heater Control Block Diagram



ControlLogix platform/wiring

1492 IN PANEL WIRING SYSTEMS FOR CONTROLLOGIX (1756 I/O)

Rack Layouts



Sensor Specifications

- Thermocouples:
  - Ref: NCSX-PRL-12-003-00
    - Type-E, Isolated, electrically floating junction Type-E, Isolated, electrically floating junction.
    - The TC shall be covered by a single layer braided jacket and fitted with a junction end fitting with holes which permit attachment with # 6 screws.
  - Similar to type Omega XCIB-E-4-3-10.

- Heaters:
  - Manufacture: BriskHeat
    - BH tech comment: “BIH series tapes are constant resistance type. Same R at full temp as at ambient turn on”.
  - ***Custom BIH Style Heating Tape:*** ½” W X 10 Ft. L, non-magnetic.
  - Heavy Insulated Heating Tape, **520 Total Watts**, 24” Leads Same End, Split Plug, 120 Volt.
  - ***Custom BIH Style Heating Tape:*** ½” W X 6 Ft. L, non-magnetic.
  - Heavy Insulated Heating Tape, **310 Total Watts**, 24” Leads Same End, Split Plug, 120 Volt

Thermocouple I/O

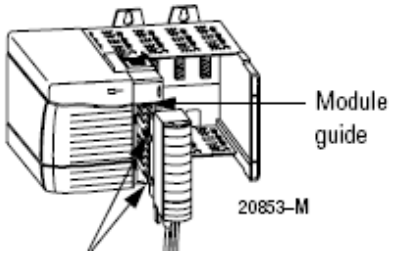
ControlLogix Enhanced Thermocouple Input Module

Catalog Number 1756-IT6I2

Specifications

Cat. No.	1756-IT6I2
Number of Inputs	6 individually isolated channels
Module Location	1756 ControlLogix Chassis
Backplane Current (mA) at 24V	120 mA
Backplane Current (mA) at 5V	200 mA
Backplane Power	3.9 W
Power Dissipation, Max.	3.9W
Thermal Dissipation, Max.	13.3 BTU/hr.
Input Signal Range	-12mV to +78mV (1.4µV per bit) -12mV to +30mV (0.7µV per bit – high resolution range)
Supported Thermocouple Types	B, E, J, K, R, S, T, N, C, D, L (TXK/XK)
Thermocouple Linearization	ITS-90
Input Resolution, Bits	16 bits (1.4µV/bit – Typical; 0.7µV/bit – High resolution range)
Data Format	Left justified, 2s complement – Integer mode IEEE 32 bit – Floating point mode
Input Impedance	> 10 MΩ
Open Circuit Detection Time	Positive full scale reading within 2 s
Overvoltage Protection	120V ac/dc maximum
Noise Rejection, Normal Mode	60 dB at 60 Hz[2]
Noise Rejection, Common Mode	160 dB minimum, tested at 600V ac/60Hz applied with 100 ohms differential resistance
Channel Bandwidth	15 Hz[2]
Settling Time to 5% of Full Scale	< 80 ms[2]
Module Conversion Method	Sigma-Delta

Isolation voltage (continuous-voltage withstand rating)	250 V user to backplane 250 V channel to channel Tested to withstand 3250V dc for 60 seconds user to backplane Tested to withstand 1900V dc for 60 seconds channel to channel	
Thermocouple Temperature/Millivolt Input Range	-12 to +78mV range	-12 to +30mV range
Thermocouple Type B	300…1820 °C 572…3308 °F	full range
Thermocouple Type C	0…2315 °C 32…4199 °F	0…1725 °C 32…3137 °F
Thermocouple Type E	-270…1000 °C -454…1832 °F	-270…415 °C -454…779 °F



Thermocouple Resolution Over Nominal Temperature Range	-12…+78mV range	-12…+30mV range
Type B, R, S, C	~ 0.15 °C ~ 0.28 °F	~ 0.08 °C ~ 0.15 °F
Type E, J, K, T, N	~ 0.05 °C ~ 0.09 °F	~ 0.03 °C ~ 0.05 °F
Type D	~ 0.07 °C ~ 0.13 °F	~ 0.03 °C ~ 0.05 °F
Type TXK/XK (L)	~ 0.02 °C ~ 0.04 °F	~ 0.01 °C ~ 0.02 °F
Calibrated Accuracy, Typical	0.05% of full range at 25 °C	
Calibrated Accuracy, Worst case	Better than 0.1% of full range at 25 °C[3]	
Calibration Interval	12 months	
Accuracy, Local Cold Junction Sensor	± 0.3 °C	
Accuracy, Remote Cold Junction Sensor	± 0.3 °C	
Input Offset Drift with Temperature	0.5 µV/ °C	
Gain Drift with Temperature, Nom.	15 ppm/ °C 1.4 µV/ °C for -12…+78 mV range 0.6 µV/ °C for -12…+30 mV range	
Gain Drift with Temperature, Max.	25 ppm/ °C 2.3 µV/ °C for -12…+78 mV range 1.1 µV/ °C for -12…+30 mV range	
Module Error over Full Temperature Range	0.15% of temperature range	
Module Scan Time for all Channels (Sample Rate)	25ms minimum – Floating point mode (millivolt) 50ms minimum – Floating point mode (temperature linearization) 10ms minimum – Integer (millivolt)	

CRYDOM SSR (protection relay)

crydom™

Series CKR240

10-30Amp • 240 Vac • AC OUTPUT

- SCR Output
- 10A, 20A & 30A Models
- Ground Terminal Included
- Zero Voltage and Random Turn-On Switching
- Low Leakage
- Integral Heatsink (22.5 mm)
- DIN Rail & Panel Mount
- Status Indicating LED
- DC or AC Control
- Integrated Overvoltage Protection by Automatic Self Turn-On (Suffix P Option)

The Series CKR Solid State Relays utilize Crydom's proprietary thermal management technology providing a compact and efficient design. Built-in DIN Rail attachment, easy-to-use Box Clamp type terminals and integral heat sinking complete the package. This compact new design offers up to 30Arms in ambient temperatures of 25°C.

Manufactured in Crydom's ISO 9001 Certified facility for optimum product performance and reliability.

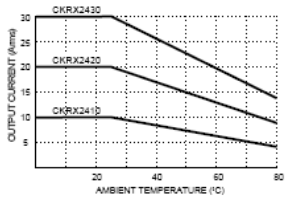
MODEL NUMBERS	CKRD2410 CKRA2410	CKRD2420 CKRA2420	CKRD2430 CKRA2430
OUTPUT SPECIFICATIONS ①			
Operating Voltage (47-63 Hz) [Vrms]	24-280	24-280	24-280
Max. Load Current @ 25°C Ambient Temperature [Arms]	10	20	30
Min. Load Current, [Arms]	0.15	0.15	0.15
Transient Overvoltage [Vpk]	600	600	600
Max. Surge Current, (16.6ms) [Apk]	120	250	625
Max. On-State Voltage Drop @ Rated Current [Vpk]	1.6	1.6	1.6
Maximum I^2t for Fusing, (8.3 msec.) [A^2sec]	60	260	1620
Max. Off-State Leakage Current @ Rated Voltage [mArms]	10	10	10
Min. Off-State dv/dt @ Max. Rated Voltage [V/µsec] ②	200	500	500
Max. Turn-On Time ③	1/2 Cycle (DC Control), 10.0 msec (AC Control)		
Max. Turn-Off Time	1/2 Cycle (DC Control), 40.0 msec(AC Control)		
Power Factor (Min.) with Max. Load	0.5	0.5	0.5

INPUT SPECIFICATIONS①	DC CONTROL	AC CONTROL Standard	AC CONTROL (E Suffix)
Control Voltage Range	4.0-32 Vdc	90-280 Vrms	18-36 Vrms
Max. Turn-On Voltage	4.0 Vdc	90 Vrms	18 Vrms
Min. Turn-Off Voltage	1.0 Vdc	10 Vrms	4.0 Vrms
Typical Input Current Range ④	8-12mA	2mA @ 120 Vrms, 4 mA @ 240Vrms	10mA @ 24 Vrms

GENERAL NOTES

GENERAL SPECIFICATIONS	
Dielectric Strength 50/60Hz Input/Output/Base	4000 Vrms
Insulation Resistance (Min.) @ 500 Vdc	10^9 Ohm
Max. Capacitance Input/Output	8 pF
Ambient Operating Temperature Range	-40 to 80°C
Ambient Storage Temperature Range	-40 to 125°C
Status Indicating Display	Green LED
MECHANICAL SPECIFICATIONS	
Weight: (typical)	10 oz. (280g)
Encapsulation:	Thermally Conductive Epoxy
Terminals:	Box Clamp Type
Maximum Wire Size:	AWG #10 (3mm)
Recommended Terminal Screw Torque Range:	5.0-8.0 in lb (0.6-0.7Nm)
Min. Side by Side Spacing	0.8 inch (20mm)

CURRENT DERATING CURVES

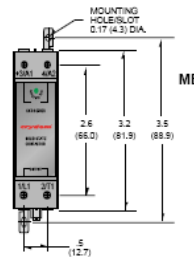


AVAILABLE OPTIONS

E 24 Vac Input (18-36 Vac)
Example: **CKRA2410E**

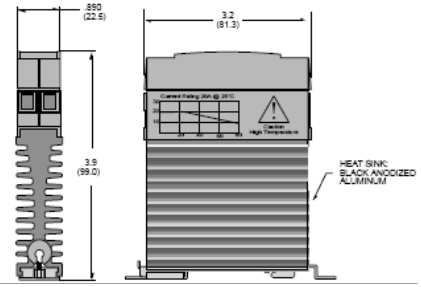
P Internal Overvoltage Protection.
Relay Will Self Trigger Between 450-600 Vpk.
Not Suitable For Capacitive Loads.
Example: **CKRD2410P** (AC & DC Control)

-10 Random Turn-On (AC & DC Control)
Phase Controllable (DC Control)
Example: **CKRD2410-10**



MECHANICAL SPECIFICATIONS

All dimensions are in inches (millimeters)



Power IO SSR (analog drive relay)

POWER-IO™ Intelligent Automation I/O Products

4-20mA activated, single phase, 25 or 40 amp, din rail contactor

•Accepts a 4-20mA analog process input and provides a high speed, time proportional AC output (TPO)
•Permits a PLC, PC, DCS or other control system to supply a TPO without any software programming or intensive CPU calculations of variable on time vs off time.
•Output cycle time ("ON" time + "OFF" time) = 0.5 second. Output resolution is one half of one sinewave (8.3 msec for 60 hz applications).

For example, when the POWER-IO unit is used to control an electric heater, band heater, heat sealing bar, etc:

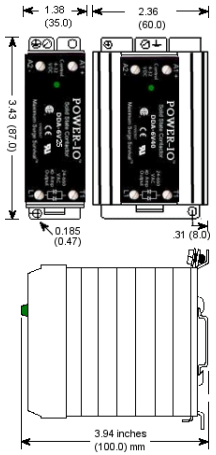
4mA = 0% = heater is off
12mA = 50% = heater is ON for 250 msec, OFF for 250 msec, ON for 1/4 second, OFF for 1/4 second...
16mA = 75% = heater is ON for 375 msec, Off for 125 msec, ON for 375 msec...
17.5mA = 84.375% = heater is ON for 422 msec, Off for 88 msec, ON for 422 msec...
20mA = 100% = heater is ON

Note: Rapid pulsing of the heaters provides the most precise temperature control, PLUS it dramatically increases the life of the heaters due to a reduction in the thermal stress of expansion and contraction.

Features

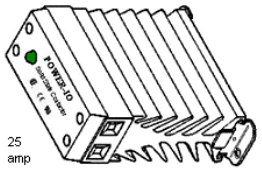
•Maximum Surge Survival™ technology -- triple layer, voltage surge protection
•Green LED for input status
•Thermally optimized heat sink permits edge-to-edge installations on a din rail
•Built-in snubber circuit
•Zero crossing activation -- low EMI, low noise to nearby electronics
•Internal 50A thyristors for high inrush capability

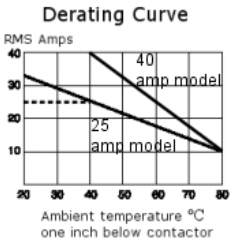
•4000 volt isolation, 1400 blocking voltage
•1000 volt per microsecond immunity
•Highest thermal efficiency -- less than 1.2 watts dissipated per amp switched.
•UL, CSA, CE
•Industry standard A1, A2, L1, T1 terminal numbers
•High density design permits more amps per square inch



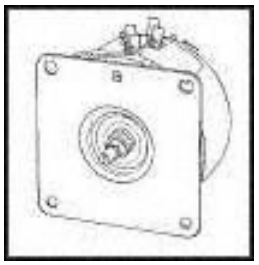
Specifications

Part Number	Line Voltage Range (VAC)	Load Current Range (A RMS)	Max Voltage Drop at 20mA
DC activated			
DMA-6V25	24-660	.10-25	6VDC
DMA-6V40	24-660	.10-40	6VDC
Off-State dv/dt	1000 v/µs		
Isolation	4000 volts		
I²T fuse	50A or less, for example: Bussman FWP50A14F, FWC32A10F, FWC20A10F. Ferraz B093910, M330015, K330013		
Turn-on time	<8.3 ms at 60hz		
Turn-off time	<8.3 ms at 60hz		
Terminals	Will accept #24-#10 AWG wire. Torque: 7-9 inch lbs.		





Variac



Newark InOne Part No.: **83F7131**
Manufacturer: **STACO ENERGY PRODUCTS**

Manufacturer Part No.: **511**
Description: **Variable Transformer Supply Voltage:120V; Power Rating:0.6kVA; Number of Phases:Single; Leaded Process Compatible:No; Current Rating:5A; Peak Reflow Compatible (260 C):No; Output Voltage Max:120VAC RoHS Compliant: No**

AC Power estimate

- 5 Equipment racks required
  - PLC Chassis rack 1
    - 1 Circuit, 120VAC @ 20 Amp
  - PLC Chassis rack 2
    - 1 Circuit, 120VAC @ 20 Amp
  - Heater Drive Rack 3
    - 1 Circuit, 120VAC @ 20 Amp
  - Heater Drive Rack 4
    - 1 Circuit, 120VAC @ 20 Amp
  - Heater Drive Rack 5
    - 1 Circuit, 120VAC @ 20 Amp
- Heater AC source power
  - If sized for max heater rating 520 W.
    120VAC @ 520 Amps required.
    - 520W/120VAC= 4.33A/htr
    - 120 htr x 4.33A = Requires 520 A
  - If sized for specified heater operation, 200 W continuous.
    120VAC @ 200 Amp required.
    - 200W/120VAC= 1.66 A/htr
    - 120 htr x 1.66A = Requires 200 A
  - **Providing circuits for 120VAC @ 360A continuous**

Control I/O M & S Costs

I/O M&S Total = $211,262

NCSX Heater/TC Instrumentation and Control Component Parts List								
	Provides for 120 Heaters and 282 Thermocouples							
Rev 1:	24 OCT 2007 R.Gernhardt							
Item	**Description**	**Mfgr**	**Model**	**unit cost**	**Qty**	**Item Cost**	**Comment**	**Source**
	PLC							
1	Logix 5560 processor with 2 M memory. (Is 2M enough??	Allen-Bradley	1756-L61	$5,105.00	1	$5,105.00	memory size???	Rumsey Electric
2	Control Logix Chassis, 10 slot	Allen-Bradley	1756-A10	$542.00	8	$4,336.00	TBD	Rumsey Electric
3	Control Logix Power supply, 10 A	Allen-Bradley	1756-PA 72	$805.00	8	$6,440.00		Rumsey Electric
4	Controlnet interface module	Allen-Bradley	1756-CNB	$1,312.00	8	$10,496.00		Rumsey Electric
5	Control Logix Ethernet interface module	Allen-Bradley	1756-ENBT	$1,760.00	1	$1,760.00		Rumsey Electric
6	MODBUS-TCP/IP communications module for 1756 chassis	ProSoft	MV156-MNET	$2,228.00	1	$2,228.00		Rumsey Electric
7	Control Logix Enhanced Isolated TC module, 6 Channel	Allen-Bradley	1756-IT6I2	$1,915.00	47	$90,005.00		Rumsey Electric
8	Interface module for above 1756-IT6I2	Allen-Bradley	1492-AIFM 6TC-3	$154.00	47	$7,238.00		Rumsey Electric
9	Cable for above 1756-IT6I2	Allen-Bradley	1492-ACABLE 025-Y	$177.00	47	$8,319.00		Rumsey Electric
10	Control Logix Ethernet interface module	Allen-Bradley	1756-ENBT	$1,760.00	1	$1,760.00		Rumsey Electric
11	Control Logix Analog Output, 8 Channel	Allen-Bradley	1756-OFB	$1,787.00	15	$26,805.00		Rumsey Electric
12	Cable for above 1756-IOFB	Allen-Bradley	??????????			$0.00	TBD	Rumsey Electric
13	Control Logix Digital Output, 16 Channel	Allen-Bradley	1756-OB16D	$727.00	8	$5,816.00		Rumsey Electric
14	Controlnet PCI interface card for local PC	Allen-Bradley	1784-PCIC	$1,569.00	1	$1,569.00		Rumsey Electric
15						$0.00		Rumsey Electric
16								
17	**SOFTWARE**							
18	Logic Programming, RSLogix5000, standard, NetWorx editi	Rockwell	9324-RLT300NXENE	$3,350.00	1	$3,350.00	TBD	Rumsey Electric
19	PIDE_AUTOTUNE software for RSLogix5000	Rockwell	9323-ATUNEENE	$490.00	1	$490.00	TBD	Rumsey Electric
20		Rockwell			1			Rumsey Electric
21	RSView SE Server 25 Display w/RSLinx Enterprise	Rockwell	9701-VWSS025LENE	3,960.00	1	$3,960.00	Server-- local?????	Rumsey Electric
22	RSView SE Server 25 Display	Rockwell	9701-VWSS025AENE		1	$0.00	Client-- Remote???/?	Rumsey Electric
23								
24	**CONTROL DISPLAY PC'S**							
25	Test cell PC, display & keybord	TBD		$1,300.00	1	$1,300.00		
26	Control room pc - supplied by CI&C	TBD						
27								
28	**HEATER DRIVE**							
29	Solid State Relay, 4-20ma in, 25 A AC TPO output	Power I/O	DMA-6V25	$99.00	120	$11,880.00		Power I/O
30	Solid State Relay, 4-32 VDC control, 20 A	Crydom	CKRD2420	$31.00	120	$3,720.00		Allied
31	Variac, 120VAC, 5 A	Staco	511	$98.00	120	$11,760.00		Newark
32	Fuse & holder, TBD			$1.00	120	$120.00		
33	Bud Panels for Variac mounting, 5.25" x 19"	Bud	PS-1252	$18.94	30	$568.20		Allied
34	Bud Panels for PLC mounting, 7" x 19"	Bud	PS-1253	$19.06	10	$190.60		Allied
35	DIN Rails, 6' length to mount SSR's and TC interfaces	Various		$5.00	12	$60.00		
36								
37	**FIELD CABLE CONNECTORS**							
38	Heater cable connectors, 16 socket, crimp type MS	Amphenol	MS3126F20-16S	$61.62	16	$985.92		Allied
39	Crimp tool, positioner, Ins/Ext for MS3126F20-163	Amphenol	M22520/1-01	$500.00	1	$500.00		
40	TC cable connectors, socket crimp type - G.Labik to purchase						TBD	
41						$0.00		
42	Misc hardware	various		$500.00	1	$500.00		
					TOTAL:	**$211,261.72**	NOTE: List cost	

AC Power, Field/Rack/Tray Wire M & S Costs

AC Pwr/Fld Tray M&S Total = $42,894

NCSX Resistance heating system field installation by: Frank Jones

Materials total: $42,894

Wire: #2 awg	$600
#4 awg	$180
#10 awg	$1000
2/0	$250
#6 & #8 awg	$140
Multi-conductor shielded (1000ft.), 105c	
Power cable for heaters ($6/ft.)	$6000
Thermo-extension cable (2000ft.):……..	
Type-E shielded-8pr.($4/ft.)	$8000
2-“GE” breakers & enclosure	$2000
42 ckt. “GE” panelboard…….	
3 ph. 4 wire, 150A	$1500
480v, square-D 70a Breaker (250 af)	$700
G-10 sheets…….	
5-1/8” 24” x 36”	$260
2-1/8” 36” x 76”	$364
PVC shed. 40 conduit, 50 ft.	$75
5-2.5kva MGE isolation Transformers	$6000
5-20a plugmold strips	$550

5-emi/rfi filters	$1500
5 fan assemblies	$500
30-25amp 1 pole breakers	$1050
5-20amp 1 pole breakers	$175
Panduit 2” x 2” in rack	$250
4” x 18” fiberglass tray fittings	
For thermo-wire	$1700
4 x 12” fiberglass tray fittings	
For heater power	$1200
4” x 18” fiberglass straight tray	
For thermo-wire	$2000
4 x 12” fiberglass straight tray	
For heater power	$1200
Aluminum and fiberglass Strut	$200
Isolation transformer	
45 kva, 480v to 208/120v…41kvdc iso.	$5500

Instrumentation and Control- Labor Estimate

NCSX RESISTANCE HEATING TEMPERATURE CONTROL SYSTEM						
Instrumentation and Control - R.Gernhardt- 10/24/07						
	Task		Man days			
DESIGN			eng	dsn	sr lab	tech
Documentaion		R.Gernhardt				
Rack layout (1 dwg)					1	
Internal PLC terminal layout drawings (6)					3	
Create Spreadsheet- End to End - Device to PLC wire list					5	
Intra rackCWD's, PLC to Drive components (10)					5	
Control		R Gernhardt, J.Dong, Sichta				
Define temp control algorithms, Associate TC W/Htr zones.					5	
Prepare I&C interface doc. & PLC tag assignment			5		10	
Select/Evaluate Control software packages			1		1	
CI&C interface development			5		2	
		Design Man Days	11	0	32	0
PROCUREMENT			eng	dsn	sr lab	tech
Connectors		R Gernhardt				
Order Heater Field cable connectors (MS type)					0.5	
Hardware						
Order PLC I/O hardware					1	
Order Heater Drive components					0.5	
Software						
Order Control display software					1	
		Procurement Man Days	0	0	3	0

FABRICATION			eng	dsn	sr lab	tech
Prototype		R Gernhardt				
Configure/Evaluate typical htr / TC control channel					5	
Rack		Tech shop				
Fabricate Variac and PLC mounting panels (40)						2
Mount Variacs (120) to panels						2
Mount Drive components (240- SSR's) on DIN rails						2
Control		R Gernhardt				
Configure & program PLC					20	
Program RSView control pages (heater ~6), (TC~6), (System~7)					20	
		Fabrication Man Hours	0	0	45	6
INSTALLATION			eng	dsn	sr lab	tech
Rack		R Gernhardt/ Tech shop				
Install and wire Drive components					1	10
Control		R Gernhardt/Tech shop				
Install / network PLC chassis (8), Wire PLC I/O,					3	3
Test- PLC & Control software					5	
Install / network test cell PC ---- J.Dong			1			
Commission I&C interface, test ----R.Gernhardt/ J.Dong			5		5	
Test Procedure					1	
		Installation Man Days	6	0	15	13
LABOR			**eng**	**dsn**	**sr lab**	**tech**
		TOTAL Man Days	**17**	**0**	**95**	**19**
		Man Hr	136		760	152
		Man Month	0.85		4.75	0.95

AC Power, Field/Rack/Tray Wire- Labor Estimate

NCSX RESISTANCE HEATING TEMPERATURE CONTROL SYSTEM					
AC Power, Field/Rack/Tray Wire- F.Jones--- 10/24/07					
Task		Man days			
DESIGN		eng	dsn	sr lab	tech
Design/drafting & supervision- F.Jones					
Machine elevation & tray details			4		
Tray support fabrication detail			4		
Rack internal layout details			3		
Existing Panel draw rev.			1		
New panel schedule dwg.			1		
Shutdown dwg			1		
AC power CWD for panel/xfmr			1		
5 rack ac power CWDs			3		
Heater power from rack to connector					
Wiring diagrams & termination details			4		
Thermocouple wiring from rack to					
Machine and termination details			4		
Tray test cell plan drawing			3		
JHA, procedure, ECN, work order			3		
Package issue and field walk down			2		
	Design Man Days	**0**	**34**	**0**	**0**
PROCUREMENT		eng	dsn	sr lab	tech
AC Power	F.Jones/tech shop				
Order Breakers, Panels, Pwr cable, field cables, x-formers			1		
Tray/Conduit	F.Jones/tech shop				
Order tray/ conduit			1		
Material research	F.Jones		1		
	Procurement Man Days	**0**	**3**	**0**	**0**
FABRICATION		eng	dsn	sr lab	tech
Tray Conduit prefab	Tech shop				4

INSTALLATION	eng	dsn	sr lab	tech
Construction/Electricians				
Install 70a, 3 pole 480v breaker				
(coordinate panel PP_141 shutdown)				2
Install conduit thru wall to test cell				2
Install 45 kva isolation transformer				
(handling and secure to floor)				4
Install primary & secondary breaker				2
Install new panelboard				
(assemble & install branch breakers)				2
Install conduit between xfmr and breaker Enclosures				2
Install ac power conductors & terminate				6
Install power and instrument dedicated trays				
around top and bottom of machine				16
Fabricate & Install tray support system				4
Install rack power conduit				4
Install 2-trays from machine to racks				8
Install 5 racks insulated to 5KV				8
Install 5 isolation xfmrs at racks				
(install 5 filters and plugmold strips)				7
Hi-pot racks to verify isolation				
(coordinate with TC work)				2
Install rack power wire 1/c #10				2
Install heater power from panel to rack				
(30-120v circuits-fan out at racks)				10
Install/terminate heater power from racks to				
Machine via tray 12				12
Install/terminate thermocouple extension				
Wire from rack to machine				24
Revision/Construction Supervision		5		
		5	**0**	**117**
	eng	**dsn**	**sr lab**	**tech**
TOTAL AC Pwr/Fld Man Days	**0**	**42**	**0**	**121**
Man Hr	0	336	0	968
Man Month	0	2.1	0	6.05

Total Costs- M&S and Labor

NCSX RESISTANCE HEATING TEMPERATURE CONTROL SYSTEM				
MATERIALS & SUPPLY	Quantity	units	unit cst	Total
Ray G estimate				
A-B PLC hardware,Software, I/O modules, term blks				
Control PC/Displays, Network modules,				
Heater Drive components and Field Cable connectors				$211,262
F.Jones estimate				
AC power, breakers, enclosures, panels, x-formers, wiring				
Cable tray, conduit, TC/Htr Field cables				
Rack filters, fans and installation materials				$42,894
TOTAL Materials cost (unloaded)				**$254,156**

TOTAL LABOR ESTIMATE				
Instrumentation & Control	eng	dsn	sr lab	tech
Computer Div. / R.Gernhardt / Electrical Tech				
Includes Design, Procurment, Fabrication and Installation				
Man Days	**17**	**0**	**95**	**19**
AC Power, Field/Rack/Tray Wire				
F.Jones- Design/Drafting / Electrical Tech (Tech Shop)				
Includes Design, Procurment, Fabrication and Installation				
Man Days	**0**	**42**	**0**	**121**
LABOR Totals (I&C + AC PWR)	**eng**	**dsn**	**sr lab**	**tech**
TOTAL Man Days	**17**	**42**	**95**	**140**

ESTIMATE BASED ON:
1) PLC feedback control system to maintain port temperatures during stanby and bakeout operations.
2) 120 zones of ACTIVE heater temperature control.
3) 282 thermocouple channels available for monitoring and feedback control of vacuum vessel and port extension temperatures.
4) Archival of TC temperatures and heater power in central I&C.
ESTIMATE INCLUDES:
1) AC power labor and M&S costs.
2) PLC programming and M&S costs
3) Rack installations and wiring cost
4) Includes TC/Htr Field cabling and terminination costs from control racks to feedthru ports at vessel.
5) Test and commissioning costs.
COSTS NOT INCLUDED:
1) Control room PCs (2?) computer division