LArIAT CRYOGENIC CONTROL SYSTEM

CONTROL LOGIC

Location: FermiLab\MESON\MC7\Fixed Target Enclosure

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ENGINEERING NOTE
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Introduction

The LARIAT cryogenic test system is currently in the MC7 Hall at FermiLab. The MC7 hall is classified as ODH class 0 area and has several medium sized cryogenic and gas components. Cryogens include liquid Argon.

This cryogenic system has approximately 50 electronic input sensing devices and 10 output devices. Input devices include RTD’s, pressure transmitters, level transmitters, and thermocouples. Output devices include solenoid valves, motor controllers, and heaters.

This engineering note will describe the control system behavior for both programmed logic and hardwired logic.

Cryogenic Control System

The LARIAT cryogenic system will be controlled by a Siemens S7-400 PLC with Siemens 505 associated I/O modules networked on a Profibus network. This PLC system will be programmed using the Siemens S7 engineering programming software.

The control system behavior is defined in terms of the “control devices” or outputs which you will find on the right side of the tables. Inputs help determine the programmed logic and are listed on the left hand side of the tables. There is a hardwired column which defines actions that are hardwired into the output devices.

PLC Inputs

4-20mA(in)	**AT606-PPM**	gas analyzers	dewpoint meter	0-1000 ppm	Vaisala
4-20mA(in)	**AT605**	filter regeneration vent gas sample	dewpoint meter	-80 to +20 C	Vaisala
4-20mA(in)	**AT606-DP**	gas analyzers	dewpoint meter	-60 to +20 C	Vaisala
4-20mA(in)	**AT607**	gas analyzers	oxygen analyzer	0 - 50 ppm	Servomex (Delta-F)
4-20mA(in)	**AT608**	gas analyzers	water analyzer	0 - 20 ppm	Tiger Optics
4-20mA(in)	**AT609**	gas analyzers (AT-608 output)	dewpoint meter	-80 to +20 C	Vaisala
4-20mA(in)	**AT610**	gas analyzers	nitrogen analyzer	0 - 100 ppm	Servomex
4-20mA(in)	**AT611**	gas analyzers	oxygen analyzer	0 - 50 ppm	Servomex (Delta-F)
4-20mA(in)	**LT208A**	cryostat level	ΔP transmitter	0-2 psid (0-16.67 ft)	GP:50
4-20mA(in)	**LT209A**	cryostat level	AMI Probe	0 - 6"	
4-20mA(in)	**LT686A**	500 Gal Argon Dewar level	ΔP transmitter	0-150" H2O	
4-20mA(in)	**PT117A**	MS-CF Regeneration Supply Pressure	Pressure Transducer	0 - 250 psia	Setra
4-20mA(in)	**PT219A**	Cryostat Pressure	Pressure Transducer	0 - 50 psia	Setra
4-20mA(in)	**PT687A**	500 Gal Argon Dewar pressure	Pressure Transducer	0-100 psig	
4-20mA(in)	**PT843A**	Vapor Comp 2 suction pressure	Pressure Transducer	0-100 psia	
4-20mA(in)	**PT845A**	Vapor Comp 2 discharge pressure	Pressure Transducer	0-100 psia	
4-20mA(in)	**FT424H**	ArgonH2 Regen flow readback from FCV424H	Flow Transmitter	0 - 30 SCFM	
4-20mA(in)	**FT653A**	Argon Regen flow readback from FCV653A	Flow Transmitter	0 - 30 SCFM	
4-20mA(in)	**AE-819-V**	ODH1 O2 Sensor		0-25% O2	
4-20mA(in)	**AE-820-V**	ODH2 O2 Sensor		0-25% O2	
4-20mA(in)	**AE-823-V**	ODH3 O2 Sensor		0-25% O2	
4-20mA(in)	**AE-824-V**	ODH4 O2 Sensor		0-25% O2	
4-20mA(in)	**PT304N**	LAr transfer line pressure downstream of filter	Pressure Transmitter	0-100 psig	
0-10VDC (IN)	**PIT264V**	Cryostat TPC bottom seal vacuum	Pressure Transducer	10E-4 - 1000 Torr	Instrutech
0-10VDC (IN)	**PIT265V**	Cryostat TPC end cap seal vacuum	Pressure Transducer	10E-4 - 1000 Torr	Instrutech
0-10VDC (IN)	**PIT266V**	Cryostat neck seal vacuum	Pressure Transducer	10E-4 - 1000 Torr	Instrutech
0-10VDC (IN)	**PIT263V**	Cryostat Insulating Vacuum	Pressure Transducer	10E-4 - 1000 Torr	Instrutech
0-10VDC (IN)	**PIT195V**	Mole Sieve-Copper Filter Vacuum	Pressure Transducer	10E-4 - 1000 Torr	Instrutech

PLC Inputs

RTD IN	**TE214A**	cryostat neck metal temperature	100 ohm platinum RTD	n/a	
RTD IN	**TE190A**	MS-CF Temperature Top	100 ohm platinum RTD	n/a	Omega
RTD IN	**TE191A**	MS-CF Temperature MidTop	100 ohm platinum RTD	n/a	Omega
RTD IN	**TE192A**	MS-CF Temperature Mid	100 ohm platinum RTD	n/a	Omega
RTD IN	**TE193A**	MS-CF Temperature MidBot	100 ohm platinum RTD	n/a	Omega
RTD IN	**TE194A**		100 ohm platinum RTD	n/a	Omega
RTD IN	**TE212A**	Upper TPC cryostat temperature	100 ohm platinum RTD	n/a	
RTD IN	**TE213A**	Lower TPC cryostat temperature	100 ohm platinum RTD	n/a	
DI (24VDC)	**ODH_ALARM1**	ODH System Alarm Input			
DI (24VDC)	**ODH_TROUBLE**	ODH trouble System Input			
DI (24VDC)	**ODH_FAN_AC_MONITOR**	ODH control system AC power monitor Input (FAN1)			
DI (24VDC)	**AT607_R1**	DF-310 Range Status	oxygen analyzer		Servomex (Delta-F)
DI (24VDC)	**AT610_R1**	SERVOPRO N2 analyzer Range Status	nitrogen analyzer		Servomex
DI (24VDC)	**AT610_R2**	SERVOPRO N2 analyzer Range Status	nitrogen analyzer		Servomex
DI (24VDC)	**AT610_R3**	SERVOPRO N2 analyzer Range Status	nitrogen analyzer		Servomex
DI (24VDC)	**AT611_R1**	DF-310E Range Status	oxygen analyzer		Servomex (Delta-F)
DI (24VDC)	**ODH_FAN_FLOW**	ODH Fan run status			

PLC Outputs

4-20mA(OUT)	**LCV105A**	Cryostat Argon Level Control Valve	Level Control Valve	0-100 %	
4-20mA(OUT)	**FCV424H**	ArgonH2 Regen flow control	Mass Flow Controller	0 - 30 SCFM	
4-20mA(OUT)	**FCV653A**	Argon Regen flow control	Mass Flow Controller	0 - 30 SCFM	
4-20mA(OUT)	**PCV220A**	Cryostat Vent	pressure control valve		
4-20mA(OUT)	**HE412A**	Regen Heater	gas heater	n/a	Omega
4-20mA(OUT)	**HE416A**	Regen Heater	gas heater	n/a	Omega
4-20mA(OUT)	**PCV852V**	gas analyzer booster pump inlet restriction	control valve	Cv max = 0.02	Swagelok
D0 (24VDC)	**PLC_ODH_FAN_CONTROL**	PLC ODH Fan Control			
RELAY OUT	**PU266**	Dry Vacuum Scroll Pump Cryostat Vacuum			
RELAY OUT	**PU854A**	Vapor Compressor 2			
RELAY OUT	**PV799**	Dry Vacuum Pump			

LArIAT PLC Logic

Pressure Control Logic

LARIAT at MC7 System----Pressure Control Logic Flow Diagram

CRYOSTAT COOLING SECTION LOGIC

PLC SOFTWARE			HARDWARE	ACTION
AUTO/Manual/Operator Set Point				**PCV220A**
PV = PT-219-A	*Loop*			Argon Vent
		open 100%		0-100%
PT219 > 12.0 psig		Override		
AUTO/Manual/Operator Set Point				**LCV105A**
PV = LT-209-A	*Loop*			Argon Supply
				0-100%
ODH Alarm		close 0%		
PT219>10 psig	or	Override		
AUTO/Manual/Operator Set Point				**PCV852A**
PV = PT-845-A	*Loop*			Analyzers intake pressure
				0-100%

Purifier Logic

LARIAT at MC7 System----Control Logic Flow Diagram

PURIFIER SECTION LOGIC

PLC SOFTWARE			HARDWARE	ACTION
				FCV424H
Operator Set Point				Argon/H2 Gas
		Permit		0-30 SCFM
No ODH Alarm	and	latch		
TE417A > 100 C	and	latch		
TE418A > 100 C	and	latch		
TE413A > 100 C	and	latch		
TE414A > 100 C	and	latch		
Low T Op SP < TE190A < 250 C	and	latch		
Low T Op SP < TE191A < 250 C	and	latch		
Low T Op SP < TE192A < 250 C	and	latch		
Low T Op SP < TE193A < 250 C	and	latch		
Low T Op SP < TE194A < 250 C	and	latch		
				FCV653A
Operator Set Point				Argon Gas
		Permit		0-30SCFM
No ODH Alarm	and	latch		
TE417A > 100 C	and	latch		
TE418A > 100 C	and	latch		
TE413A > 100 C	and	latch		
TE414A > 100 C	and	latch		
Low T Op SP < TE190A	and	latch		
Low T Op SP < TE191A	and	latch		
Low T Op SP < TE192A	and	latch		
Low T Op SP < TE193A	and	latch		
Low T Op SP < TE194A	and	latch		

ODH System Logic

LARIAT at MC7 System----Control Logic Flow Diagram

ODH and MISC SECTION LOGIC

PLC SOFTWARE		HARDWARE		ACTION
Operator Command				**ODH_FAN_CONTROL**
ON when AE-819 is below19.5%	or	AE-819 < 19.5%	or	FIRUS Alarm
ON when AE-820 is below 19.5%	or	AE-820 < 19.5%	or	Horn/Strobe
ON when AE-823 is below 19.5%	or	AE-823 < 19.5%	or	
ON when AE-824 is below 19.5%	or	AE-824 < 19.5%	or	
Daily Test	EN/DIS or			

Heaters Logic

LARIAT at MC7 System----Control Logic Flow Diagram

HEATER SECTION LOGIC

PLC SOFTWARE			HARDWARE		ACTION
AUTO/Manual/Operator Set Point		***Hi Limit Control***			**HE-412-A (0-100%)**
PV =TE414A	*Loop*				
		Permit		Permit	
TE413A < 300C	and	latch	TE415A < 300 C	Man Reset	
TE414A < 300C	and	latch			
TE190A < 250 C	and	latch			
TE191A < 250 C	and	latch			
TE192A < 250 C	and	latch			
TE193A < 250 C	and	latch			
TE194A < 250 C	and	latch			
PT117A > 25 PSIG	and	latch			
AUTO/Manual/Operator Set Point		***Hi Limit Control***			**HE-416-A(0-100%)**
PV =TE418A	*Loop*				
		Permit		Permit	
TE417A < 300C	and	latch	TE419A < 300 C	Man Reset	
TE418A < 300C	and	latch			
TE190A < 250 C	and	latch			
TE191A < 250 C	and	latch			
TE192A < 250 C	and	latch			
TE193A < 250 C	and	latch			
TE194A < 250 C	and	latch			
PT117A > 25 PSIG	and	latch			

Alarms and Auto-Dialer

AD alarms	AD #
Analog	
LT-209-A Cryostat level High	1
LT-209-A Cryostat level Low	2
PT-219-A Cryostat pressure High	3
PT-219-A Cryostat pressure Low	4
LT-686-A Argon Dewar pressure High	5
LT-686-A Argon Dewar pressure Low	6
Filter temperatures High	7
Filter temperatures Low	8
Digital	
ODH	9
ODH trouble	10
Commercial/Vent Fan A/C power loss	11
PLC Watchdog	12