DRAWING TITLE

UNIT-CONTROL BALANCE OF PLANT FUNCTIONAL SPECIFICATION

Solar® Turbines
A Caterpillar Company

TURBOMACHINERY SYSTEMS PROVIDER

YPFB Transporte S.A.

CUSTOMER

PROJECT NAME	
YPFB TRANSPORTE SAIPURU **PSN: CC02141**	DRIVER Centaur 50
	EQUIPMENT C40-P-1
	LOCATION Saipuru, Bolivia

REV	DESCRIPTION	DATE	ERCC
A	Initial Submittal	11 Oct 2023	CDM
B	As-Shipped Release	02 Jan 2024	CDM

APPROVED	
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DRAWING NO.

G2111 - 149008

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B0	**66195**	**YPFB SAIPURU C50**	**B**	**1 OF 37**

TABLE OF CONTENTS

INTRODUCTION

Document Purpose & Scope

This document describes the unit balance of plant control system. Unit balance of plant generally refers to turbomachinery related systems that are not completely located on the driver or driven equipment skids, but are under the control of or interface to the unit control system.

The purpose of the document is to:
1. ***Clearly and completely define the control objectives for this project.***
2. ***Provide a functional description of the control system solutions designed to meet the objectives***

Once approved, this document will serve as a basis for the design of the control system hardware and software.

Functional descriptions will include the inputs to the system, the outputs from the system, and how the outputs change in response to changes in the inputs. It is not the purpose of this document to describe the specific hardware and software that will be used to implement the actual control system.

Review Guidelines

This document is intended to be the primary means of communicating the functional description of the unit balance of plant control system between Solar and the customer's technical personnel. It is expected that the document will undergo some intermediate revisions before being finalized.

To expedite the review process, the following guidelines are recommended:

1. Electronic review of the document is preferred over hardcopies. If possible, PDF format should be used to make direct marked-up comments or changes to the document. Solar will review the marked-up document, and incorporate the comments and modifications, as necessary on the next document update/revision.
2. A customer single point of contact is desired. This person should be responsible for internal distribution of the document, as well as reviewing the document for clarity, completeness and consistency before forwarding it to Solar.

References

The following documents were used as references for this specification.

Document Title	***Drawing No.***	***Rev / Date***
Process and Instrumentation Diagram	SC-E24-PR-01-03-02	Rev 01 / Jan 2017
Anti-Surge Document	71911-149653	Rev A0 / Sept 2001

Change Summary

Rev	***Summary of Changes***
A	Initial release
B	Updated BOP to implement Customer Markups

CONTROL OBJECTIVES

The primary balance of plant control objectives are as follows:

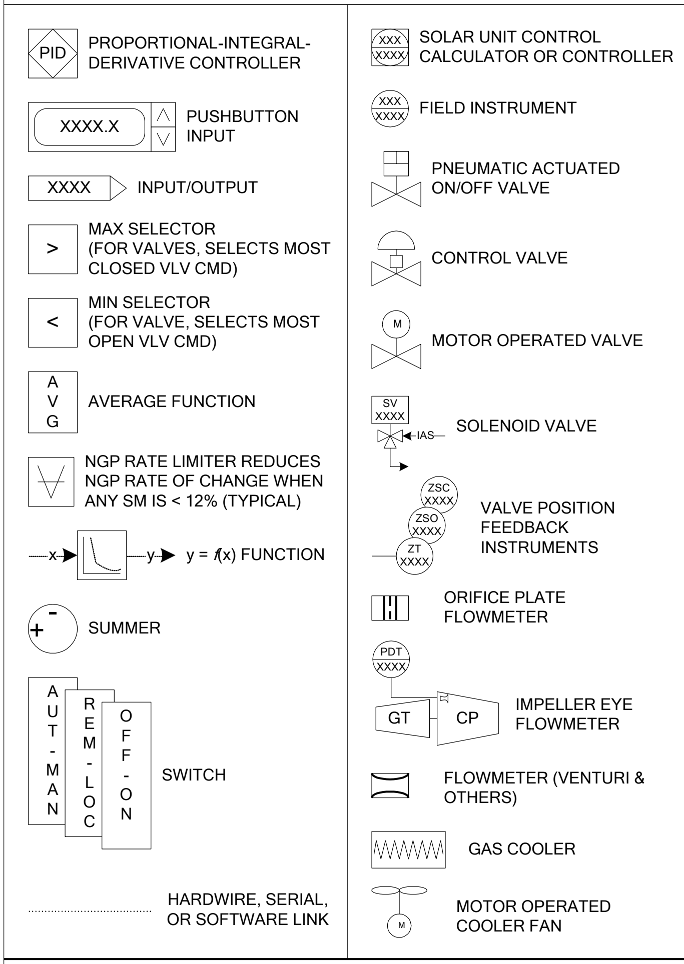
1. Yard Valves Sequencing
2. Anti Surge Control
3. Process Control Utilizing NGP Speed
    - Suction Pressure
    - Flow
    - Discharge Pressure
4. Process Control Utilizing Anti Surge Valve
    - Suction Pressure
    - Flow
    - Discharge Pressure
5. Gas Cooler Control
6. Communication Layout

For project that consists of multiple compressor trains, only one train's I/O and control functions are described in this document. I/O and control functions apply to all trains in the plant and should be considered identical unless otherwise noted.

LEGEND

The table below shows the legend for symbols, abbreviations and labels used throughout the BOP FS document

SYMBOLS



TAG NUMBER IDENTIFICATION

ASC	- Anti-surge Controller
BDV	- Blowdown Valve
FC	- Flow Calculator
FCV	- Flow Control Valve
FIC	- Flow Indicator and Controller
FT	- Flow Transmitter
LCV	- Level Control Valve
LDE	- Load Equalization Controller
LIC	- Level Indicator and Controller
LSC	- Load Share Controller
LT	- Level Transmitter
PCV	- Pressure Control Valve
PT	- Pressure Transmitter
PIC	- Pressure Indicator & Controller
PID	- Proportional-Integral Derivative Controller
SDV	- Shutdown Valve
SIC	- Speed Indicator and Controller
TCV	- Temperature Control Valve
TRC	- Train Recycle Controller
TT	- Temperature Transmitter
TIC	- Temperature Indicator and Controller
ZSC	- Closed Limit Switch
ZSO	- Open Limit Switch
ZT	- Position Transmitter

ABBREVIATIONS

ABDV	- Atmospheric Blowdown Vlv
Aft Clr	- After Cooler
AIF	- Air Inlet Filter
ASC	- Anti-surge Control/Controller
ASP	- Setpoint from Auxiliary Panel
ASV	- Anti-surge Valve
Aut	- Auto
Aux	- Auxiliary
Axl	- Axial
BV	- Bypass Valve
CCV	- Capacity Control Valve
Clr	- Cooler
Cmd	- Command
Con	- Control, Controller
CP/Cpsr	- Compressor
DCS	- Distributed Control System
DE	- Driven End
Det	- Detection, Detected
Dis	- Discharge
DLV	- Discharge Loading Valve
DV	- Discharge Valve
EMD	- Electric Motor Drive
EQV	- Equalization Valve
Enbl	- Enable
Encl	- Enclosure
ESD	- Emergency Shutdown
EXC	- Export Compressor
Exp	- Export
Ext	- External
IAS	- Instrument Air Supply
FO	- Fail Open
FC	- Fail Closed / Flow Calculator
FL	- Fail Last
Fltr	- Filter
F&G	- Fire and Gas
FG	- Fuel Gas
FME	- Flow Measurement Element
FSV	- Fast Stop Valve
FV	- Flare Valve
GB	- Gearbox
GOV	- Gas Operated Valve
GT	- Gas Turbine
H	- High (alarm)
HBV	- Hot Bypass Valve
HH	- High-High (shutdown)
HMI	- Human Machine Interface
HPC	- High Pressure Compressor
HPVV	- High Pressure Vent Valve
Htr	- Heater
I/P	- Current to Pressure Converter
Ind	- Indication
Inst	- Instrument
Int Clr	- Inter Cooler
IPC	- Intermediate Prs Compressor
I/Z	- Current to Position Converter
KD	- Derivative Gain
KI	- Integral Gain
KP	- Proportional Gain
L	- Low (alarm)
LDE	- Load Equalizer
LL	- Low-Low (shutdown)
LO	- Lube Oil
LOC	- Local
LPC	- Low Pressure Compressor
LPVV	- Low Pressure Vent Valve
LSC	- Load Share Controller
LSP	- Setpoint from Local Panel
LV	- Loading Valve
Lvl	- Level
Man	- Manual
MCC	- Motor Control Center
MOV	- Motor Operated Valve
Mstr	- Master
Mtr	- Motor
NC	- Normally Closed
NDE	- Non-Driven End
NGP	- Gas Producer Speed in %
NO	- Normally Open
NOK	- Condition is Not OK
NPT	- Power Turbine Speed in %
OFS	- Offset
OK	- Condition is OK
OOP	- Out of Position
OP	- Output
PFD	- Process Flow Diagram
PLC	- Programmable Logic Controller
Pmp	- Pump
Pos	- Position
Pri	- Primary
Prs	- Pressure
RCP	- Remote Control Panel
RCV	- Recycle Control Valve
Rel	- Release
Relsd	- Released
Rem	- Remote
Resv	- Reservoir
RSP	- Setpoint from Remote Panel
Rup	- Rupture
SCADA	- Supervisory Control & Data Acquisition
Scrbr	- Scrubber
Sec	- Secondary
SHtr	- Super Heater
SLV	- Suction Loading Valve
Sol	- Solenoid
SP	- Setpoint
SPH	- High Setpoint
SPL	- Low Setpoint
SS	- Side Stream
Stat	- Status
Stn	- Station
Stnr	- Strainer
Suc	- Suction
Sup	- Supply
SV	- Suction Valve
Sys	- System
TCP	- Turbine Control Panel
TD	- Turndown
Tmp	- Temperature
Tnk	- Tank
TRC	- Train Recycle Controller
Trn	- Train
TRV	- Train Recycle Valve
UCP	- Unit Control Panel
VFD	- Variable Frequency Drive
Vnt	- Vent
VV	- Vent Valve
WHRU	- Waste Heat Recovery Unit

Figure 1 - Legend

BALANCE OF PLANT DEVICE LIST

This section describes the I/O points for the unit balance of plant. Physical I/O (hardwired) points are defined as well as virtual I/O points such as local and remote set points from the IO or station control / DCS, and calculated parameters going to the station control or DCS.

The following notes apply to the I/O points.

Note Number	Note
1	RTD Modules can read from -328 to +1568 Deg F based on 100 Ohm Platinum RTDs. Nominal software RTD bounds are between -160 to 400 deg F. However, see software for specific fault detection ranges.
2	
3	
4	
5	
6	

Analog Inputs

No	Rev	Customer Tag No	Solar Tag No	Description	From	Signal Type	Range	Units	Control SP	Alarm & Shutdown							Notes
										lo SD	lo AL	hi AL	hi SD	Arming Point	lo SD Action	hi SD Action	
1	A	ZT5113	ZT7631	HPC ASV Pos	Field	4-20mA	0-100	%CL	-	-	-	-	-	-	-	-	
2	A	PT5110	PT4410	HPC Suc Prs	Field	4-20mA	0-1500	psig	-	650	700	-	-	Cpsr Press'd	CD-NL	-	
3	A	TE5110	TE7410	HPC Suc Tmp	Field	RTD	0-400	deg F	-	-	50	200	-	-	-	-	See Note 1
4	A	PT5111	PT4430	HPC Dis Prs	Field	4-20mA	0-2000	psig	-	-	-	1210	1220	-	-	CD-NL	
5	A	TE5111B	TE4430	HPC Dis Tmp	Field	RTD	0-400	deg F	-	-	-	140	170	-	-	FS-NL Prs	See Note 1
6	A	PDT5110	PDT4400	HPC Impeller Eye DP Surge	Field	4-20mA	0-7.21	psid	-	-	-	-	-	-	-	-	
7	A	PDT5110-2	PDT4401	HPC Impeller Eye DP Map	Field	4-20mA	0-400	inH2O	-	-	-	-	-	-	-	-	
8	A	PDT5115	PDT7620	HPC Loading Vlv DP	Field	4-20mA	0-100	psid	25	-	-	-	-	-	-	-	
9	A	TE5112	TT7460	HPC Aft Clr Tmp	Field	RTD	0-400	deg F	-	-	-	-	-	-	-	-	
10	A	FT-6100	Process Control Suction Flow	Process Ctrl Suction Flow Input	Field	4-20mA	0-500	MMSCFD	-	-	-	-	-	-	-	-	
11	A		NGP_EXT	NGP Speed ExternalSP	Customer	4-20mA	72-100	% NGP	-	-	-	-	-	-	-	-	
12	A		CUSP_Speed	NGP Speed CustomerSP	Customer	Ethernet	72-100	% NGP	-	-	-	-	-	-	-	-	
13	A		CUSP_Proc_Dis_Prs	Dischare Pressure Customer SP	Customer	Ethernet	950-1150	psig	-	-	-	-	-	-	-	-	
14	A		CUSP_Proc_Suc_Prs	Suction Pressure Customer SP	Customer	Ethernet	700-1000	psig	-	-	-	-	-	-	-	-	
15	A		CUSP_Proc_Flow	Flow Customer SP	Customer	Ethernet	180-330	MMSCFD	-	-	-	-	-	-	-	-	

Analog Outputs

No	Rev	Tag No	SolarTag No	Description	To	Signal Type	Range	Units	Action	Notes
1	A	ASV5113	FCE7631	HPC ASV Cmd	Field	4-20mA	0-100	%CL	Ind & Auto/Man Con	

Discrete Inputs

No	Rev	Tag No	Solar Tag No	Description	From	Signal Type	Range	Alarm & Shutdown		Notes
								Arming Point	Action	
1	A	ZSC5115	ZSC7611	HPC LV Closed Pos	Field	Dry Contact	0=off,1=clsd	-	-	
2	A	ZSO5115	ZSO7611	HPC LV Open Pos	Field	Dry Contact	0=off,1=opnd	-	-	
3	A	ZSC5110	ZSC7621	HPC SV Closed Pos	Field	Dry Contact	0=off,1=clsd	-	-	
4	A	ZSO5010	ZSO7621	HPC SV Open Pos	Field	Dry Contact	0=off,1=opnd	-	-	
5	A	ZSC5113	ZT7631_FC	HPC ASV Closed Pos	Field	Dry Contact	0=off,1=clsd	-	-	
6	A	ZSO5113	ZT7631_FO	HPC ASV Open Pos	Field	Dry Contact	0=off,1=opnd	-	-	
7	A	ZSC5114	ZSC7601	HPC VV Closed Pos	Field	Dry Contact	0=off,1=clsd	-	-	
8	A	ZSO5114	ZSO7601	HPC VV Open Pos	Field	Dry Contact	0=off,1=opnd	-	-	
9	A	ZSC5111	ZSC7641	HPC DV Closed Pos	Field	Dry Contact	0=off,1=clsd	-	-	
10	A	ZSO5111	ZSO7641	HPC DV Open Pos	Field	Dry Contact	0=off,1=opnd	-	-	
11	A	PSHH5111	PS4430	HPC Dis Prs PSHH	Field	Dry Contact	0=NOK,1=OK	-	CD-NL	
12	A	VSHH5110	VS7460	Aftercooler #1 High Vib Switch	Field	Dry Contact	0=OK,1=NOK	-	-	
13	A	VSHH5111	VS7461	Aftercooler #2 High Vib Switch	Field	Dry Contact	0=OK,1=NOK	-	-	
14	A		SB7510	Remote Start	Stn Con Sys	Dry Contact	0=OFF,1=ON	-	-	
15	A		SB7511	Remote Normal Stop	Stn Con Sys	Dry Contact	0=NOK,1=OK	-	CD-NL	
16	A		SB7512B	ESD-Backup System	ESD Sys	Dry Contact B/U	0=NOK,1=OK	-	FS-LO Dprs	Part of SB7512
17	A		SB7512A	ESD-Control	ESD Sys	Dry Contact	0=NOK,1=OK	-	FS-LO Dprs	Part of SB7512
18	A		SB7513	Remote Fast Stop	Stn Con Sys	Dry Contact	0=NOK,1=OK	-	FS-NL Prs	

Discrete Outputs

No	Rev	Tag No	Solar Tag No	Description	To	Signal Type	Range	Action	Notes
1	A	SVO5110	SV7621	HPC SV Opn Cmd	Field	Discrete	0V=off,24V=opn	Ind & Auto/Man Con	
2	A	SVC5110	SV7622	HPC SV Cls Cmd	Field	Discrete	0V=off,24V=cls	Ind & Auto/Man Con	
3	A	SVO5115	SV7611	HPC LV Opn Cmd	Field	Discrete	0V=cls,24V=opn	Ind & Auto/Man Con	
4	A	SV5113	SV7631	HPC ASV Enbl Sol	Field	Discrete	0V=off,24V=enbl	Ind & Auto Con	
5	A	SV5114	SV7602	HPC VV Cls Cmd	Field	Discrete	0V=opn,24V=cls	Ind & Auto/Man Con	
6	A	SVO5111	SV7641	HPC DV Opn Cmd	Field	Discrete	0V=off,24V=opn	Ind & Auto/Man Con	
7	A	SVC5111	SV7642	HPC DV Cls Cmd	Field	Discrete	0V=off,24V=cls	Ind & Auto/Man Con	
8	A	E5010	M7460	Aftercooler #1 Start	MCC	Discrete	0=off,1=enbl	Ind & Auto/Man Con	
9	A	E5011	M7461	Aftercooler #2 start	MCC	Discrete	0=off,1=enbl	Ind & Auto/Man Con	

PROCESS FLOW DIAGRAM

The Process Flow Diagram (PFD) shows the balance of plant components that are under Solar's scope of control. The intent of the PFD is to generally identify the process controllers, physical I/O to and from the process controllers, and software links between the controllers. Details on start-up and shutdown sequencing are in the Yard Valves section. For wiring details of the I/O, refer to the electrical schematic, process P&IDs and other documents identified in the Introduction.

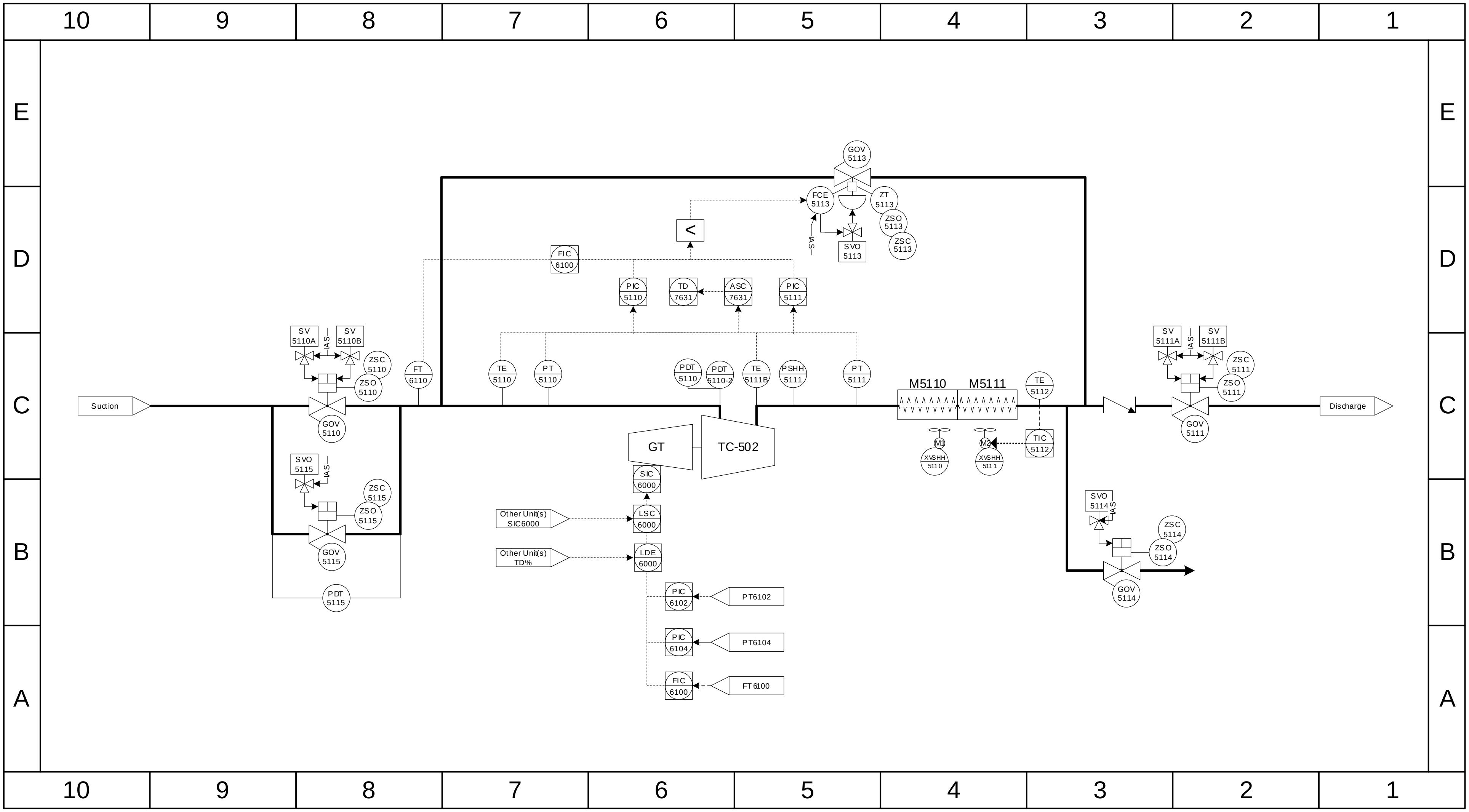


Figure 2 – Process Flow Diagram

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UNIT - CONTROL SYSTEMS

This section describes the controllers for the balance of plant systems.

The controllers described in this section are shipped to site with factory gains. The controllers must be field tuned to ensure optimal performance and system stability. To reduce interactions between the controllers, the following speed of response hierarchy is recommended (from fastest to slowest):

- ***Anti-surge control (ASC) – response to pressure and flow transients should be in the order of hundreds of msec to open the ASV and up to a few minutes to close the ASV.***
- ***Surge margin control (SMC) - response to compressor surge margin transients should be in the order of a few seconds up to a few minutes.***
- ***Pressure control (PIC) using valves – response to pressure transients should be in the order of a few seconds up to a few minutes, and marginally slower than SMCs.***
- ***Temperature control (TIC) using valves – response to temperature transients should be in the order of a few minutes due to lag times associated with temperature measuring elements.***
- ***Pressure and/or flow control using speed – response to pressure or flow transients should be in the order of a few minutes, and marginally slower than TICs. It is expected that major process transients will be handled by recycle valves with the speed control eventually regaining control of the process.***

Yard Valves

The control system will sequence the yard valves during start-up, normal operation, and shutdowns.

Milestones

Sequencing of the yard valves is associated with certain milestones that are defined below, and used in the table following this section.

Offline – The unit is not rotating and a start is not in progress.

Manual Yard Valve Operation – The operator has manual control of the yard valves from the UCP. Manual operation of the yard valves is permitted only while the unit is shut down (including slow roll if applicable), and following conditions are met:

- Pre-lube oil pressure established
- No Fire shutdown detected
- Compressor seal system OK
- Backup relay system is not active

Manual operation of the suction and discharge valves is permitted only when the compressor is pressurized.

Compressor pressurized to suction (Low DP) – The process piping and compressor are pressurized to allow the proper pressure differential across the suction valve, as indicated by the condition defined in the table below.

Compressor depressurized to suction (High DP) – The process piping and compressor are not pressurized to the suction pressure, as indicated by the condition defined in the table below.

Compressor ventilated – The pressure in the process piping and compressor is below the pressure level defined in the table below.

Pressurized, depressurized and ventilated states are defined by the table below:

Depressurized to Suction	Pressurized to Suction	Ventilated
PDT7620 > SP + 5 psid	PDT7620 <= SP	PT4410 < 15 psig

Table 1 - Pressurization States

Start – A unit start is initiated when the following conditions have been met:

Start Command – The command to start the unit is given at the UCP or from a remote input.

Permissives OK – Interlocks from other systems (such as ESD, fire & gas, etc.) must be OK to allow a UCP start.

Automatic Yard Valve Sequence – The UCP has automatic control of the yard valves. Selection of automatic and manual yard valve sequence modes is performed at the operator interface. When a start is initiated, the UCP places the yard valves under automatic control.

Compressor seal system OK – The UCP activates and checks the compressor seal system. A successful check allows the start sequence to continue.

Engine lube oil system OK – The UCP activates and checks the engine lube oil system. A successful check allows the start sequence to continue.

Recycle Purge – The process recycle line is purged through their respective loading valve and vent or blowdown valve for a period of 5 minutes (adjustable).

Compressor Purge – The compressor is purged through their respective loading valve and vent or blowdown valve for a period of 5 minutes (adjustable).

Pressurizing – Process gas upstream of the suction valve is used to pressurize the process piping and compressor through their respective loading valve upstream of the compressor. On pressurized unit start, the pressure across the suction valve is equalized through their respective loading valve for a period of 10 seconds (field adjustable).

Transition to Ready – Unit has been pressurized to suction. During this transition, the loading valve will remain open while the suction and discharge valve is commanded open.

Ready/Running – The loading valve is commanded closed. The yard valves are now in their correct positions to proceed with the unit start sequence.

Pressurized Hold – Suction and discharge valves closed, along with any other unit isolation valve. The unit remains pressurized during hold time period.

Depressurize – Isolate and Vent – Process gas is vented through the vent or blowdown valve(s) once the suction and discharge valves are closed, along with any other unit isolation valves.

Idle – The unit is operating at the NPT idle set point (34-52%, typical) or the NGP idle set point (70-78%, typical), which ever is greater.

> **NPT idle set point** – The lowest operating speed required to avoid power turbine and driven equipment critical speeds.
>
> **NGP idle set point** – The operating speed for idling the gas producer.

On load speed – The unit is operating above both the NPT load set point and the NGP load set point.

> **NPT load set point** – The lowest normal operating speed for the driven equipment. For compressors, the set point is the last speed line of the performance map.
>
> **NGP load set point** – The lowest speed required for normal operation of the gas producer.

Cooldown lockout/non-lockout shutdown – A shutdown that causes the UCP to ramp the unit down to idle speed. The unit remains at idle for a defined time period (3 minutes), before the UCP automatically fast stops the unit to a pressurized state. If during the cooldown idle time the shutdown condition goes away and the operator acknowledges and resets the shutdown, then the unit may be re-started and re-loaded. A lockout type shutdown does not allow remote acknowledge or reset of the shutdown. A non-lockout type shutdown allows remote acknowledge and reset of the shutdown.

Fast stop lockout/non-lockout shutdown – A shutdown that causes the UCP to close the fuel valve to stop the unit. A lockout type shutdown does not allow remote acknowledge or reset of the shutdown. A non-lockout type shutdown allows remote acknowledge and reset of the shutdown.

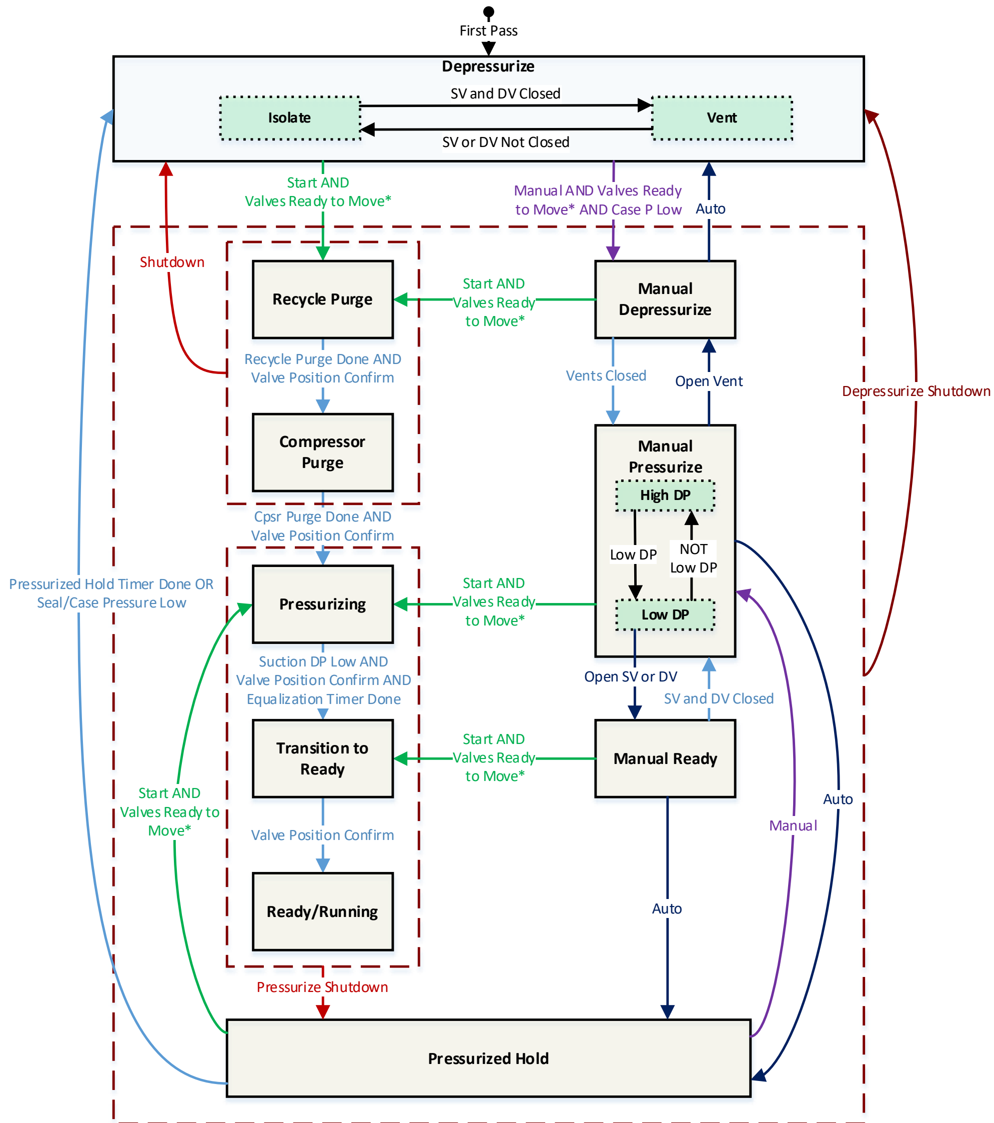
Fast stop pressurized shutdown – The unit is stopped with the compressor pressurized (the vent and/or blowdown valves remain closed). The unit remains pressurized during the pressurization hold time period (field adjustable for compressor with dry seals). When the timer expires, the unit is depressurized.

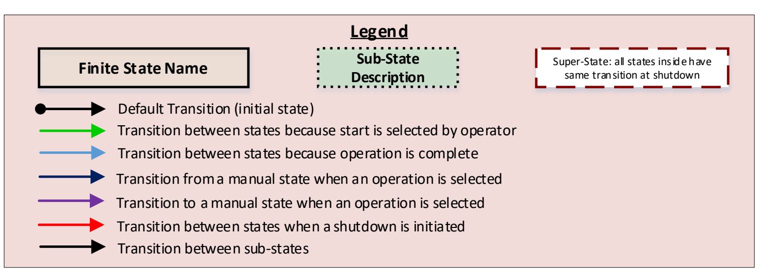
Fast stop depressurized shutdown – After the suction and discharge valves have closed (along with any other unit isolation valve if applicable), the vent and/or blowdown valves open. To minimize the flaring of gas, only the following fast stop shutdowns will cause depressurization:

- Compressor seal system failure
- Lube oil system failure
- Fire Detected
- Gas Detected
- Manual Emergency stop
- Activation of the relay backup system by the following failures or shutdowns:
    - PLC microprocessor failure
    - External Watch Dog timer fault
    - Manual Emergency Stop
    - Fire Detected shutdown
    - Gas Detected shutdown
    - Power Turbine (NPT) Backup Overspeed shutdown

Yard Valve Control State Diagram

The yard valve control state diagram shows the operation states for yard valve control and transition criteria required to move from one state to another. Transitioning from one state to another must follow the paths detailed in the diagram. Only one state is active at any given time. The state diagram in combination with the sequencing table defines the position of each valve in each operation state.





*Valves Ready to Move is based on Seal System OK and Lube Oil Established (Pressure above pump check limit and temperature above permissive limit).

Sequencing

The yard valves will be sequenced as shown below:

Sequencing Description / Valve	LV (Loading Valve)	SV (Suction Valve)	VV (Vent Valve)	ASV (Anti-Surge Valve)	DV (Discharge Valve)
	Compressor				
Manual Yard Valve Sequence					
Manual Pressurize - High DP	O/C	C	O/C	O/C	C
Manual Pressurize - Low DP	O/C	O/C[1]	O/C[2]	O/C	O/C[1]
Manual Ready	O/C	O/C	C	O/C	O/C
Manual Depressurize	O/C	C	O/C	O/C	C
Auto Yard Valve Sequence					
Recycle Purge	O	C	O	O	C
Compressor Purge	O	C	O	C	C
Pressurizing	O	C	C	O	C
Transition to Ready	O	O	C	O	O
Ready/Running - < On Load	C	O	C	O	O
Ready/Running - > On Load	C	O	C	A/M	O
Pressurized Hold	C	C	C	O	C
Depressurize - Isolate	C	C	C	O	C
Depressurize - Vent	C	C	O	O	C

Key	O = open C = close O/C = open or close A = automatic mode M = manual mode A/M = auto or man mode	NOTE: 1. Suction/Discharge Vlv open when Low DP 2. Vent Valve open when Suction/Discharge Vlv are close

Table 2 - Yard Valve Sequencing

Fail To Pressurize Shutdown

If the system is not pressurized after a period of 5 minutes (field adjustable) in the Pressurizing state, then a FS-NL shutdown occurs with a “Fail to Pressurize” indication given at the HMI.

Manual Yard Valve Sequence

The operator may manually purge and pressurize the system from the HMI. Manual yard valve operation will follow the state diagram and sequence table. The unit may be started from any manual control state and will proceed with the appropriate automatic control sequence state based on the presently active manual control state.

Backup Shutdown System

The backup shutdown system is a relay-based system in the UCP, and designed to provide a safe and orderly shutdown of the yard valves in the event of controller failure. An external watchdog timer is provided in the backup shutdown system to independently monitor the condition of the controller. Timing out of the external watchdog timer enables the backup shutdown system to take control of and position the yard valves to safe and shutdown state.

Spring-Return Loading Valve (Fail Closed) - In the event of controller failure and/or ESD, the open command signal wire from the PLC controller to the solenoid is disabled/opened through an interposing relay contact to ensure power to the solenoid is disconnected, and that the valve can stroke to its fail-safe position.

Spring-Return Vent Valve (Fail Open) – The suction and discharge valve closed limit switches are monitored by the backup shutdown system through a timer relay. In the event of controller failure, the control of the vent valve is transferred to the backup shutdown system. The solenoid is energized by the backup system to keep the valve closed while the suction and discharge valves are transitioning to the closed position. After the suction and discharge valves have been confirmed closed through their respective timer relay, the power to the vent valve solenoid is disabled/opened to stroke the vent valve to its fail-safe position and allow compressor venting.

Double-Acting Suction and Discharge Valves (Fail Last) - In the event of controller failure and/or ESD, the control of the valve is transferred to the backup relay system. The command signal from the controller to the open-solenoid is disabled/opened through an interposing relay contact to ensure power to their respective solenoid is disconnected. At the same time the backup shutdown system energizes the close-solenoids to close the valves, and maintain the close command for few seconds through a timer relay which is activated by the valve close limit switch. The close-solenoids are de-energized when their respective timer relay timed-out.

In the event of loss of electrical power, the double-acting valves may remain in their last position. This could result in unit isolation valves remaining open, requiring valves to be closed manually. Appropriate valve actuator designs are recommended to ensure fail safe operation when electrical power is lost. An example solution may include plumbing the actuator to drive the valve to a safe position along with a reserve air supply tank, and/or redundant power supplies. A review of these hazards and associated systems is recommended.

Double Acting Yard Valves

Double acting yard valves are not deemed safe due to the inherent issue of these valves are not fail safe. A loss of power will freeze the valves in their current state. In the worst-case scenario, the suction and discharge valves failing in the fully open position.

If the customer can not exchange their current double acting yard valves with spring loaded fail safe valve the easiest way to modify the valve is to convert them into fail safe double acting by modifying the plumbing of supply and vent on the Close command solenoid to make the failsafe close and Open command Solenoid to make them fail safe open.

A common double acting valve arrangement is as follows:

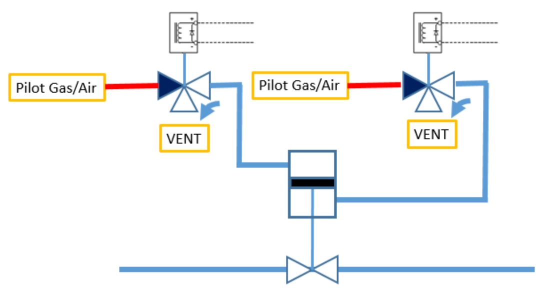


Figure 3 – Common Double Acting Valve Arrangement

In the figure above the open and close solenoids are de-energized so it blocks the incoming supply gas or air and whatever is in the valve assembly is vented off.

To open the valve, the open solenoid is energized allowing gas/air to push on the piston to move the valve in the desired position:

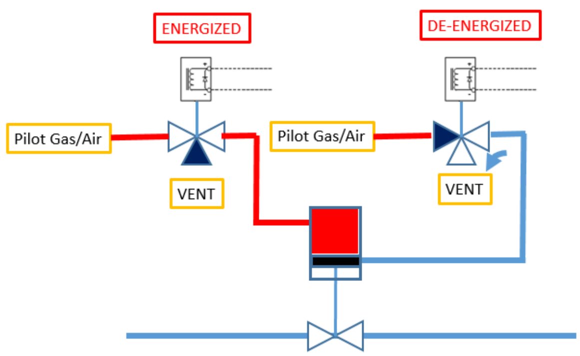


Figure 4 – Double Acting Valve Open

The valve is held for a set amount of time after which the solenoid is then de-energized allowing the gas in the valve assembly to vent out. Since there are no internal springs the valve stays in that position.

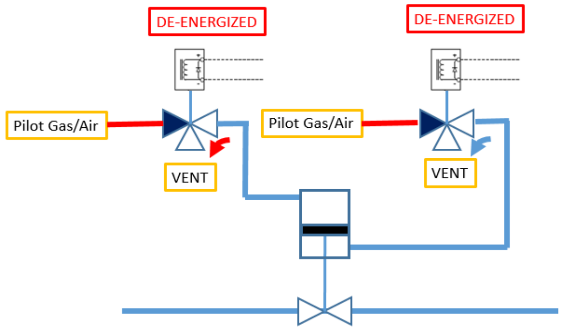


Figure 5 – Double Acting Valve Open Hold Position

The design change would swap the pilot gas/air and vent on the closed solenoid for fail safe closed and on the open solenoid for a fail safe open valve.

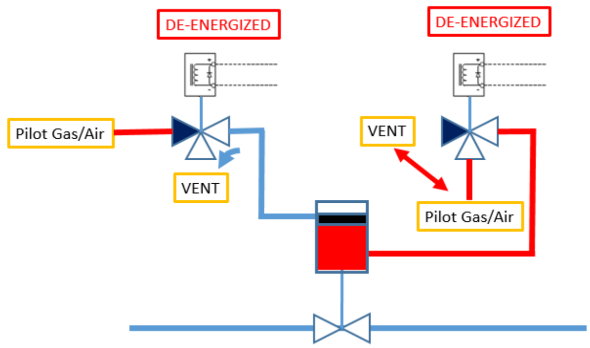


Figure 6 – Double Acting Valve Fail Safe

This plumbing change makes it fail safe because the de-energized solenoid's plumbing continually pushes on the piston to the desired fail safe position. Depending on the age of the valve there may be some minimal leakage but the re-plumbing by far makes the system safer.

Since this is a re-design of a common double acting valve there are some vendors that have different mechanisms to ensure a fail safe position. That must be confirmed by the customer prior to any plumbing changes.

Double Acting Valve Commands – This criterion applies to double acting yard valves where the valve solenoids or actuators are not held constantly since the valves fail in the position they are in when the motive is removed. Therefore, the command to open and close are limited and after the position is reached are held for an additional time set to a tunable constant. The timers for these valves are initiated whenever the position of the direction of command is active. There does exist a possibility that the switches are not calibrated correctly leading to a pressurized process gas to continually leak through the vent. The amount of gas flowing can be below the case pressure switch. This may lead to the compressor spinning or process gas leaking past the compressor seals into the package or lube oil system.

Valve	***Tag No***	***Timer Initiated***	***Additional Hold Time (s)***
SV	SVO7621	ZSO7621=1	30
	SVC7622	ZSC7621=1	30
DV	SV7641	ZSO7641=1	30
	SV7642	ZSC7641=1	30

Table 3 – Double Acting Yard Valve Hysterisis

Valve Out Of Position

The control system verifies the correct position of the following valves with their respective commands. If a valve fails to transfer or hold its position, then the valve is considered out of position (OOP). There are three types of valve checks that are performed.

Valve OOP Checks

Both Limit Switches On (ZSC & ZSO On) – If the valve open and closed limit switches are both on after the valve command has transitioned to full open or full closed and the time delay (field adjustable) has elapsed, then the specified action is initiated. If the valve command has been constant for greater than the time delay and the limit switches both indicated on, then the specified action is executed immediately.

Command vs. Limit Switches (Cmd vs. ZSC/ZSO) – If the valve open or closed limit switch is inconsistent with the full open or full closed command for the specified time delay (field adjustable), then the specified action is initiated. The time delay applies only when the valve command has transitioned. If the valve command has been constant for greater than the time delay and the appropriate limit switch is not indicated on, then the specified action is executed immediately.

Command vs. Position (Cmd vs. Pos) – This criterion applies to valves with position transmitters. If the valve position feedback is inconsistent with the command (+/- the hysteresis) for the specified time delay, then specified action is initiated.

	Valve	***Tag No***	***ZSC & ZSO On***	***Cmd vs. ZSC/ZSO***	***Cmd vs. Pos***	***OOP Criteria***
Cpsr	LV	GOV-5115	N/A	N/A	N/A	*Hysteresis (+/-%)*
			15	15	N/A	*Time Delay (sec)*
			Always Armed	Always Armed	N/A	*Arming Point*
			FS-NL	FS-NL	N/A	*Action*
	SV	GOV-5110	N/A	N/A	N/A	*Hysteresis (+/-%)*
			20	20	N/A	*Time Delay (sec)*
			Always Armed	Always Armed	N/A	*Arming Point*
			FS-NL	FS-NL	N/A	*Action*
	ASV	GOV-5113	N/A	N/A	10	*Hysteresis (+/-%)*
			5	5	5	*Time Delay (sec)*
			Always Armed	Before “Accelerate” Seq.	“Accelerate” to “Cooldown”	*Arming Point*
			FS-NL	FS-NL	Alarm	*Action*
	DV	GOV-5111	N/A	N/A	N/A	*Hysteresis (+/-%)*
			20	20	N/A	*Time Delay (sec)*
			Always Armed	Always Armed	N/A	*Arming Point*
			FS-NL	FS-NL	N/A	*Action*
	VV	GOV-5114	N/A	N/A	N/A	*Hysteresis (+/-%)*
			15	15	N/A	*Time Delay (sec)*
			Always Armed	Always Armed	N/A	*Arming Point*
			FS-NL	FS-NL	N/A	*Action*

Table 4 – Valve OOP Logic

Anti-Surge Control

ASC-7631

The anti-surge control (ASC) system has two distinct functions: compressor surge *detection* and *avoidance*.

The inputs to the ASC are flow differential pressure across the flow meter (h_W); compressor suction and discharge pressures (P_S, P_D) and temperatures (T_S, T_D); and the anti-surge valve (ASV) position feedback. The outputs from the ASC are the discrete command to the ASV enable solenoid, and the analog command to the ASV.

The surge detector monitors flow differential pressure pulses across the flow meter. Flow pulses may indicate a compressor surge event. When a flow pulse is encountered, the ASC step changes the command to the ASV to 15% more open to increase the flow into the compressor. This action helps the compressor recover from possible surge and avoid further events. If the ASC detects 5 flow pulses within a 10 second moving window, then the train is fast stop shutdown.

The surge avoidance function is based on the reduced head vs. reduced flow factors as described by the equations shown.

$$\text{Reduced Head} = \frac{\left(\frac{P_D}{P_S}\right)^{\sigma} - 1}{\sigma} \qquad \text{Reduced Flow} = \sqrt{\frac{h_W}{P_S}} \qquad \sigma = \frac{\ln\left(\frac{T_D}{T_S}\right)}{\ln\left(\frac{P_D}{P_S}\right)}$$

Equation 1 - ASC

The equations have proven to be insensitive to changes in gas pressure and temperature, and moderate changes in gas specific gravity. The ASC models the compressor surge limit line as a polynomial and, therefore, more accurately controls the amount of necessary gas recycling. From the surge limit line, a protection margin constant based on compressor turndown is added which determines the anti-surge control line set point (ASCLSP). The ASC compares the operating flow factor with ASCLSP to determine if gas recycling through the anti-surge valve (ASV) is necessary to keep the compressor operating a safe distance away from surge. Typically, the ASC will begin to open the ASV if the turndown drops below 10%. The ASC uses a proportional-integral (PI) algorithm to close and open the ASV. One set of gains is used to slowly close the ASV, and another set is used to quickly open the ASV. The close integral gain is scheduled as function of differential flow (error) between compressor operating point and surge control line. The gains for the PI algorithm can be adjusted at the operator interface.

	Close (Slow) Gains	**Open (Fast) Gains**
HPC	KT_HPC_ASC_Slow_Gain_Kp	KT_HPC_ASC_Fast_Gain_Kp
	KT_HPC_ASC_Slow_Gain_Ki_Y[n]	KT_HPC_ASC_Fast_Gain_Ki

Table 5 - Adjustable Gains

Automatic & Manual Control

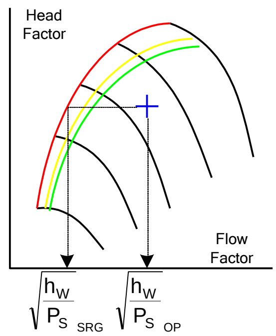
The ASC allows manual control of the ASV from the operator interface so long as the compressor does not operate at the left of the deadband line (typically 12% turndown). If the compressor operates at the left of the deadband line then the ASC overrides manual mode. However, the operator can manually open the ASV at any time from the turbine control panel push button switch, if provided. If the operator transfers control from manual to automatic, the ASC will begin to close the ASV, if needed.

ASV Start Position

During the start sequence on some application, it may be necessary to partially close the ASV to expedite loading and avoid unnecessary heating the compressor. This can be accomplished by setting the value of parameter, KT_HPC_ASV_Partial_Pos (default setting = 30.0 %closed) at the operator interface.

Turndown Calculator (TD-7631)

The turndown calculator takes inputs of pressure, temperature, and flow to calculate the compressor turndown. The turndown is defined to be the distance from the operating reduced flow factor to the reduced flow factor at the surge limit line as a percentage, shown below graphically and mathematically.



$$\text{TURNDOWN} = 100 \cdot \frac{\sqrt{\frac{h_W}{P_S}}_{OP} - \sqrt{\frac{h_W}{P_S}}_{SRG}}{\sqrt{\frac{h_W}{P_S}}_{OP}}$$

Figure 7 - Turndown

The following control block diagram shows the specific I/O used with the ASC (note that valve assembly shown is typical).

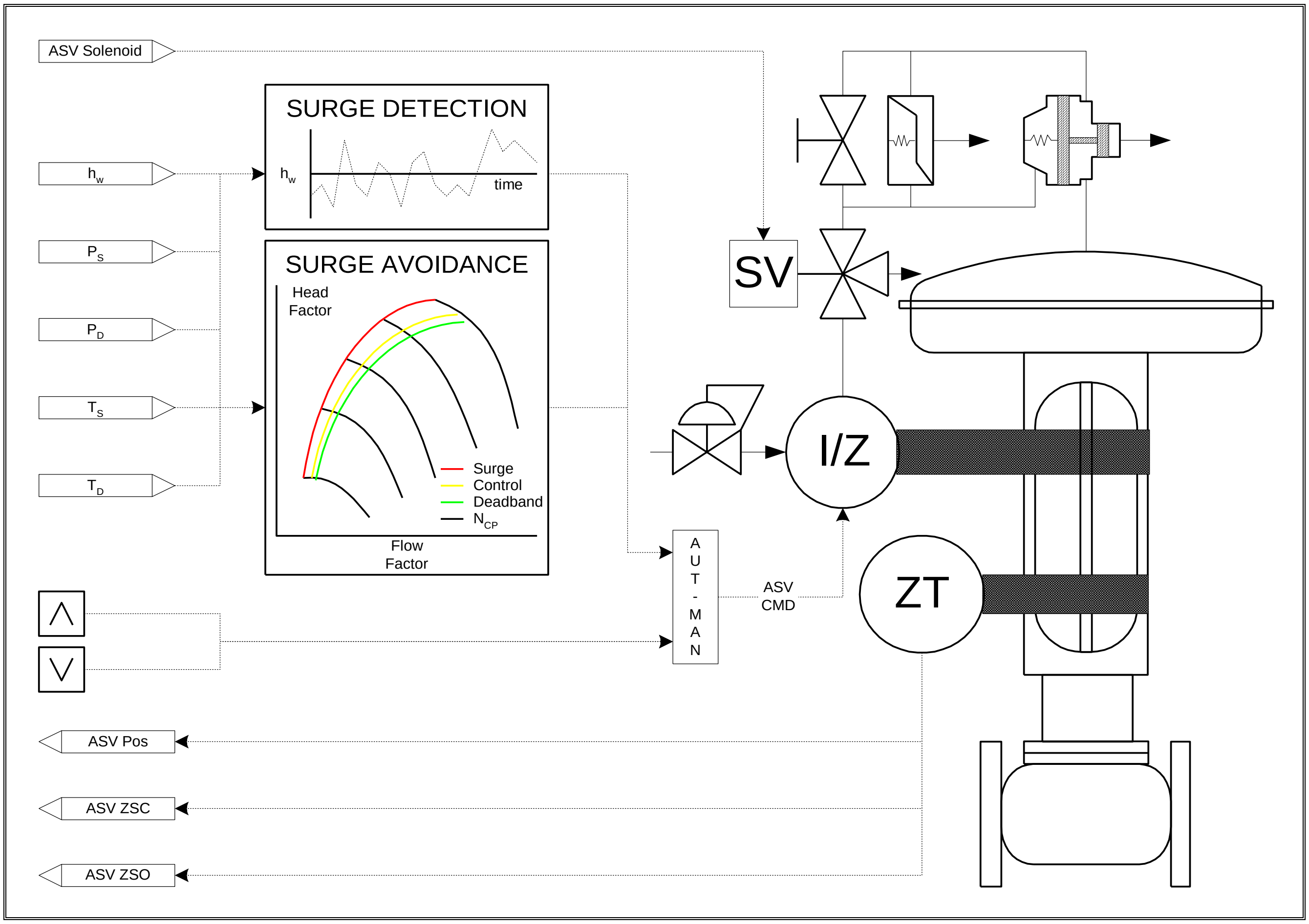


Figure 8 - ASC

ASC I/O

The table below shows the specific I/O used for the ASC:

Description	Tag Number HPC ASC-7631
Suction Pressure	PT4410 (PT5110)
Discharge Pressure	PT4430 (PT5111)
Suction Temperature	TE7410 (TE5110)
Discharge Temperature	TE4430 (TE5112)
Flow ΔP	PDT7631 (PDT5110)
ASV closed position	ZT7631-FC (ZSC5113)
ASV opened position	ZT7631-FO (ZSO5113)
ASV command	FCE7631 (FCE5113)
ASV position feedback	ZT7631 (ZT5113)
ASV enable solenoid	SV7631 (SVO5113)

Table 6 - ASC I/O

Suction Pressure (PIC-5110)

A pressure indication and controller (PIC) controls the suction pressure of the compressor train.

Under this control mode, the gas turbine speed (NGP) is modulated to control the suction pressure (PV) of the compressor train to the desired set point (SP). The PIC increases the NGP when the pressure is above the set point. The PIC decreases the NGP when the pressure is below the set point.

The PIC uses a proportional-integral (PI) algorithm to modulate NGP. The gains (KP & KI) for the PI algorithm can be adjusted at the main or auxiliary operator interface (HMI). The *Local* (LSP) or *Auxiliary (ASP)* pressure set point can be adjusted locally at the active operator interface. Alternatively, a *Remote (RSP), Customer (CSP) or External (ExtSP)* pressure set point can be used by the PIC when selected at the active operator interface.

The following control block diagram shows the specific I/O used with the PIC.

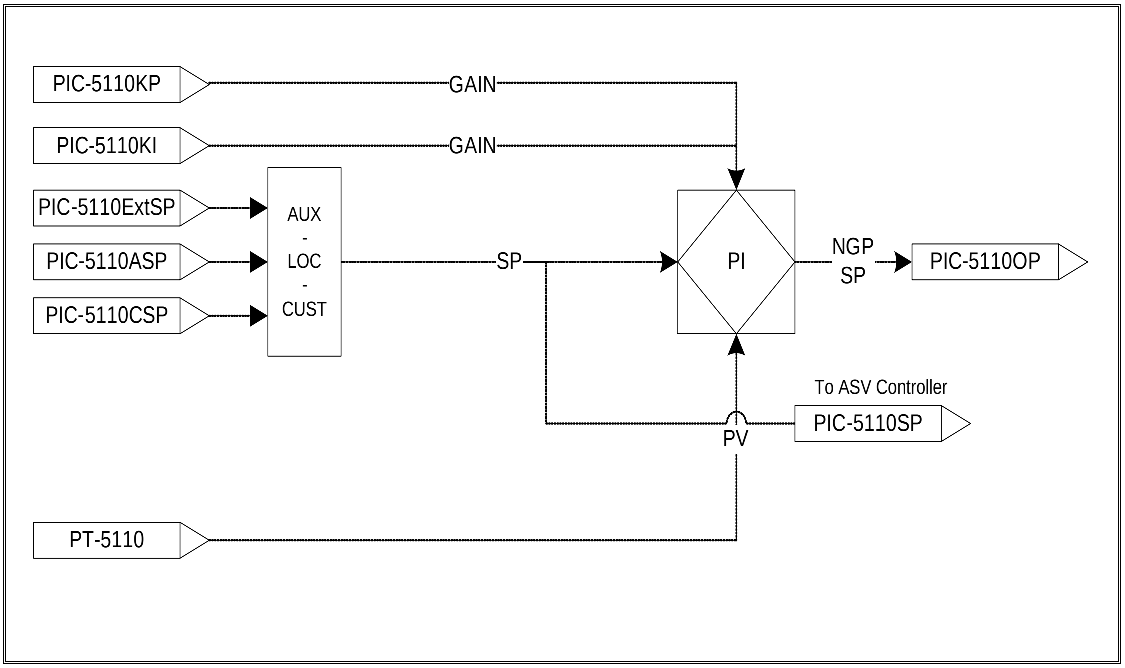


Figure 9 - PIC-5110

Discharge Pressure (PIC-5111)

A pressure indication and controller (PIC) controls the discharge pressure of the compressor train.

Under this control mode, the gas turbine speed (NGP) is modulated to control the discharge pressure (PV) of the compressor train to the desired set point (SP). The PIC decreases the NGP when the pressure is above the set point. The PIC increases the NGP when the pressure is below the set point.

The PIC uses a proportional-integral (PI) algorithm to modulate NGP. The gains (KP & KI) for the PI algorithm can be adjusted at the main or auxiliary operator interface (HMI). The *Local* (LSP) or *Auxiliary (ASP)* pressure set point can be adjusted locally at the active operator interface. Alternatively, a *Remote (RSP), Customer (CSP) or External (ExtSP)* pressure set point can be used by the PIC when selected at the active operator interface.

The following control block diagram shows the specific I/O used with the PIC.

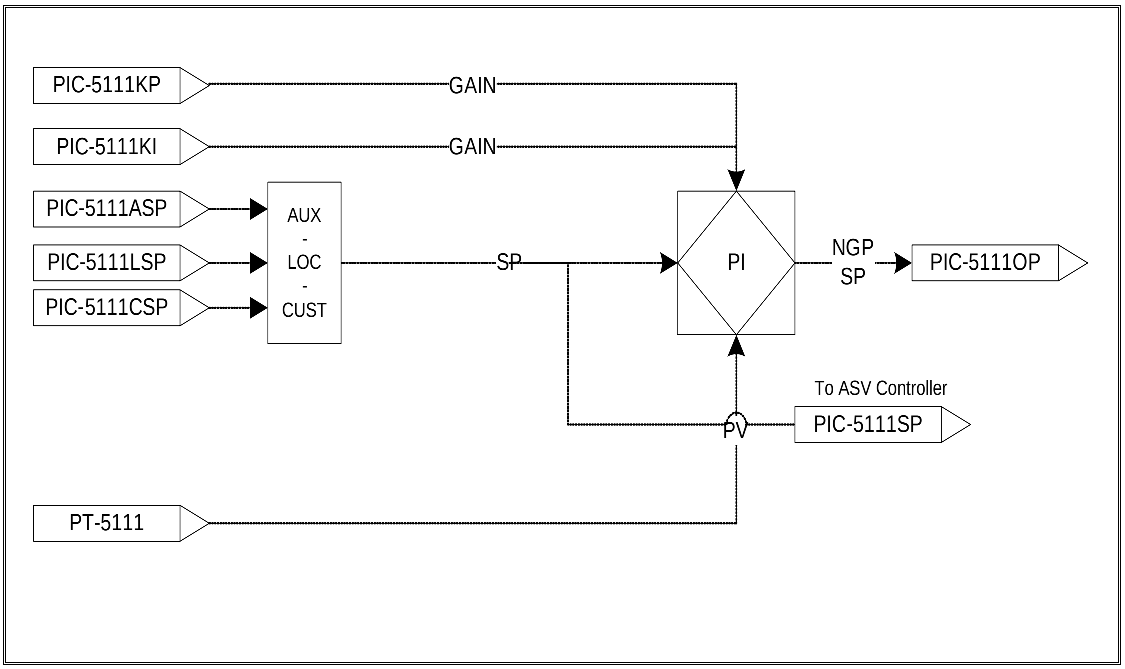


Figure 10 - PIC-5111

Flow (FIC-6100)

A flow indication and controller (FIC) controls the flow of the compressor train.

Under this control mode, the gas turbine speed (NGP) is modulated to control the flow (PV) of the compressor train to the desired set point (SP). The FIC decreases the NGP when the flow is above the set point. The FIC increases the NGP when the flow is below the set point.

The FIC uses a proportional-integral (PI) algorithm to modulate NGP. The gains (KP & KI) for the PI algorithm can be adjusted at the main or auxiliary operator interface (HMI). The *Local* (LSP) or *Auxiliary (ASP)* flow set point can be adjusted locally at the active operator interface. Alternatively, a *Remote (RSP), Customer (CSP) or External (ExtSP)* flow set point can be used by the PIC when selected at the active operator interface.

The following control block diagram shows the specific I/O used with the FIC.

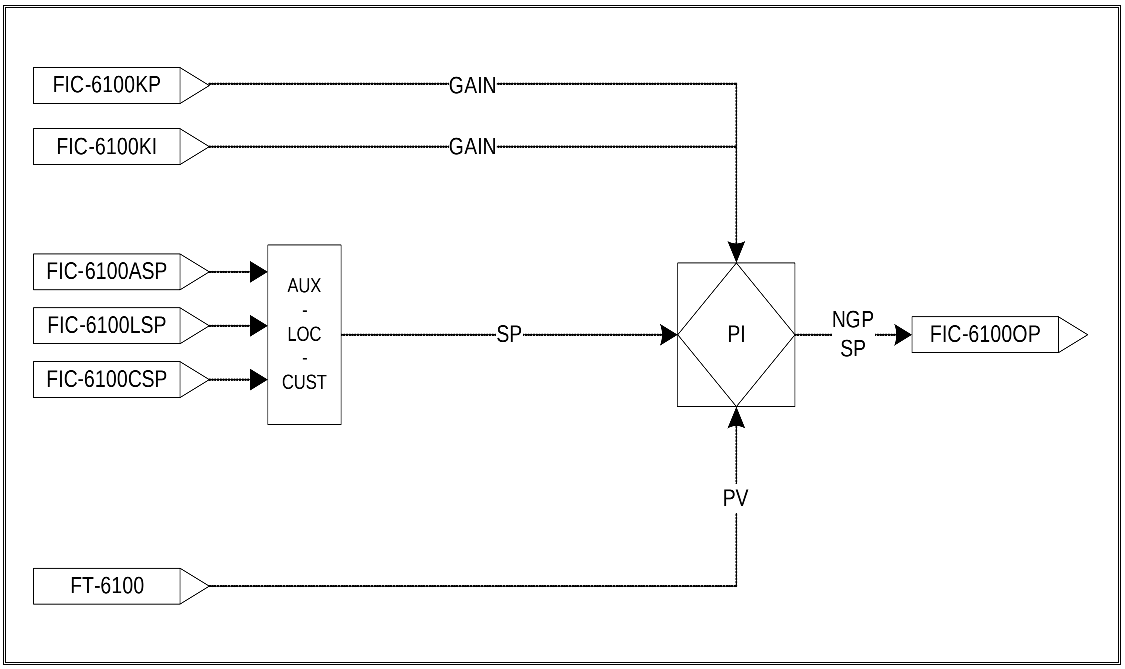


Figure 11 - FIC-6100

Process Control Using Anti-Surge Control Valve

In addition to ASC duty, ASV-7631 also controls the compressor train suction and discharge pressures, and flow as well.

The ASC is coupled with two PICs and an FIC– suction pressure (PIC-5110A), discharge pressure (PIC-5111A), and flow (FIC-6100A). The process variables for the pressure controllers are the same pressure signals used for PIC-5110 and PIC-5111 discussed above. The set point for PIC-5110A is the set point of PIC-5110 *subtracted* by an operator adjustable pressure offset (PIC-5110OFS). The set point for PIC-5111A is the set point of PIC-5111 *added* to an operator adjustable pressure offset (PIC-5111OFS). The process variable for the flow controller is the same flow signal used for FIC-6100 discussed above. The set point for FIC-6100A is the set point of FIC-6100 *added* to an operator adjustable flow offset (FIC-6100OFS). Staggering the set point eliminates interaction between the speed and valve control.

Suction Pressure (PIC-5110A)

PIC-5110A will modulate the ASV if the suction pressure drops below its set point. When PIC-5110A is in control of the suction pressure, PIC-5110 will still reduce speed because its set point has not been achieved. As PIC-5110 reduces speed, PIC-5110A will detect a rise in suction pressure and begin to close the ASV. PIC-5110 will continue to reduce speed until it satisfies its set point, which will cause PIC-5110A to close the ASV because the pressure will be above its own set point. At this point, the control system has recovered from the process transient. However, if PIC-5110 reaches the minimum speed limit before achieving its set point, then PIC-5110A will continue to recycle gas to maintain its pressure set point.

The following control block diagram shows the specific I/O used with the PIC.

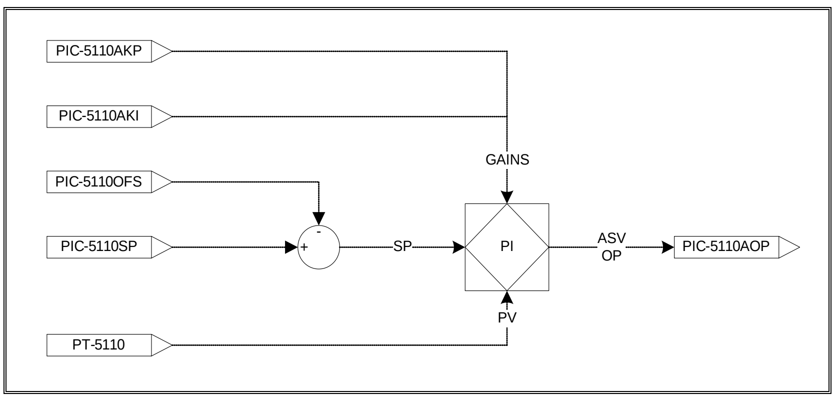


Figure 12 - PIC-5110A

Discharge Pressure (PIC-5111A)

PIC-5111A will modulate the ASV if the discharge pressure exceeds its set point. When PIC-5111A is in control of the discharge pressure, PIC-5111 will still reduce speed because its set point has not been achieved. As PIC-5111reduces speed, PIC-5111A will detect a fall in discharge pressure and begin to close the ASV. PIC-5111 will continue to reduce speed until it satisfies its set point, which will cause PIC-5111A to close the ASV because the pressure will be below its own set point. At this point, the control system has recovered from the process transient. However, if PIC-5111 reaches the minimum NGP limit before achieving its set point, then PIC-5111A will continue to recycle gas to maintain its pressure set point.

The following control block diagram shows the specific I/O used with the PIC.

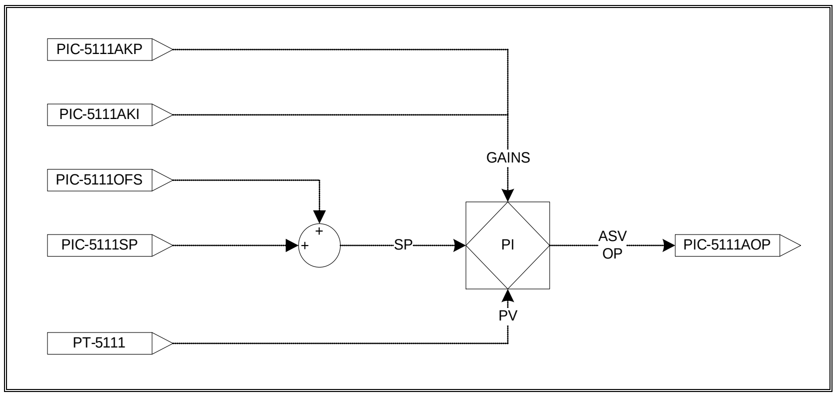


Figure 13 - PIC-5111A

Flow, FIC-6100A

FIC-6100A will modulate the ASV if the flow exceeds its set point. When FIC-6100A is in control of the flow, FIC-6100 will still reduce speed because its set point has not been achieved. As FIC-6100 reduces speed, FIC-6100A will detect a fall in flow and begin to close the ASV. FIC-6100 will continue to reduce speed until it satisfies its set point, which will cause FIC-6100A to close the ASV because the flow will be below its own set point. At this point, the control system has recovered from the process transient. However, if FIC-6100 reaches the minimum NGP limit before achieving its set point, then FIC-6100A will continue to recycle gas to maintain its flow set point.

The following control block diagram shows the specific I/O used with the FIC.

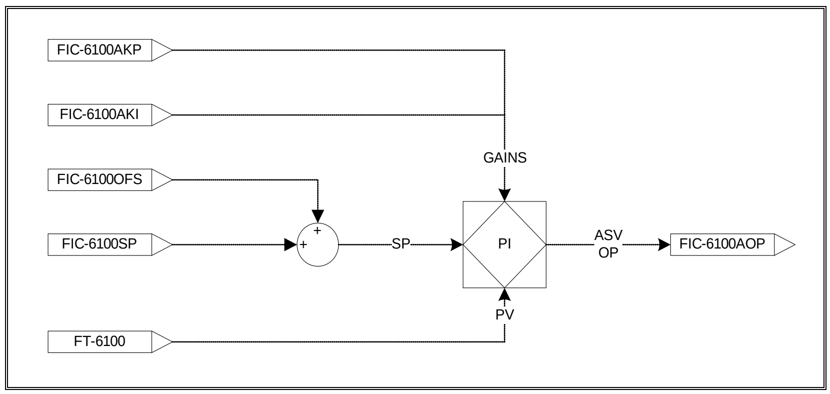


Figure 14 - FIC-6100A

Command To ASV-7631

The outputs of PIC-6102A, PIC-6104A (discussed above), and ASC-7631 are inputs to a min function that selects the most open valve command of the three controllers. This ensures that the ASV will open as necessary to satisfy any pressure or ASC requirements. The ASV will close if the pressure and ASC requirements are met. The final valve command is used as a reset to the three controllers to prevent wind-up.

The following control block diagram shows the specific I/O used with the min function.

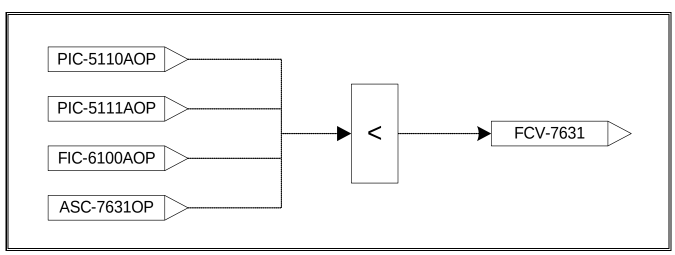


Figure 15 – ASV-7631 Command

In addition to ASC duty, ASV-7631 also controls the compressor train suction and discharge pressures, and flow as well.

Gas Cooler Control

TIC-5112

A temperature indication and controller (TIC) controls temperature by switching the cooler fan motor on and off.

Under this control mode, the motor is used to control the process gas temperature (PV) to the desired set points. The TIC turns the motor on when the temperature exceeds the high set point (SPH). The motor remains on until the temperature drops below the low set point, then it shut off. The motor remains off until the temperature gains exceeds the SPH.

The temperature set points can be adjusted locally at the operator interface or commanded via communications link.

The following table shows the specific I/O used with the TIC.

Description	Tag Number
Aftercooler temp	TE-5112 (TT7460)
Motor Command	E5010 (M7460), E5011 (M7461)
High Temp SP	TIC-5112SPH
Low Temp SP	TIC-5112SPL
Motor Vib Sw	VSHH-5110 (VS7460)
Motor Vib Sw	VSHH-5111 (VS7461)

Table 7 – TIC-5112

Multiple Unit Load Sharing

Load Share Controller (LSC-6000) & Load Equalizer (LDE-6000)

A load share controller (LSC) and a load equalizer (LDE) manage the operation of multiple units to ensure stable load sharing of the process. One LSC and one LDE reside in each of the UCPs. A dedicated link is used for communication of selected control variables.

Units can be organized into load share groups. Each unit is assigned a load share group number. This number identifies which group the unit is currently configured to operate in a load sharing scheme. For example, in a five unit station, two units share the same suction and discharge headers. These two units are defined to be group 1 and they load share. The remaining three units share the same suction and discharge headers, different from the first two. These three units are defined to be group 2 and they load share as a group. Later on, the two units are switched over to operate in parallel with the other three. In this case, all the units' group numbers are set to 2, and they load share as a group. The group numbers are defined by the operator. Up to 4 groups can be used.

Load Share Controller (LSC)

The LSC has three modes of operation.

Off – When the LSC is off, the UCP ignores the actions of the other units. Likewise, the other units ignore the actions of the UCP. There is no load sharing.

On – When the unit is under automatic control (under the control of a PIC or FIC) and the LSC is turned on, then the unit load shares with other units in the group. The units communicate their respective speed set point to the rest of the group. The highest of these is selected as the group's base speed set point. All the units in the group control on this base speed set point. Note that as process conditions vary, the base speed set point will change to keep the process variable in line with its process set point.

NGP Master – When the unit is under manual speed control and the LSC is turned on, then the unit becomes an NGP master. The other units in the group will follow the speed of the NGP master unit.

Load Equalizer (LDE)

The LDE has two modes of operation.

Off – When the LSC is off, the LDE is automatically turned off. When the LSC is on, the LDE can be turned on or off. When the LDE is off, the bias added to the LSC base speed set point is zero.

On – When both the LSC and LDE are on, then individual biases are added to the base speed set points of each unit to equalize the load by keeping the group's compressor turndowns the same. The units communicate their respective turndown to the rest of the group. In the case of unit with multiple compressors, the lowest turndown is used. An average of all the turndowns is calculated and used as the group's turndown set point. Units operating below the turndown set point automatically have their speed set point biased up to 2% (tunable limit, up to 5% maximum), which increases the turndown. Note that the speed set point communicated to the LSC above does not include the speed bias generated by the LDE. Units above the turndown set point have a bias of zero. A proportional-integral (PI) algorithm is used to generate the speed bias of each unit. The gains (KP & KI) for the PI algorithm can be adjusted at the operator interface.

Speed Control (SIC-6000)

The speed controller (SIC) selects the NGP SP that will be used to control the fuel actuator. The SIC has two operating modes, auto and manual which can be selected through control panel or HMI push button. The output of these two modes are inputs to the SIC fuel control.

Auto Mode

In auto mode, the NGP SP output from the process controller described above (PIC-6102/PIC-6104/FIC-6104) is an input to the LSC and LDE. If the LSC is off, then the NGP SP is an input to the set point rate limiter. If the LSC is on, then the NGP SP is compared with other units in the same group, and the maximum is selected. This base NGP SP is input to the LDE. If the LDE is off, then the base NGP SP is an input to the set point rate limiter. If the LDE is on, then the load equalization speed bias is added to the base NGP SP and is then input to the set point rate limiter.

Manual Mode

In manual mode, there are multiple set point inputs that can be manually selected through a switch or screen push button on the active control panel (*Local* or *Auxiliary*) to control the turbine/compressor speed.

External NGP SP – An external speed set point (SIC-6000ExtSP) is normally 4-20mA input that can be enabled through HMI screen push button. When external speed set point is disabled, one of the modes below can be selected to control the speed.

Local NGP SP – When in *Local* control mode which can be selected through a selector switch on the control panel, the local NGP set point (SIC-6000LSP) is used.

Auxiliary NGP SP – When in *Auxiliary* control mode which can be selected through a selector switch on the control panel, the auxiliary NGP set point (SIC-6000ASP) is used.

Alternatively, *Remote* or *Customer* speed control can be enabled from the active control panel HMI. The NGP set point is normally sent through the communication link.

> **Remote NGP SP** – When in *Remote* control mode which can be enabled through HMI screen push button, the remote NGP set point (SIC-6000RSP) is used.
>
> **Customer NGP SP** – When in *Customer* control mode which can be enabled through HMI screen push button, the customer NGP set point (SIC-6000CSP) is used.

The manual mode NGP SP output is an input to the LSC. If the LSC is off, then the NGP SP is input to the set point rate limiter. If the LSC is on, then the unit becomes an NGP Master, and the other units in the group follow the unit's NGP SP. Note that in NGP Master mode, the LDE is automatically disabled. The NGP SP is then input to the set point rate limiter.

NGP SP Rate Limiter

The function of the rate limiter is to control the NGP SP ramp up/down rate. If the compressor operates at the left of the ASC deadband line, an operator adjustable set point (typically, 12% turndown), then the rate limiter reduces the NGP SP deceleration. The rate limiting prevents any interaction between the NGP control and recycle valve that will be modulating to keep the compressor away from the surge limit line. If the compressor operates at the right of the deadband line, then NGP is allowed to accelerate or decelerate at its maximum rate of up to 0.5%/second. The NGP SP output from the rate limiter is an input to the fuel algorithm.

Fuel Control

In the fuel control algorithm, the NGP SP and the limits from the controlling parameters (NGP, NPT, T5, and Fuel flow) are compared to their respective actual readings, and differences/errors are calculated. The SIC selects the lowest difference/error from this group and generates the appropriate output signal to the fuel controller.

The following control block diagram shows the specific I/O used with the SIC.

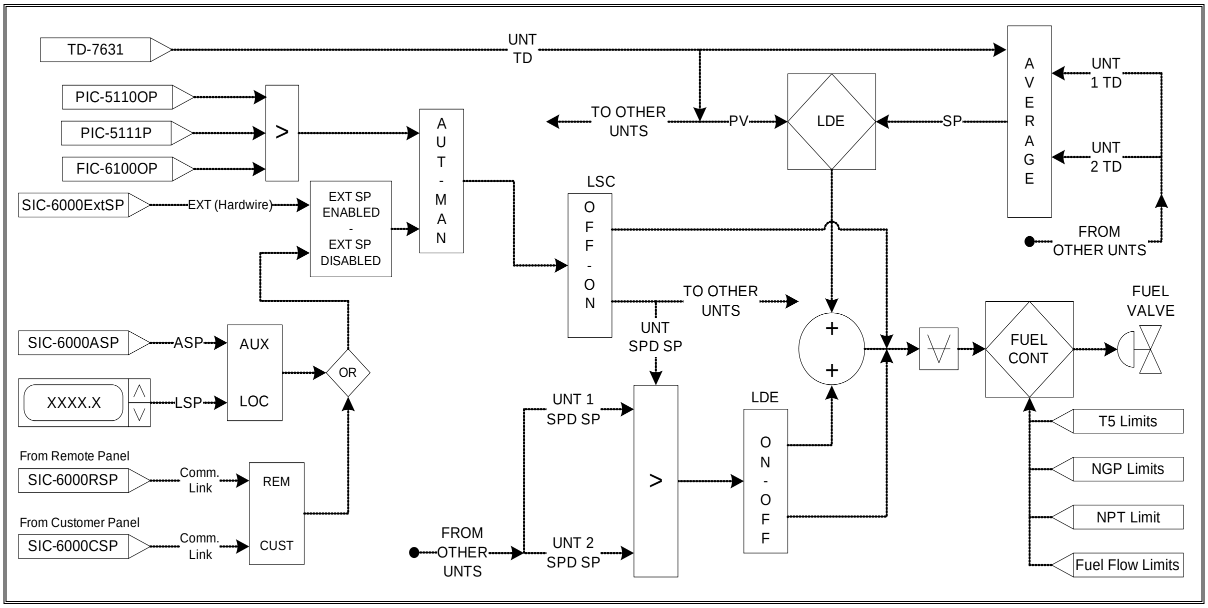


Figure 16 - SIC-6000

Customer Control System Interface

Safety Shutdown System

The unit control panel will interface with customer furnished safety shutdown system. As a standard, the unit control panel provides two interface points for the safety shutdown system. Two Emergency Shutdown (ESD) dry-contacts, normally closed signals from the safety system are required. One signal (SB7512) connects to the PLC system and other signal (SB7512-BU) connects to unit control panel back-up relay shutdown system. The two dry contacts are controlled from a single switch that when activated will initiate a unit fast stop shutdown with compressor depressurization.

Fire and Gas System

The unit control panel will interface with customer furnished turbine enclosure fire and gas system. The Following "dry contact" signals from the fire and gas system are required for the safe operation of the unit.

Tag No.	Description	Signal Type	Range
FIRE-DET	Fire Detected Shutdown	Dry Contact	0-Fire, 1=OK
GAS-DET	Gas Detected Shutdown	Dry Contact	0=Gas Det, 1=OK

FIRE-DET signal (unit confirmed fire) when activated will initiate a unit fast stop shutdown with compressor depressurization through the PLC and backup relay shutdown system. Fire Detected shutdown will interrupt the post-lube cycle for 9.5 minutes so as not to add fuel to the fire in case the fire is due to leaking oil and provide time for the fire system to extinguish the fire. Post Lube will resume after 9.5 minutes to protect the turbine.

GAS-DET signal when activated will initiate a unit fast stop shutdown with compressor depressurization through the PLC and backup relay shutdown system.

Station/DCS Serial Interface

The unit control panel will interface with customer furnished station or DCS system. With the available communication link, the customer has the option to control and monitor the unit remotely. The applicable serial interface points/signals are defined on a separate Serial Link list that will be provided when project is completed, and as part of the "as-shipped" documentation. Typically, all the basic unit control commands and status from the local HMI are also available remotely.

Station/DCS Hardwired Interface

The unit control panel will interface with customer furnished station or DCS system. The applicable interface points/signals are defined on the Device List section of this document. As a standard, the unit control panel provides the following interface connections for remote control of the unit.

Remote Start (SB7510) – only active when in Remote control mode.

Remote Normal Stop (SB7511) – initiates cooldown stop.

Remote Fast Stop (SB7513) – initiates fast stop shutdown with compressor pressurized.

COMMUNICATION INTERFACE

This section describes the communication interface between the UCP and other systems such as DCS's, and station control systems for remote monitoring and control.

Ethernet Network Interface – Supervisory Monitoring & Control

A dedicated link for monitoring and control from a supervisory device is provided. Data is available via a tag based addressing system. The external device must be able to read TCP\IP addresses and poll the tags to obtain the data. The data typically consists of:

- Operation summary data
- Driver temperatures
- Driver and driven vibration levels
- Balance of plant data
- Alarm and shutdown status
- Remote start command
- Remote cooldown command
- Remote faststop command
- Remote process set points

See Electrical Loop Schematics for Node Addresses.

Communication Interface Layout

Figure below shows the general communication interface layout. Refer to the project electrical loop schematic (ELS) for actual interface cable routing and termination.

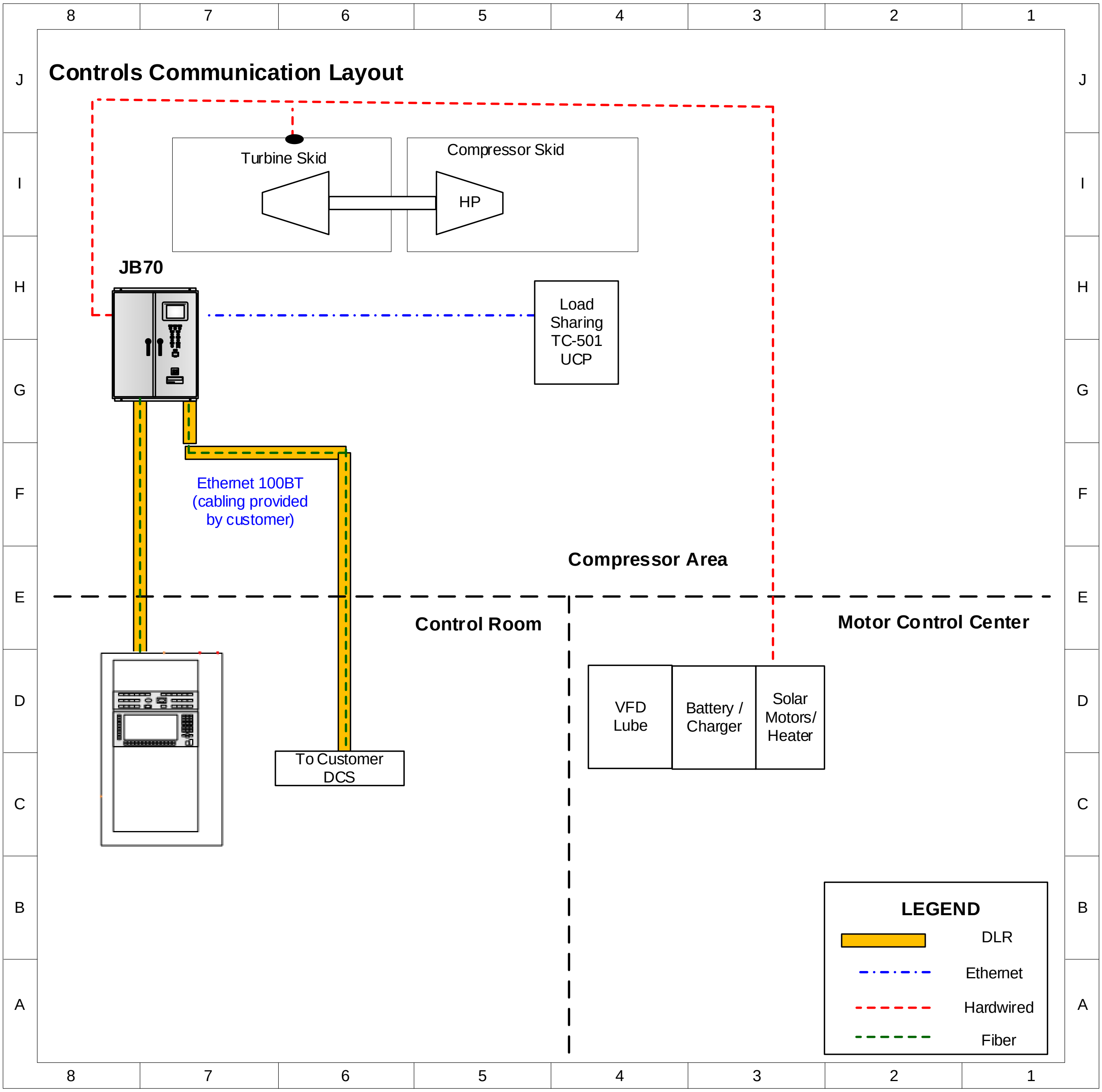


Figure 17 – Communication Layout

GLOSSARY	
Auxiliary Control Mode	Control mode that is selected through a selector switch on the control panel. When selected, the unit control is through the designated auxiliary control panel. When furnished by Solar, auxiliary control panel is another control panel aside from the local control panel.
Backup System	The UCP has a relay backup system that is activated in the event of PLC microprocessor failure and safety related shutdowns. The system is used to control important turbine function including some of the process yard valves, if applicable.
CD-LO	Cooldown Shutdown– lockout type (can be reset locally only)
CD-NL	Cooldown Shutdown– nonlockout type (can be reset locally or remotely)
Ext SP Enabled/ Disabled	When enabled, the 4-20mA signal from an external source will be used to adjust the control set point for NGP speed, or process (pressure and flow) control.
External NGP SP	NGP speed set point that is normally 4-20mA signal from an external source, and used to control the compressor speed when Ext SP mode is enabled.
External Watchdog Timer	Monitors the condition of the PLC through a hardwired timer relay. Initiates a microprocessor fault and activates the backup system when proper signal is not received from the PLC.
Fire Detected	Confirmed fire is detected at the turbine area that initiates a unit fast stop depressurized shutdown and activates the backup system.
FS-LO Dprs	Fast Stop Depressurized Shutdown – lockout type (can be reset locally only)
FS-LO Prs	Fast Stop Pressurized Shutdown – lockout type (can be reset locally only)
FS-NL Dprs	Fast Stop Depressurized Shutdown – nonlockout type (can be reset locally or remotely)
FS-NL Prs	Fast Stop Pressurized Shutdown – nonlockout type (can be reset locally or remotely)
Gas Detected	High Gas level above shutdown set point is detected at the turbine area, and unit fast stop depressurized shutdown is initiated and backup system is activated.
Load Share Group Number	A Group Number to each compressor train. A group defines the trains that are load sharing on common suction and/or discharge headers. A Group Number will be changed if valves are reconfigured to include the train in a different group.
Local Control Mode	Control mode that is selected through a selector switch on the control panel. When selected, the unit control is through the designated local control panel that is normally the control panel that has the PLC and the selector switch.
Manual Fast Stop	Inputs (switches) to the UCP that are activated manually by operator to initiate a Fast Stop Depressurized Lockout shutdown.
Operator Interface	Interface between operator and unit control system
Pressuriza-tion Hold Time Period	Period of time where compressor is held pressurized (vent valve closed) while unit is shutdown. The compressor is depressurized when the timer expires.
Remote Control Mode	Control mode that is enabled/disabled through HMI screen push button on the active control panel. When enabled, the unit control is through the designated remote control system, and normally via communication link.
Turndown	Distance from the operating reduced flow factor to the reduced flow factor at the surge limit line expressed as a percent at constant head.
T5	Temperature measured at the third stage turbine nozzle used for control.

END OF DOCUMENT