



Vertex Digital Control for Performance and Compressor Control

Volume 3 Commissioning Manual for Main Control

Manual 35072 consists of 3 volumes (35072V1, 35072V2, & 35072V3)



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Chapter 18.

Introduction

Scope

This document provides a guideline for the Vertex configuration and commissioning. These are guidelines and the user must apply their own discretion to use these guidelines.

Software Tools Used

- Control Assistant
- Vertex Controller (Performance and Anti-Surge Controller)
- Applicable documents

This document is prepared based on the Woodward standard procedures for performance testing. Activities will be deployed in compliance with the requirements set in Woodward's Quality Manual and Business Disciplines. The primary procedures to be adhered to are:

- 2-07-2599 - One Woodward Product Lifecycle (PLC) Process
- 4-04-1938 - Engineering Services ETO Systems Process

Configurations Used:

1. Single Stage motor driven compressor with variable speed for ASC control.
2. Two stages motor driven compressor with variable speed for Load sharing section

Table 18-1. Acronyms

Acronym	Description
A	Ampere
ASC	Anti-Surge Controller
ASV	Anti-Surge Valve
CCS	Compressor Control System
DO	Digital Output
EWS	Engineering Work Station
FAT	Factory Acceptance Test
I/O	Input / Output
ITCC	Integrated Motor and Compressor Control
MCS	Maximum Continuous Speed
MOS	Minimum Operative Speed
MTS	Maintenance and Training System
NMR	Non Material Requirement
PIB	Process Interface Building
SLL	Surge Limit Line
SCL	Surge Control Line
TCS	Motor Control System
VA	Volt Ampere
VAC	Volts Alternating Current
VDC	Volts Direct Current

W	Watt
OEM	Original Equipment Manufacturer
SAT	Site Acceptance Test
NSD	Normal Shutdown
ESD	Emergency Shutdown

Chapter 19. Prerequisites

The start of the commissioning phase implicates that all activities from the previous phases have been successfully completed, namely Installation Checkout Plan and Site Acceptance Testing. Without signed acceptance of these prior phases and written consensus on system configuration by the OEM supplier and end-user, Woodward does not recommend continuing process start-up and performance testing of any system, so as to prevent damage to the system with possible personal injury, loss of life, or property damages.

Safety Equipment

All personnel must adhere to site-specific safety procedures at all times.

Documents

Reference the Pre-commissioning and Site Acceptance Tests. Anti-surge Valve has been tested as per the Ref. 5.

Chapter 20. Configuration

Drafting a General Layout Plan

Control Loops- One ASC, one PFC, and one motor current limiter

Analog Inputs:

1. Compressor suction differential pressure (dP), Range:0-1300 mmH2O
2. Compressor Discharge Pressure (Pd), Range:0-75 kg/cm2 A
3. Compressor Suction Pressure (Ps), Range: 0-60 kg/cm2 A
4. Compressor Discharge Temperature (Td), Range:0-60 Deg C
5. Compressor Suction Temperature (Ts), Range:0-30 Deg C
6. VFD speed (N, 4-20 mA signal), Range:0-15000 RPM
7. Motor Current (I), Range: 0-500 Amp.
8. Performance controller dedicated PT-1010 (0-150 kg/cm2 A) using "Process/Performance Input".

Analog Outputs:

1. ASC valve output (ASV), Range: 0-100% using "Stage 1 AS Valve Demand"
2. Performance Controller Output Valve (PFV), Range: 0-100% using "Performance Valve Output Demand"

Boolean Inputs:

1. Emergency Stop
2. Alarm/Reset Command
3. Train Start Command
4. Driver Startup Complete Feedback
5. Normal Shutdown using "Train Normal SD Req"
6. Quit Normal Shutdown using "Train Quit Normal SD Req"
7. Performance Controller Auto mode using "PFC Auto Mode Req"
8. Performance Controller Full Manual mode using "PFC Full Man Mode Req"

Boolean Outputs

1. Trip Output
2. Surge Detected output using "ASC1 Surge Detected"
3. Consecutive Surge Detected output using "ASC1 Consecutive Surge Detected"

Startup Permissive:

1. ESD signal is healthy
2. Ready to start available.
3. ASV solenoid is energized.

Control Narrative:

1. Operator will issue reset command.
 - a. The Performance controller ramps to reset position that is 10%.
2. Operator push Motor start button.
 - a. This command issues a Train Start Command to the Vertex.
 - b. The Performance controller will ramp to startup position, which is 20%.
3. When operator is sure about motor startup, then operator will issue Driver startup complete feedback.
4. The startup will be completed and PFC would control the PV.
5. Once min speed is achieved, then ASC will be online.
6. Operator would place ASC controller into Auto mode.
7. When operator confirms the stable motor conditions:
 - a. Place performance controller into Auto mode, which controls the suction pressure of compressor.

Shutdown procedure:

1. NSD- ASC ramps up to shut down position, Perf ramps down to 0% demand.
2. ESD-Immediate ASC open to shut down position, Perf ramps to shut down position.

Limiter Loops:

- Limiter1: If motor current gets higher than configured value, the performance controller will not increase load to further value.
- Limiter2: If suction pressure drops below configured set point, then performance controller will not increase its driver's output.
- Pressure override control (P1): If discharge pressure of compressor drops below configured set point, then ASC will start opening to ASV.

Configuration Mode Activation

Vertex screen prior to configuration:

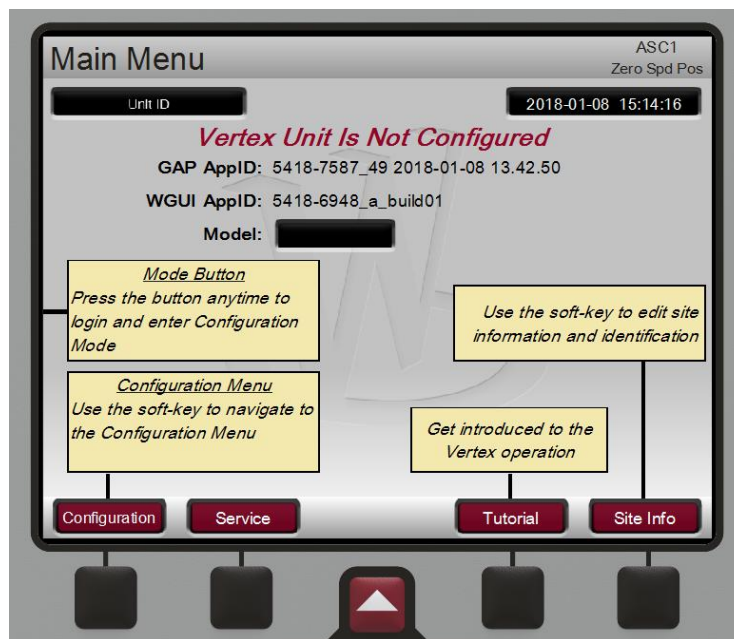


Figure 20-1. Configuration Main Menu

To activate configuration mode, follow the steps below.

1. Press Mode button on the left side of Vertex screen to access the User Login and Mode Selection screen. Change User Level to "Configure". Change Mode to "Configuration". Refer to Vertex volume 1 manual for configuration mode activation. Press Mode again to return to Main Menu screen.
2. Access the Configuration Menu screen by pressing the Configuration function key on bottom-left side of Main Menu.
3. Ensure access to the following screen on the Vertex:

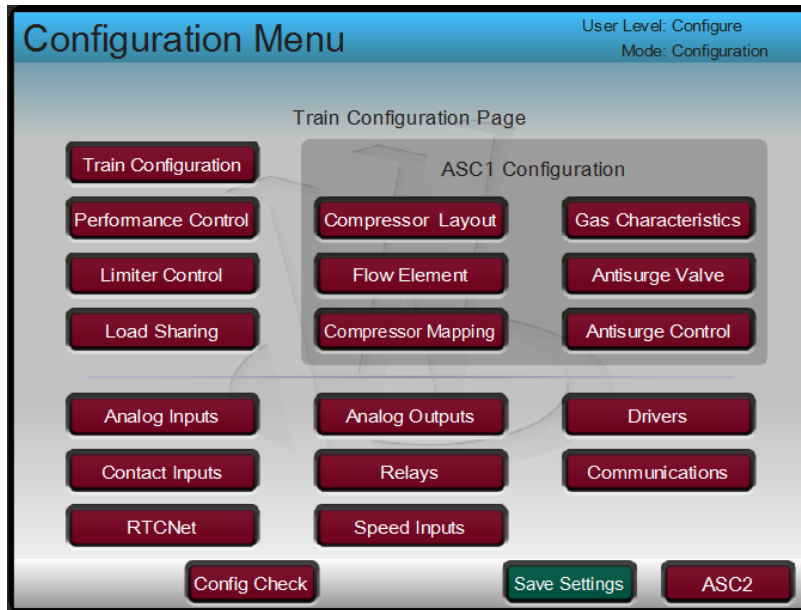


Figure 20-2. Configuration Menu

Based upon the IO list mentioned, configure signals into the Analog Inputs, Analog outputs, Contact Inputs, and Relays. We are not using Drivers since we do not have any actuator output. Similarly, we are not using RTCNet since number of inputs < 9. Speed signal is standard 4-20 mA signal, so Speed Input option is not used.

Hardware Configuration:

Default unconfigured screen:

The screenshot shows the 'Analog Input Summary' screen with the following data:

550 ms	Fault	Function	Tag	Value	Units
AI_01	●	Stage 1 Flow	AI_01	-25.0	kPa
AI_02	●	Stage 1 Discharge Pressure	AI_02	-25.0	kPa A
AI_03	●	Stage 1 Suction Pressure	AI_03	-25.0	kPa A
AI_04	●	Stage 1 Discharge Temperature	AI_04	-25.0	C
AI_05	●	Stage 1 Suction Temperature	AI_05	-25.0	C
AI_06	●	--- Not Used ---	AI_06	-25.0	EU
AI_07	●	--- Not Used ---	AI_07	-25.0	EU
AI_08	●	--- Not Used ---	AI_08	-25.0	EU

Buttons at the bottom: Back, Channel Events.

Figure 20-3. Analog Input Summary

Analog Inputs:

A typical screen is shown below. Configure appropriate ranges, units, and tag numbers. For process inputs, engineering units are set inside train configuration pages (text message displayed “**Set in Train Configuration**”) such as Stage 1 Flow. For those process variables, ignore unit selection during hardware channel configuration.

Figure 20-4. Analog Input 01 Configuration

Analog Outputs:

Below is an example screen. Note that ASV is a signal fail to open valve; therefore, the option for “Fail Open Actuator” has been checked. However, Performance controller output is configured for AO2 channel and actuator is not “Fail Open”.

Figure 20-5. Analog Output 01 Configuration

Boolean Inputs:

The Boolean input 01 is always dedicated to Emergency shutdown signal. Below is a sample configuration page for contact input 04:

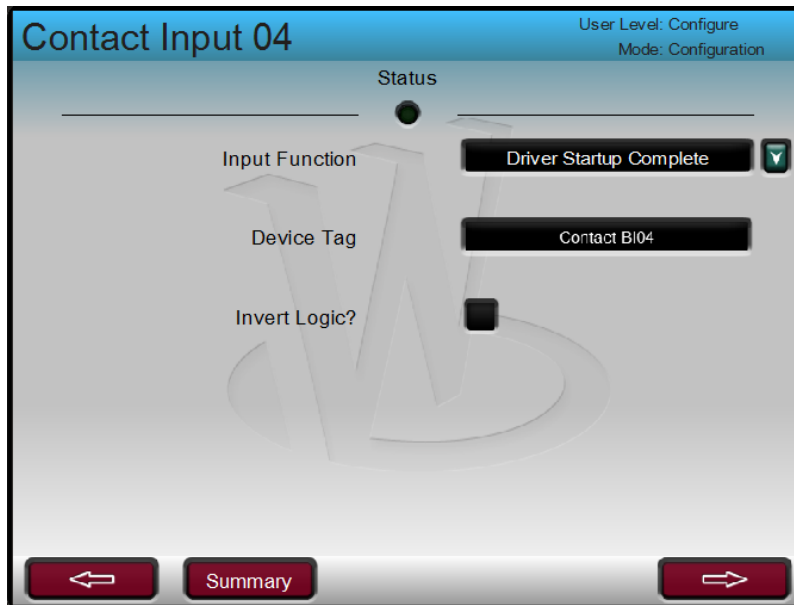


Figure 20-6. Contact Input 03 Configuration

Boolean Outputs:

The Boolean output 01 is reserved for Shutdown. Below is the sample configuration of one relay output 03.



Figure 20-7. Relay Output 03 Configuration

Intermediate Analog Inputs Configuration Screen:

Note that engineering units for certain parameters are not configurable in the Analog Input section; therefore, the default values are still displayed.

	Fault	Function	Tag	Value	Units
AI_01	<input type="radio"/>	Stage 1 Flow	AI_01	0.0	mm H2O
AI_02	<input type="radio"/>	Stage 1 Discharge Pressure	AI_02	43.8	kg/cm2 A
AI_03	<input type="radio"/>	Stage 1 Suction Pressure	AI_03	21.0	kg/cm2 A
AI_04	<input type="radio"/>	Stage 1 Discharge Temperature	AI_04	14.2	C
AI_05	<input type="radio"/>	Stage 1 Suction Temperature	AI_05	7.1	C
AI_06	<input type="radio"/>	External Speed Signal (4-20 mA)	AI_06	15000.0	RPM
AI_07	<input type="radio"/>	Motor Curr/Power 4-20 mA	AI_07	291.7	AMP
AI_08	<input type="radio"/>	Process/Performance Input	AI_08	55.5	kg/cm2 A

Figure 20-8. Analog Input Summary

Intermediate Analog Output Screen:

	Fault	Function	Tag	Value	Units
AO_01	<input type="radio"/>	Stage 1 AS Valve Demand	AO 01	100.0	%
AO_02	<input type="radio"/>	Performance Valve Output Demand	AO 02	0.0	%
AO_03	<input type="radio"/>	— Not Used —	AO 03	0.0	EU
AO_04	<input type="radio"/>	— Not Used —	AO 04	0.0	EU
AO_05	<input type="radio"/>	— Not Used —	AO 05	0.0	EU
AO_06	<input type="radio"/>	— Not Used —	AO 06	0.0	EU

Figure 20-9. Analog Output Summary

Contact Input Summary:

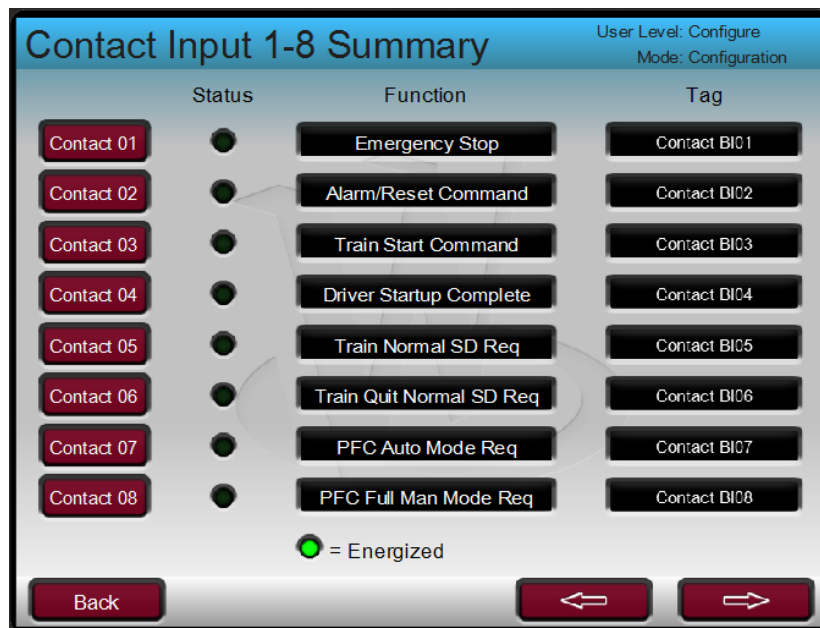


Figure 20-10. Contact Input Summary

Relay Output Summary:

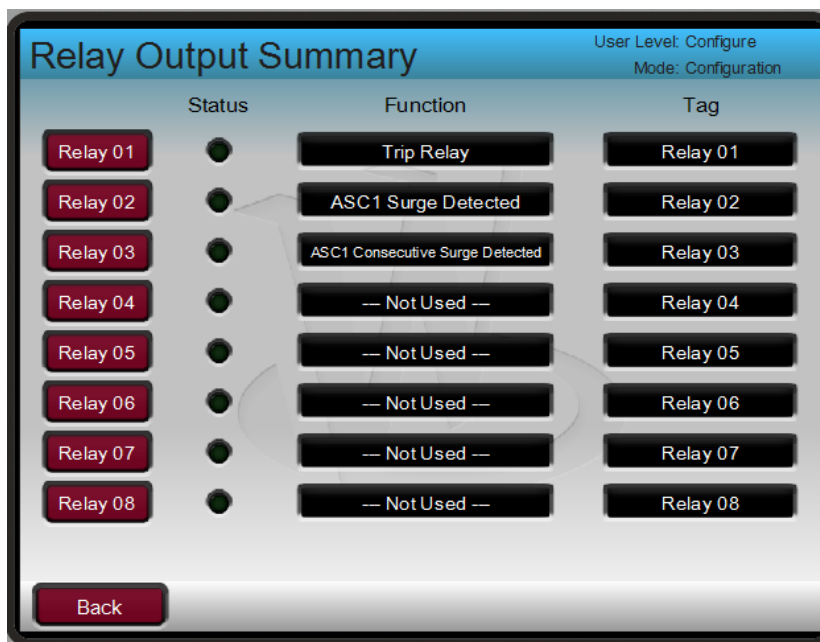


Figure 20-11. Relay Output Summary

Train Configuration:

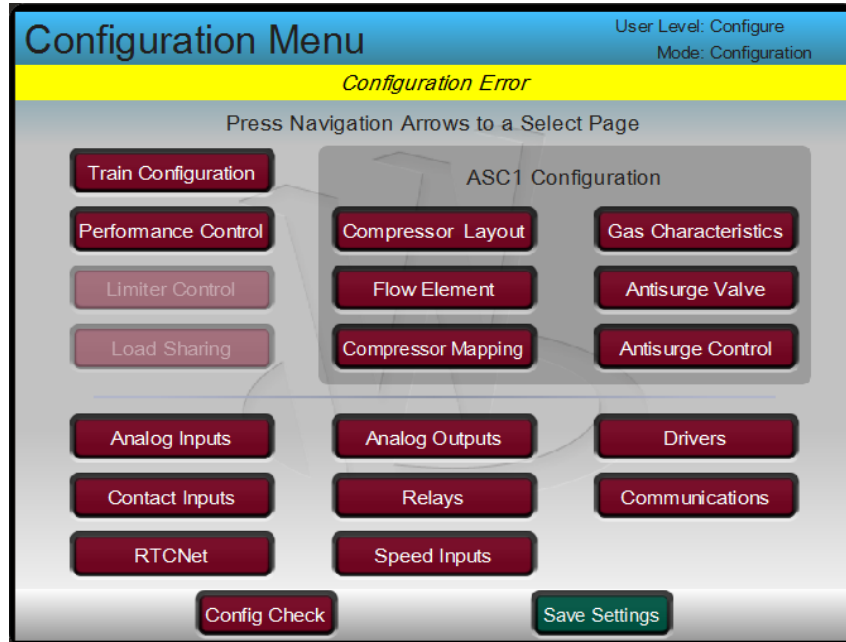


Figure 20-12. Train Configuration Main Menu

1. Inside Train configuration task:
Configure 1 stage ASC and 1 PFC controls.

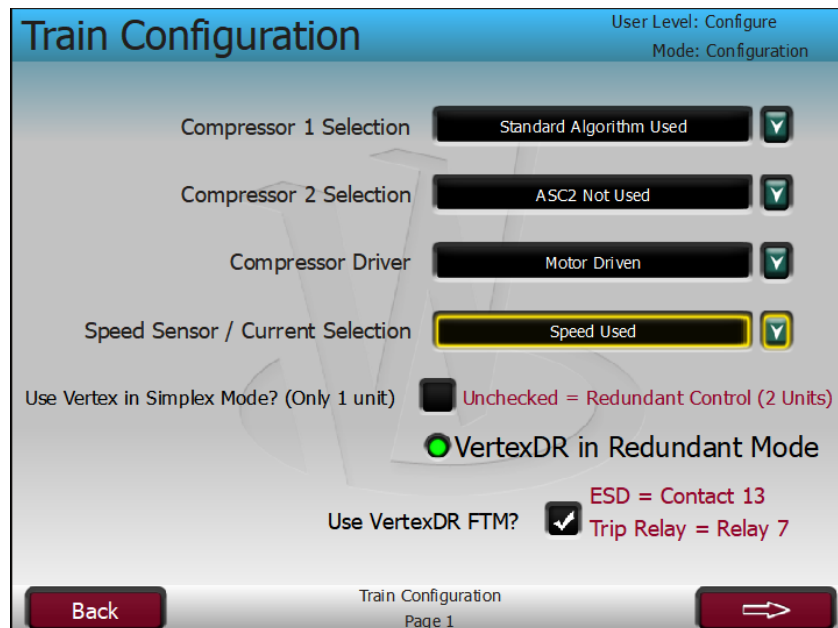


Figure 20-13. Train Configuration

2. Compressor 1 Selection:
Standard Algorithm Used.
3. Compressor 2 Selection:
Since no second stage is involved, we use option "ASC2 Not Used".
4. Compressor Driver:
It is a motor driven compressor, therefore the selected option is "Motor Driven". This option is only used for the overview screen display, and no functional impact occurs.

5. Speed Sensor and/or Current Selection:
Use the pull-down menu to select these if used.
6. Select if this is a Simplex or Redundant configuration of the VertexDR.
7. Select whether or not the Woodward DR-FTM is used.
8. Intermediate configured screen:

The screenshot displays the 'Train Configuration' screen with the following settings:

- Compressor 1 Selection:** Standard Algorithm Used
- Compressor 2 Selection:** ASC2 Not Used
- Compressor Driver:** Motor Driven
- Speed Sensor / Current Selection:** Speed and Current Used
- Use Vertex in Simplex Mode? (Only 1 unit):** Unchecked = Redundant Control (2 Units)
- Use VertexDR FTM?:** ESD = Contact 1
Trip Relay = Relay 1

At the bottom of the screen, there is a 'Back' button on the left, 'Train Configuration Page 1' in the center, and a right-pointing arrow button on the right.

Figure 20-14. Train Configured Screen

Units Defined in the Controller

Default Screen:



Figure 20-15. Units Defined in the Controller

- Metric-Imperial: Refer customer supplied data such as thermodynamic datasheet, Performance maps, the unit system used is metric. Therefore, option “Metric Units for all signals” is used.
- Pressure Unit Used:
Based upon same data, pressure units are kg/cm² (Abs).
- Temperature Unit used:
Temperature units are used as degrees C as per the documents.
- Flow Unit for Mapping Used:
Refer compressor map flow units. It is am³/Hr. Therefore, the selected unit is Actual m³/Hr.
- Polytropic Head Unit Used:
Based upon map data it is N-m/kg, so unit is used as N-m/kg.
- Flow Element Delta P Unit Used:
This delta P unit is taken from the Flow measuring device calibration data sheet. It is mmH₂O. Therefore, option “mmH₂O” is used.
- Mass/Standard Flow Unit:
Mass flow or standard flow units used based upon the map which is kg/hr. If not sure, then leave it as default.
- Load Unit:
Load units used from compressor Thermodynamic data sheet. Here it is MW.

Intermediate Configuration:

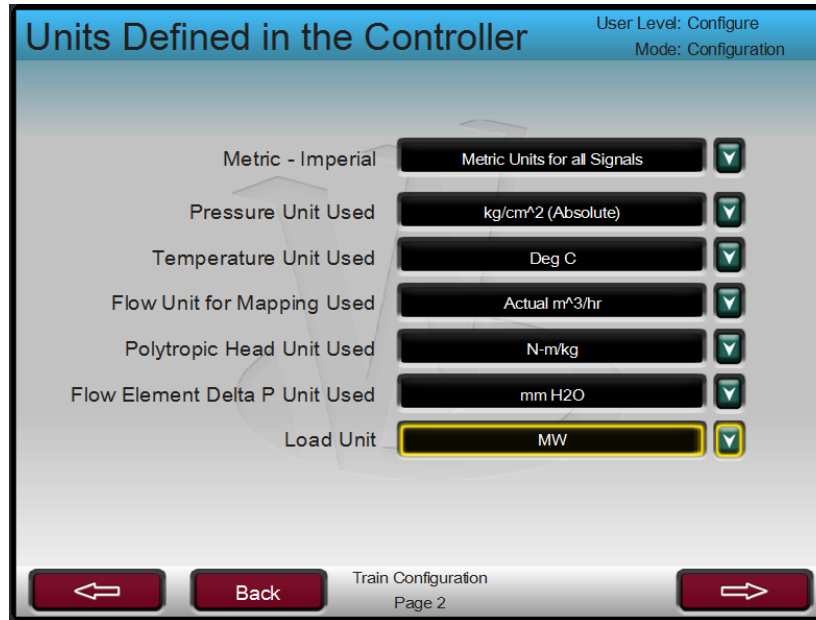


Figure 20-16. Units Defined in the Controller Screen

- Access next page.
Altitude and Standard Conditions- Atmosphere pressure at site. It must be at unit of kPaA for metric and psia for imperial. If no specific value has been provided by the customer, then leave this field as default.
- Stand Conditions:
For metric, Degree C is used
For imperial Degree F is used.
If no specific value has been provided by the customer, then leave this field as default.
- Stand Conditions:
For metric kPa (Absolute) is used
For imperial psia is used
If unsure about exact values, then leave default settings

Intermediate Configuration Page:

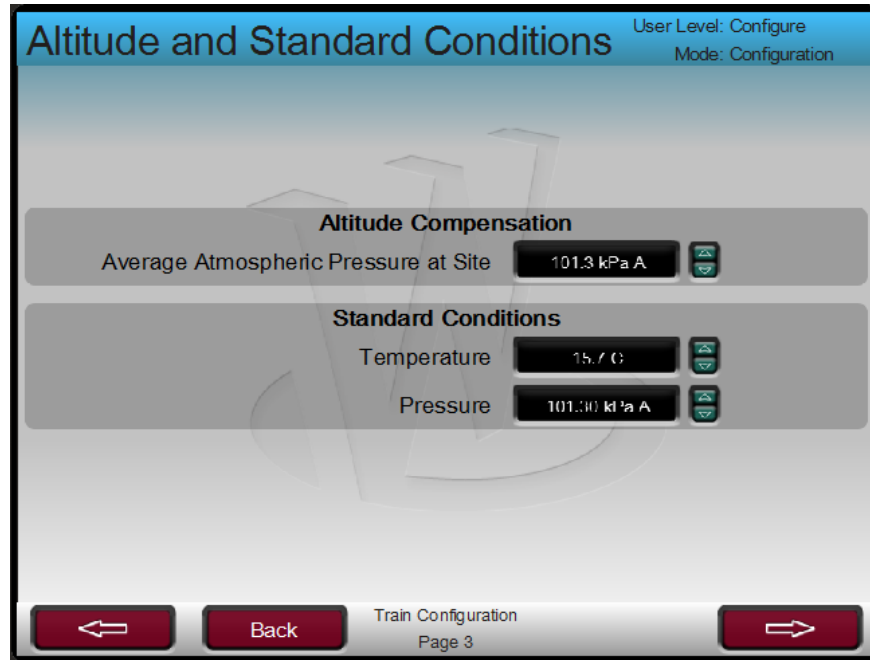


Figure 20-17. Altitude and Std. Conditions

Access next page, Train Parameters.

Train Parameters:



Figure 20-18. Train Parameters

- **External Trips in trip Relay:**
If the user wants to change the state of Vertex trip relay based upon any trip signal, then this option should be checked.

- **Reset Clears Trip Relay:**
If Vertex controller Reset button is used for Trip clearing then check this box.
- **Trip on Normal Shutdown Complete:**
If this option is checked, at the end of normal shutdown command, Performance controller will ramp to shut down state.
- **Use Trip Emergency Push Button:**
Vertex panel Trip button is used to trip the unit, therefore, keep this box checked.
- **Use Remote Start:**
Check this box if a remote start command is used to start the train.

Performance Control Configuration



Figure 20-19. Configuration Menu Performance Controller

Performance Configuration:

As per the control design, the performance controller will control dedicated PT1010. Enable performance controller with option of “Dedicated Signal”.

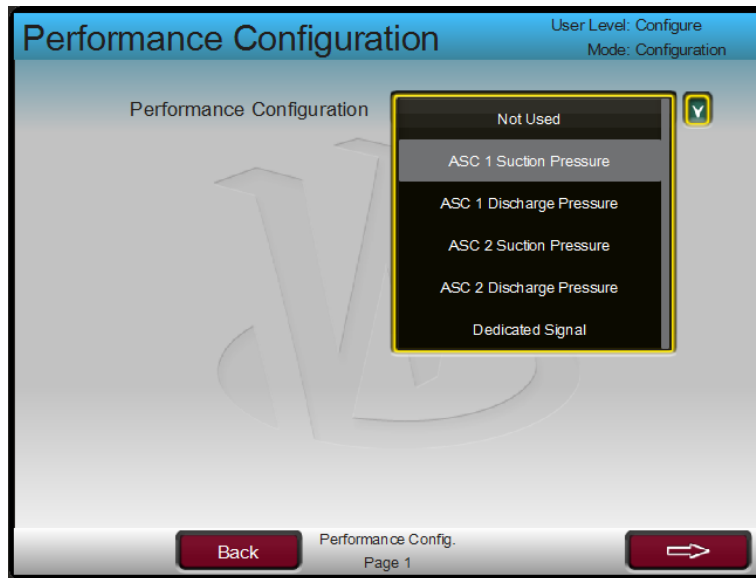


Figure 20-20. Performance Controller Configuration

- **Minimum Setpoint:**
Enter minimum value of set point of the Performance controller. Refer to the operating conditions, the operating target of PT1010 is 50 kg/cm A. Therefore, operating range is assumed to be 30 to 70 kg/cm² A. The minimum value is set as 30 kg/cm² A.
- **Maximum Setpoint:**
Enter maximum value of set point of the Performance controller.
- **Inverted:**
If performance output to be increased when PV > SP (such as discharge pressure control with performance valve in discharge), then don't check "Inverted?" option. If performance output to be decreased when PV > SP (such as suction pressure control with performance valve in suction), then check "Inverted?" option. Here, if PV of performance controller (PT-1010) > SP then Performance controller's output should reduce, therefore, invert option is checked.
- **Set Point Rate:**
Rate of change of set point value.
- **Use Set point Tracking:**
During startup, the Performance controller's set point tracks its process variable, therefore the user does not need to define initial set point. If this option is not checked, then the user needs to configure the initial set point.
- **Startup Selection:**
Desired state of performance controller when startup is finished. In this example, performance controller is required for auto mode; therefore, Auto Start option is selected.

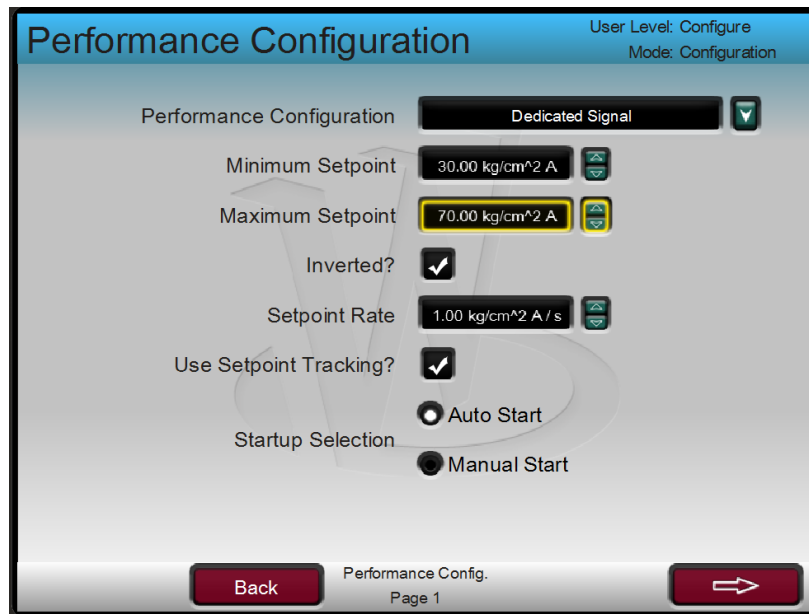


Figure 20-21. Performance Configuration Screen

Press the function key below arrow mark to access next screen

Performance Configuration (continued)

- Use Remote Set point:
If the set point is to be used as remote analog signal, then check it. In this case, the operator would enter set point the remote AI hardwired signal. If the remote Set point is selected, then the user can select set point ramp rate as well.
- Use Driver Limit Tracking:
If the project requires Performance controller to track the output of the secondary controller, such as speed controller, then this feature may be used. In this case, the operator can place performance controller on tracking, so that the performance controller will track the speed and adjust its output with range of 0-100% with min Gov to max Gov of speed signal. Not required in this example.
- Use Remote Manual Demand:
Check this box if performance controller manual demands are to be controlled by remote analog signal. In this case, the operator would enter manual demands through hardwired remote demand signal.
- Performance Drive Type:
Drop down menu to select driver type of Performance controller. This selection is for display purposes on load-sharing screen only.

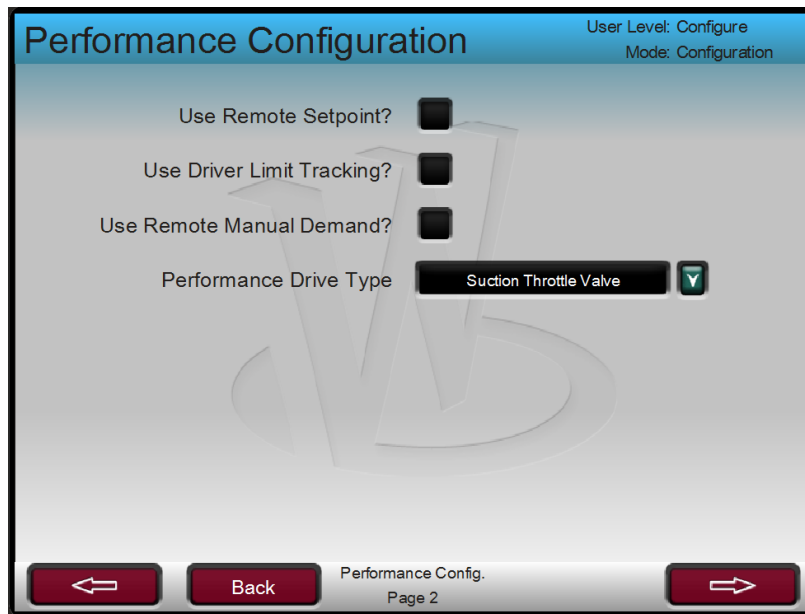


Figure 20-22. Configuration of Performance Controller

Press right arrow to access next Page.

Performance Sequencing:

- **Reset Position:**
This is the position of Performance controller's driver before startup. In the example, it is required to have some positive feed flow before the startup; therefore, when the unit is issued reset command, the performance controller raises demands to 10%.
- **Startup Position:**
This is the position to which Performance controller demand will ramp, when Unit start command is issued. In this project, it is set to 15%.
- **Startup Delay:**
Delay time between when startup command is issued and actual unit startup. Unless specified, leave this setting to default value.
- **Sequence Ramp Rate:**
Ramp rate through which the performance controller's demand ramps before unit startup.
- **Use Remote Start:**
If there is no external start, complete feedback exists and the Train reset condition startup is completed, i.e. the train is started remotely.
- **Use Manual Start:**
Used if unit start up is required manually.

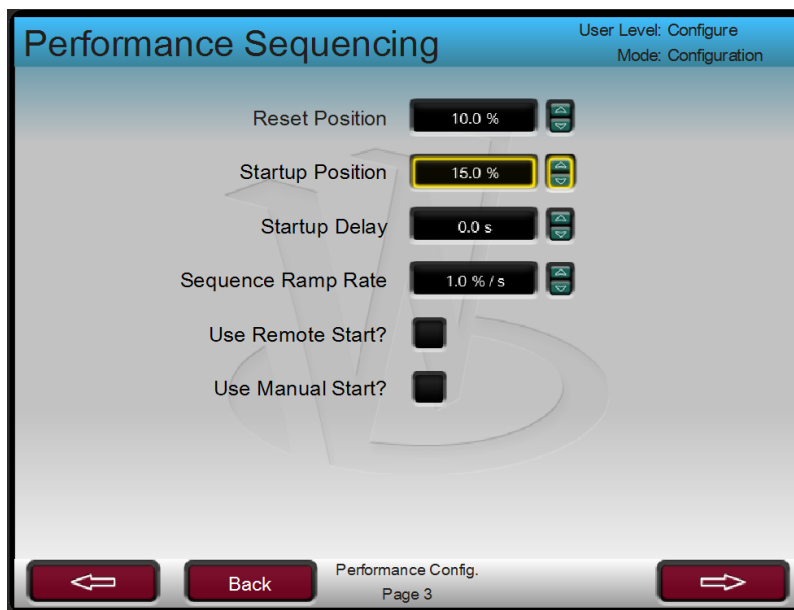


Figure 20-23. Performance Controller Sequencing

Press right arrow to access next page.

Performance Configuration–Decoupling:

This section is to be handled in Service mode.

Press the Back button and refer to Train Configuration page:



Figure 20-24. Configuration Main Menu

Limiter Control Configuration:

Performance Limiter 1 is used to limit motor current.

Limiter 1 configuration option as “Motor Current/Power Input”. The reference of Motor current set point should be obtained from the end user. At the configuration stage, keep the maximum value of Motor current/power range as set point. The motor data sheet supplied by the customer provides trip value of motor current at 300 amp. Therefore, Limiter 1 PV will be motor current. The set point range is set to 150-275 AMP. Initial set point is set to 250 amp. If motor current increases higher than configured set point, the limiter output should decrease, so invert option should be unchecked.

The screenshot shows the configuration interface for Performance Limiter 1. The title bar indicates 'Performance Limiter 1' and 'User Level: Configure Mode: Configuration'. The main configuration area includes:

- Limiter Configuration:** A dropdown menu set to 'Motor Current/Power Input'.
- Minimum Setpoint:** 150.00 AMP
- Maximum Setpoint:** 275.00 AMP
- Initial Setpoint:** 250.00 AMP
- Inverted?:** Unchecked checkbox
- Setpoint Rate:** 1.00 AMP / s
- Use Remote Setpoint?:** Unchecked checkbox

At the bottom, there are 'Back' and 'Limiter 2' buttons, and the text 'Limiter Configuration Page 1' is centered.

Figure 20-25. Configuration Performance Limiter 1

Limiter 2: Since no other limiter is planned at this stage, Limiter 2 is not used.

At this stage, Train and Performance controller configurations are complete. The next step is to carry out Anti-surge 1 configuration.

ASC1 Configuration

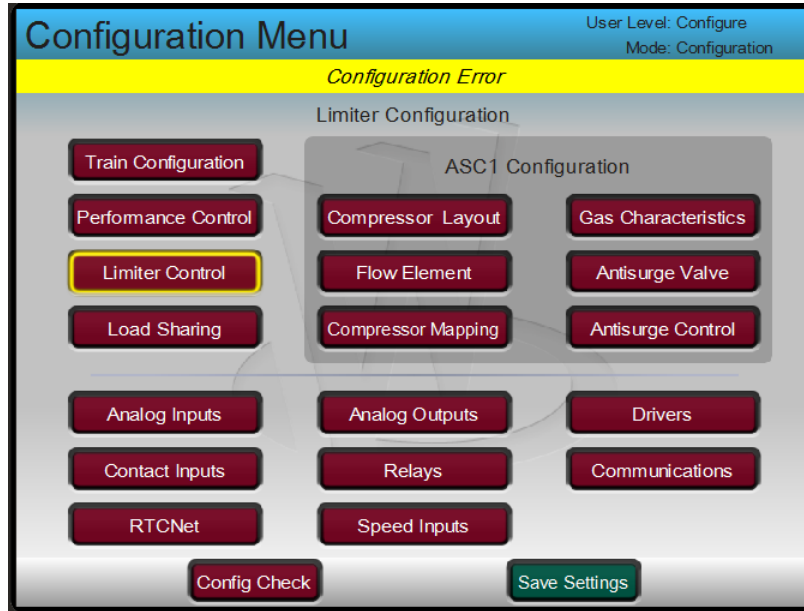


Figure 20-26. Configuration Main Menu

Compressor Layout

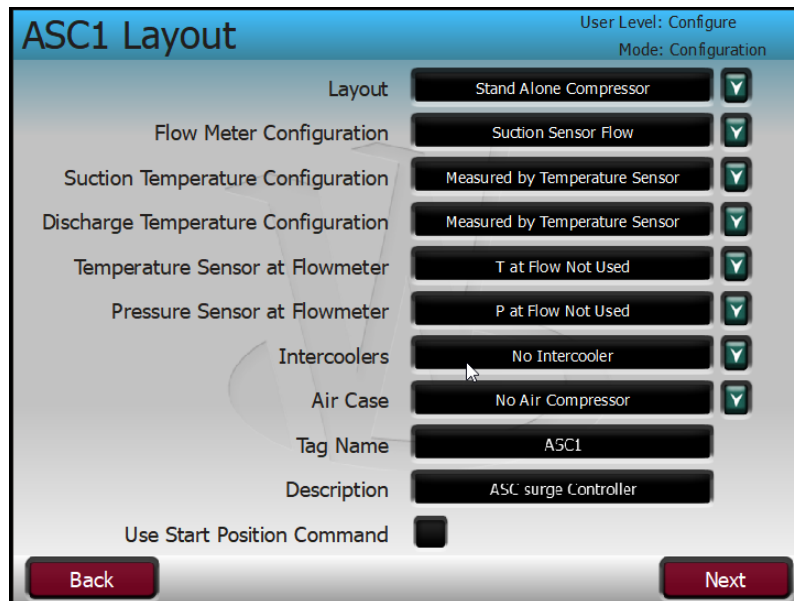


Figure 20-27. ASC1 Layout

Layout: The P&ID shows that dedicated anti-surge valve is used for single anti-surge control. Therefore, the standalone compressor option is selected.

Flowmeter Location:

- Refer to P&ID of the project.
The Flow element FE-1030 is located at the discharge side of the compressor. Therefore, the option of “Flow meter at Discharge side” is selected.
- Temperature Usage:
Temperature transmitters at suction (TT-1205) and discharge side (TT-1206) of compressor have been used. Therefore, the option of “Suction & Discharge used” is applied.
- Intercoolers:
No intercoolers have been used between the stages, therefore option “No Inter-cooler” is used.
- Air Case:
The compressor application is not an air compressor (Feed Gas), therefore No Air Compressor” option is used.
- Tag Name:
Configure Tag name of the Anti-Surge Controller.
- Description:
Enter text for Anti-Surge Controller.
- Use Start Position Command:
Since Train startup command is used for ASC startup as well, no separate ASC start position command is used. Start Position Command checkbox is unchecked.

Configuration Screen:

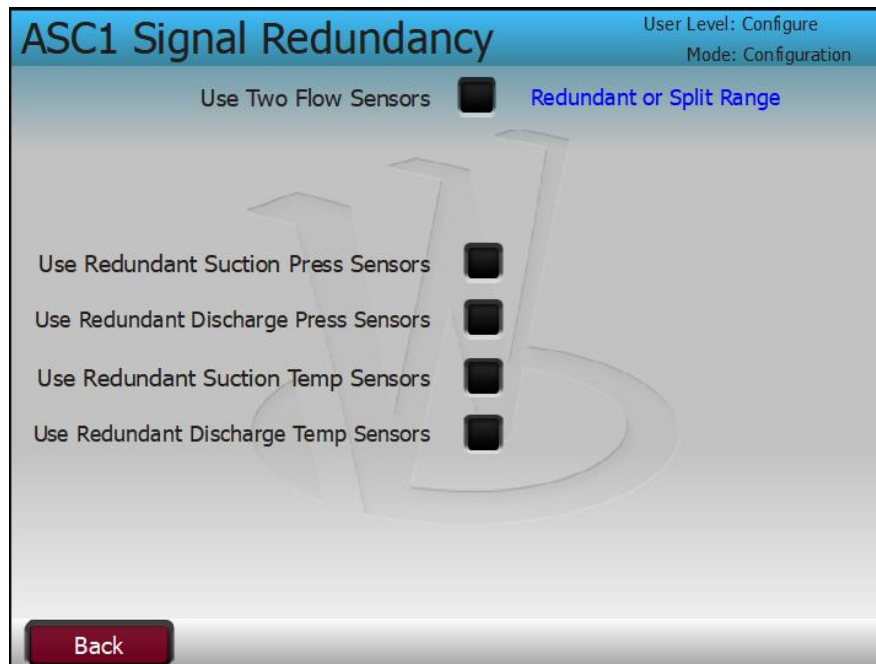


Figure 20-28. ASC1 Signal Redundancy Configuration Screen

Gas Characteristics:

On this page, properties related to feed gas of the compressor is entered such as molecular weight, specific heat ratio, and compressibility. To find data, refer to the supplied thermodynamic data sheet as shown below. Relevant data points have been highlighted. The selected case is "Normal".

(ALL DATA ON PER UNIT BASIS)	NORMAL	RATED	60% TURNDOWN	LEAN GAS CASE	ALTERNATE	RICH GAS CASE	
● GAS HANDLED (ALSO SEE PAGE ___)	NATURAL GAS						
△ GAS PROPERTIES (1-2.1.1.4)							
○ Nm ³ /h(1.033kg/cm ² A & 0° C DRY)							
● WEIGHT FLOW (kg/h) (DRY)(WET)	51340	53907	30804	49950	51520	50470	
INLET CONDITIONS							
● PRESSURE (kg/cm ² A)	41.00	41.00	41.00	41.00	45.00	41.00	
● TEMPERATURE (° C)	15.0	15.0	15.0	30.0	43.0	10.0	
○ RELATIVE HUMIDITY %							
● MOLECULAR WEIGHT	17.82	17.82	17.82	16.46	16.26	19.71	
■ Cp/Cv(K1) OR (KAVG)	1.445	1.445	1.445	1.412	1.404	1.474	
■ COMPRESSIBILITY(Z1)OR(ZAVG)	0.906	0.906	0.906	0.935	0.943	0.867	
■ INLET VOLUME (m ³ /h (DRY)(WET)	1555	1633	933	1778	1779	1299	
DISCHARGE CONDITIONS							
● PRESSURE (kg/cm ² A)	50.50	53.00	50.50	50.50	50.50	50.50	
■ TEMPERATURE (° C)	32.4	36.6	33.8	48.5	53.8	26.4	
■ Cp/Cv(K2) OR (KAVG)	1.442	1.441	1.438	1.407	1.401	1.473	
■ COMPRESSIBILITY(Z2)OR(ZAVG)	0.908	0.909	0.910	0.938	0.945	0.867	
■ BHP REQUIRED (kW)	478	621	325	543	341	407	
■ TRAIN BHP REQUIRED (kW)	478	621	325	543	341	407	
■ BHP REQUIRED AT DRIVER INCL EXT. LOSSES (kW) (*)	493	636	340	558	356	422	
■ SPEED (RPM)	11200	12246	10423	12321	10463	10091	(A)
■ TURNDOWN (%)	47.1	42.8	12.0	49.5	62.4	42.1	(A)
■ POLYTROPIC HEAD (N-m/kg)	26190	32510	26280	30800	17900	22210	
■ POLYTROPIC EFFICIENCY (%)	81.6	81.0	73.7	81.7	79.8	80.5	
● CERTIFIED POINT	Yes	Yes			Yes		
□ PERFORMANCE CURVE NUMBER	(Power)	(Head & Flow)			(Head & Flow)		(A)
PROCESS CONTROL (1-3.4.2.1)							
METHOD ○ SUCTION THROTTLING ○ VARIABLE INLET ● SPEED VARIATION ○ DISCHARGE ○ COOLED BYPASS							
FROM _____ (kg/cm ² G) GUIDE VANES FROM 70 % BLOWOFF FROM _____							
TO _____ (kg/cm ² G) (2-3.4.2.2) TO 105 % TO _____ TO _____							
SIGNAL ● SOURCE (1-3.4.2.1) Compressor discharge pressure by Performance Controller (A)							

Figure 20-29. Gas Characteristic Data

- Gas Molecular weight:
Enter gas molecular weight. According to the customer data it is 17.82.
- Gas Specific Heat Ratio:
Enter the Cp/Cv ration from data sheet. Since flow meter has been placed at discharge side of compressor, the Cp/Cv ratio of compressor discharge is used. Enter value 1.442
- Compressibility at Suction (Z1): Enter value of Z1 from the data sheet. Z= 0.906
- Compressibility at Suction (Z2): Enter value of Z2 from the data sheet. Z= 0.908

Compressibility at Standard conditions (Zstd.): If Zstd has not been mentioned by the thermodynamic data sheet, then calculate it. For rough control, the average value of Z1 and Z2 can be a last option. The Zstd. for this configuration is based upon average value of Z1 and Z2. $Z_{std} = (0.906+0.908)/2 = 0.907$.

Configured Screen:

Parameter	Value
Gas Molecular Weight	17.8 g / mol
Gas Specific Heat Ratio	1.442
Compressibility at Suction (Z1)	0.906
Compressibility at Discharge (Z2)	0.908
Compressibility at Standard conditions (Zstd)	0.907

Back

Figure 20-30. ASC1 Configured Gas Characteristic

End of Gas Configuration screen. Press function key “Back” to reach main configuration screen.

ASC1 Flow Element:

This configuration option is used for calibration of flow element. Refer FMD data sheet to get values for configurations.

Below is the information drawn out from the Orifice data sheet:

Flow meter type = Orifice

Parameter	Value
Flow Element	Throat
Type of Transmitter	Raw Flow at Sensor
Expansion Factor	Fixed Expansion Factor
Method Used	Flow Data from Calibration Sheet
Flow Element Delta P Unit Used	mm H2O
Mass/Standard Flow Unit	kg/hr
Flow Coefficient Used	0.200
Status	Error: Value Not Sent

Back Calibration

Figure 20-31. ASC1 Flow Element Configuration

Flow Element:

Orifice is the flow meter type, therefore, Flow Element type is “Orifice plate”.

- **Type of Transmitter:**
The flow transmitter FT-1030, sends raw flow values without compensation for pressure and temperature. It is highly recommended to use raw flow at sensor without any compensation.
- **Expansion Factor:**
Unless specifically mentioned by the data sheet, expansion factor (also known as Y factor) is set as fixed. Based upon available data, the Y factor is not mentioned to be variable, therefore option “Expansion factor fixed” is chosen.
- **Method Used:**
For calibration purposes, the process parameters such as tested flow and corresponding differential pressure, based upon mentioned gas type, pressure has been used, and then flow data from calibration sheet is used. If geometric data of flow device such as diameter, pipe diameter, expansion factor, etc. are used, then geometrical method is used. Referring data sheet, calibration method is used.
- **Flow Element Delta P Unit Used:**
Referencing the data sheet, the units for flow element is mmH2O, therefore, it is used as the option.
- **Mass/Standard Flow Unit:**
Refer flow data sheet, the normal flow unit is Nm3/hr. SO this unit has been used.
- **Flow Coefficient Used:**
This field is non user configurable but reflects the calibrated coefficient value.
- **Status:**
This text field is reflection of the current status of flow device calibration. Before the calibration the status is “Error: Value Not Sent”. Once calibration is done, the status text color changes to green .

Configuration screen:

ASC1 Flow Element		User Level: Configure
		Mode: Configuration
Flow Element	Orifice plate	▼
Type of Transmitter	Raw Flow at Sensor	▼
Expansion Factor	Expansion factor fixed	▼
Method Used	Flow Data from calibration sheet	▼
Flow Element Delta P Unit Used	mmH2O	▼
Mass/Standard Flow Unit	Nm3/Hr	▼
Flow Coefficient Used	0.200	
Standard Flow Unit	Nm3/Hr	
Status	Error: value not send	

Back Calibration

Figure 20-32. ASC1 Configured Flow Element

The next step is to calibrate the flow meter. Press right side function key below “Calibration” tab to go to the next page.

Flowmeter Calibration:

This page is used for calibration of flow device. Refer to the flow device data sheet.

Table 20-1. Flow Device Data

64575 Nm ³ /h flow of the gas with MW of 17.82:	At pressure 49.5 kgf/cm ² -g
Temperature:	32.4 °C
Compressibility:	0.91, with differential pressure of 1250 mmH ₂ O with pressure loss of 0.0292 kgf/cm ²
Flow:	64575 Nm ³ /h
Delta Pressure at Flow:	1250 mmH ₂ O
Molecular Weight:	17.82
Pressure at Flowmeter:	50.53 kgf/cm ² -A (49.5 kgf/cm ² -g + atm. Pressure (1.03))
Temperature at Flowmeter:	32.4 °C
Compressibility at Flow (Z):	0.91

- **Percentage Lost:**
It is percentage loss of the flow, which has not been mentioned in the data sheet (only pressure loss is mentioned) therefore, leave this box at default value.
- **Intermediate Result:**
The intermediate calculated result is displayed which is ready to be sent to the controller.
- **Status:**
If calculated value has not been sent to the controller, then status box shows “Error: Value Not Sent”.

Select button “Send calculated value to control” and press Enter button on keyboard.

The status box text should change to green color “Configuration OK”.

Configuration Screen:

The screenshot shows the 'ASC1 Flowmeter Calibration' screen. At the top right, it indicates 'User Level: Configure' and 'Mode: Configuration'. The screen lists the following parameters and values:

- Flow: 64575 Nm³/Hr
- Delta Pressure at Flow: 1250.000 mm H₂O
- Molecular Weight: 17.8 g / mol
- Pressure at Flowmeter: 50.5 kg/cm² A
- Temperature at Flowmeter: 32.4 C
- Compressibility at Flow (Z): 0.910
- Percentage lost: 0.00 %
- Intermediate Result: 1826.376
- Status: Configuration OK

At the bottom, there is a green bar above a button labeled 'Send calculated value to control'. Below that are two buttons: a left arrow button and a 'Back' button.

Figure 20-33. ASC1 Flowmeter Calibration Screen

Flow device calibration is finished. Press <- functional key to return to the previous page.

Compressor Mapping

This configuration page is used to configure compressor Map details and rated conditions.

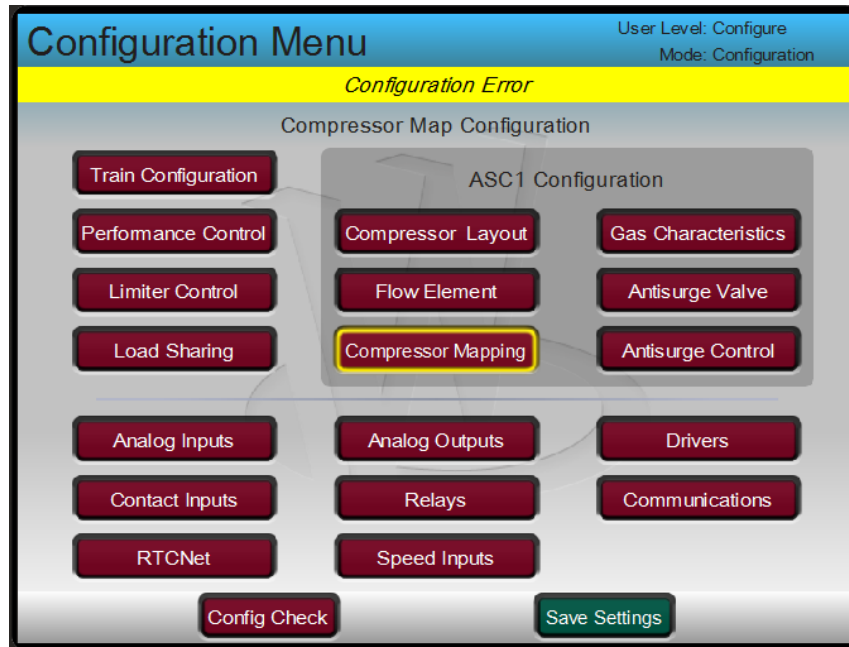


Figure 20-34. Main Configuration Screen-Mapping

- **Status of Actual Map:**
The status text box displays by default “Rated condition changed –Re-confirm”. The status changes based upon the current map configuration status.
- **Type of Map Entered:**
The customer provided compressor Map 102-J Feed Gas (Normal) displays compressor map options as discharge pressure (Pd) vs flow (Q) or Polytropic Efficiency (H) vs Flow (Q). Either option can be chosen. By default, Polytropic Head (H) vs flow (Q) is selected.
- **Type of flow for Mapping:**
Flow type on the map is actual flow ($\text{am}^3/\text{hr} \cdot 10^3$). Therefore, the “Actual Flow” option has been selected.
- **Flow Unit Used for Configuration:**
This text box is for status display only and not available for configuration.
- **Pressure Unit Used for Configuration:**
If on Map, pressure units are in gauge instead of absolute (for example compressor map pressure units are in $\text{kg}/\text{cm}^2 \text{ g}$ and not $\text{kg}/\text{cm}^2 \text{ A}$) then option “Pressure Unit in Gauge for Mapping”, should be opted. In the customer provided data, the pressure unit on compressor map is $\text{kg}/\text{cm}^2 \text{ A}$; therefore, the “Pressure Unit in Abs for Mapping” option has been selected.
- **Y Axis Unit Used for Configuration:**
Status display of Y axis unit as on compressor Map.
- **Number of points used:**
Minimum 3 points are recommended for configuration. A maximum 10 points can be configured. Refer to the compressor map. A total of 5 points have been identified for this example. All 5 points are at the end of the speed curve.
- **Choke Map:**
Since there is no requirement for Choke control from the data, no Choke map configuration is used. In Vertex, Choke control is only used for alarm and not for control.

Configuration Screen:

ASC1 Map Type

User Level: Configure
Mode: Configuration

Status of Actual Map **Rated condition changed - Re-confirm**

Type of Map Entered H = F(flow) ▼

Type of flow for Mapping Actual Flow ▼

Flow Unit Used for Configuration ACMH

Pressure Unit Used for Mapping Pressure Unit in Abs for Mapping ▼

Y Axis Unit Used for Configuration N-m/kg

Number of points Used 5 Points Used ▼

Choke Map Choke map Not Used ▼

Back →

Figure 20-35. ASC1 Map Type

Select the right arrow to access the next page.

ASC1 Units and Multiply Factors:

- Status of Actual Map:
Status text display of current map configuration status
- Actual Flow Engineering unit:
Status of actual flow engineering unit
- Multiply Factor on Actual Flow:
Referring to compressor map, the flow unit is $\text{am}^3/\text{HR} * 10^3$. Therefore, the multiplication factor is 10^3 . Option of E+03 is selected.
- Mass Flow unit:
Status of Mass flow unit
- Mass Flow Multiplier:
There is no specific display for using flow multiplier; therefore, option X1 is left as default.
- Standard Flow unit:
Status of standard flow unit
- Standard Flow multiplier:
There is no specific display for using flow multiplier; therefore, option X1 is left as default.
- Head unit:
Status of compressor head.
- Head multiplier:
Refer compressor map, the polytropic head unit is $\text{N-M}/\text{KG} * 10^3$. There multiplier of 10^3 is used. Option E+03 is used.

Configured Screen:

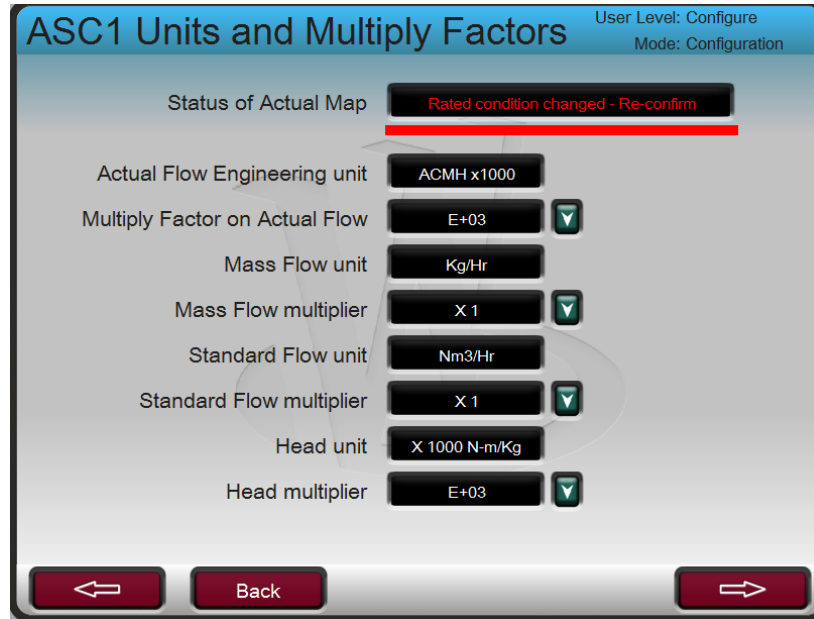


Figure 20-36. ASC1 Units and Multiply Factors

Select the right arrow to access next page.

ASC1 Rated for Mapping:

This configuration page is used to configure rated conditions. Refer thermodynamic data sheet for the used case of 102-J Feed Gas (Normal).

Table 20-2. Used Case of 102-J Feed Gas (Normal)

Suction Temperature:	Temperature $T_s = 15\text{ }^\circ\text{C}$
Suction Pressure:	$PS = 41.00\text{ kg/cm}^2\text{ A}$

- Discharge Temp (estimated):
This is an estimated discharge temperature for display purposes. When configuration is complete, it is recommended to verify compressor map discharge temperature is very close to estimated discharge temp.
- Discharge Pressure:
Referring to datasheet, $P_d = 50.5\text{ kg/cm}^2\text{ A}$. Note that discharge pressure should be 20% higher than the suction pressure to avoid configuration error.
- Actual Flow at Rated:
Refers to rated conditions, the rated case volumetric flow $Q_s = 1555\text{ am}^3/\text{hr}$. Therefore, configured value = $1.555\text{ ACMH} \times 1000$
- Rated Speed:
The compressor speed at rated condition. Referring to the compressor map, the rated speed is 11200.
- Percent Speed at Rated:
Unless mentioned by the customer, rated speed is assumed to be 100% speed. Referring to the compressor map, the rated speed 11200 rpm is 100%.
- Polytropic Efficiency:
Referring to the thermodynamic data sheet, the polytropic efficiency related to the used normal case is 81.6.

Configuration Screen:

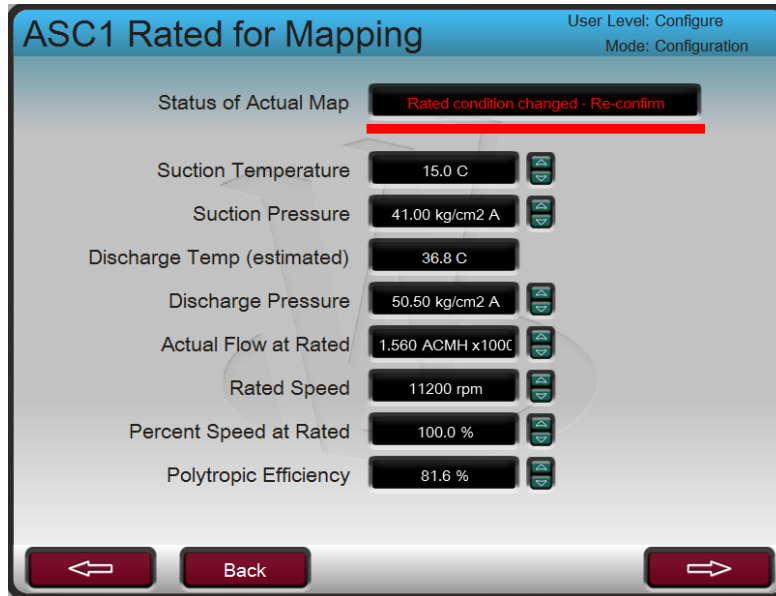


Figure 20-37. ASC1 Rated for Mapping

Select the right arrow to access the next page.

ASC1 Estimated Conditions

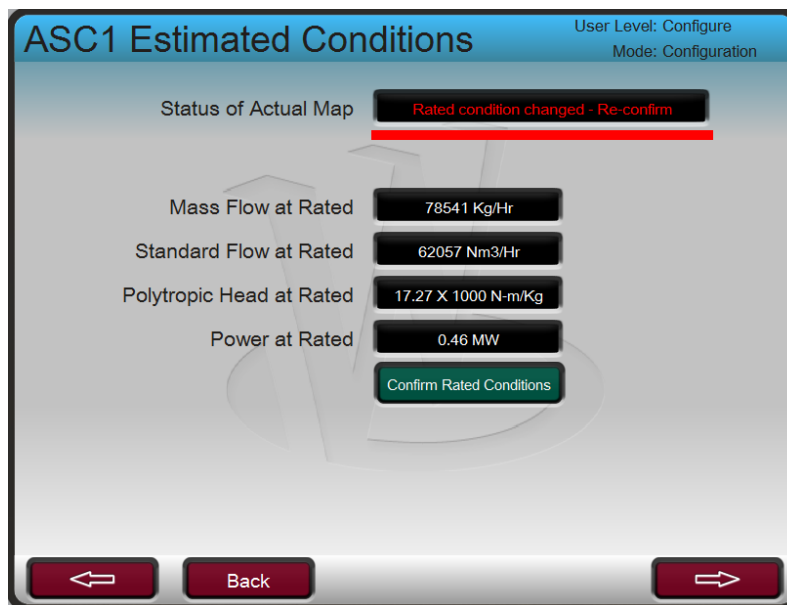


Figure 20-38. ASC1 Estimated Conditions

This page consists of the status of estimated process parameters. Therefore, no field is available for configurations. Verify and cross-check if estimated conditions have significant deviation from the rated conditions mentioned on the compressor map.

Select button "Confirm Rated Conditions", and press Enter button.

Configured Page:

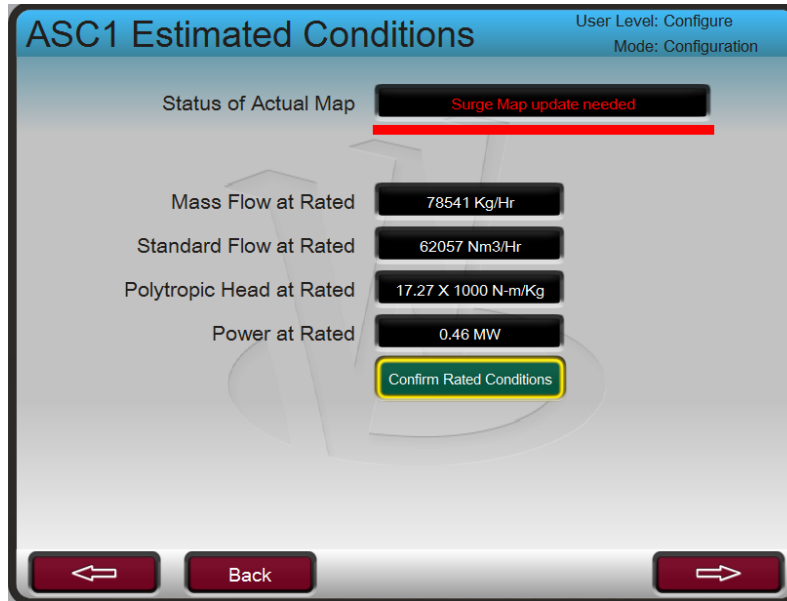


Figure 20-39. ASC1 Estimated Conditions Screen

Select the right arrow to access the next page.

ASC1 Surge Map Configuration

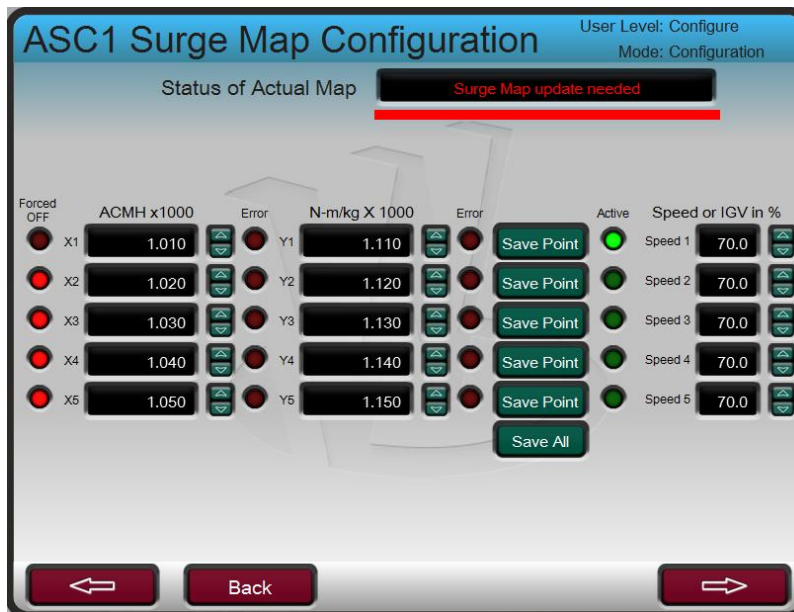


Figure 20-40. ASC1 Surge Map Configuration

This page is used to configure surge map points and corresponding speed (percentage). Note that speed (percentage) is indicative only and does not impact on control calculations.

Refer to the compressor map. The five map points are highlighted in red. The speed at rated condition is 11200, which is 100%. Start from the lowest point. Below are approximate calculated results.

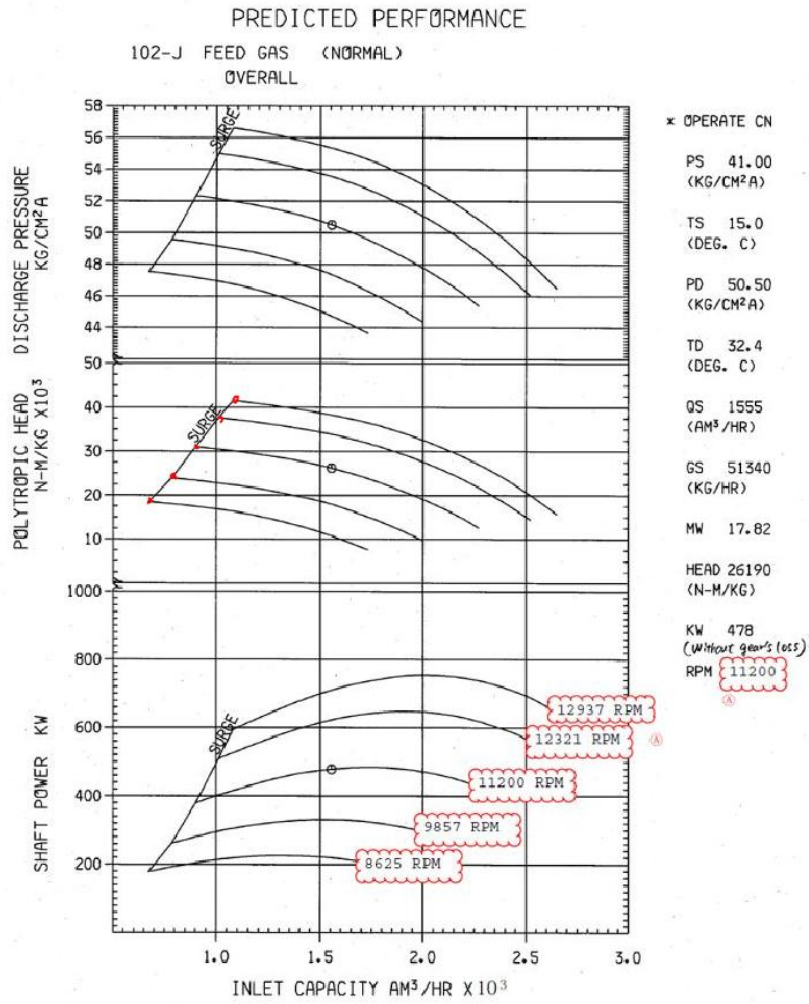


Figure 20-41. Predicted Performance Curve

Table 20-3. Example Surge Points

Points	X (ACMH*10 ³)	Y (N- m/kg*10 ³)	Speed	% Speed
X1	0.6629	18.622	8625	77%
X2	0.7808	23.893	9857	88%
X3	0.8876	31.006	11200	100%
X4	1.0112	37.608	12231	109.20%
X5	1.0842	41.575	12937	115.50%

Configured Screen:

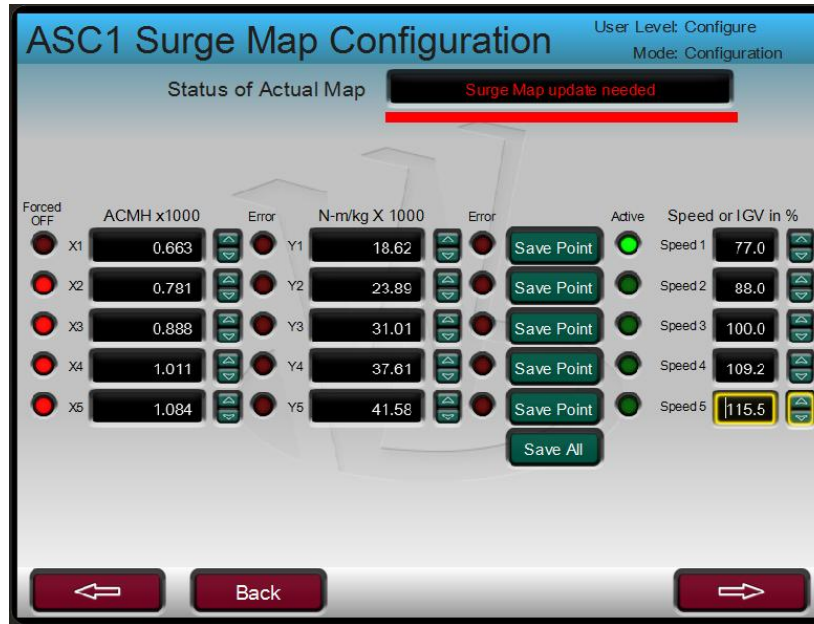


Figure 20-42. ASC1 Surge Map Configuration

Select "Save All" button and press Enter. Or select individual "Save Point" buttons and press Enter.

Final Configuration Screen:

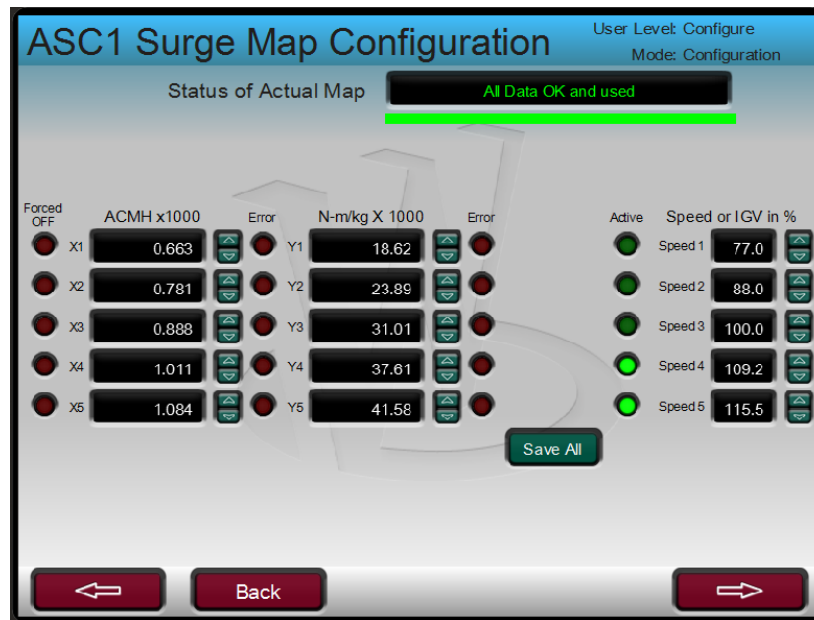


Figure 20-43. ASC1 Surge Map Configuration Screen

Select right arrow to access next page.

ASC1 Map Display Configuration

On this screen the Map display configuration is selected. The user can modify the type of map display and X axis variables. In the supplied data, map type was preferred as H vs Flow, therefore, type of Map option is selected as H = F (flow). Note that scaling of Y-axis and X-axis are both configurable. The default is set to map display auto configuration of scales. Refer to right side function key labeled as: "Auto Scale (On)".

Configuration Screen:

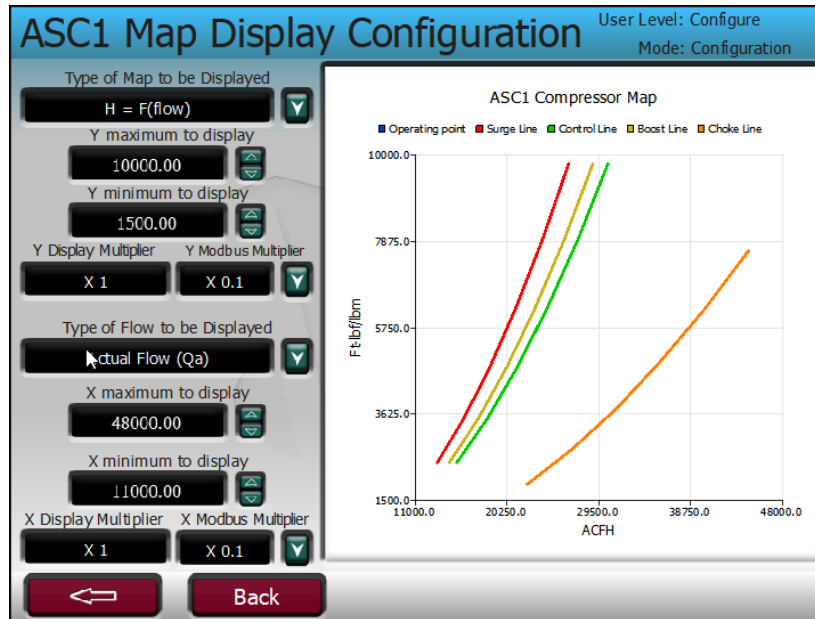


Figure 20-44. ASC1 Map Display Configuration Screen

Use this screen to configure the Min/Max values for both the X and the Y axis. The previous revision has an AutoScale button which is no longer available.

Antisurge Valve:

This configured screen is used to set parameters related to anti-surge valve.

- **Gain Compensation:**
If anti-surge valve is not linear, then gain compensation option is selected. Under gain compensation there are two options available. Both are described below:
- **Linearization Curve Used:**
If the valve response is required to be quick opening or equal percentage then this option may be used. Unless not required specifically by the control, linearization option is not used. If linearization curve is used, then press the function key below "Linearization" option.
- **Compensation based on CV:**
Refer to the operation manual for detailed description. If different proportional coefficients are required for controls for different operating conditions, then compensation based upon CV is used. In that case, from the compressor map, enter "Normal Flow value" related to rated condition. Enter anti-surge valve Cv factor for AS Valve Cv.
- **Valve Min Position:**
If specified, enter the minimum anti-surge valve lower limit below whichever valve closure is not required. By default, configure at the default value.
- **Dither:**
For detailed description of dither, refer to the operation manual. No specific need to use dither based upon given control schematic.

- **Inhibit Full Manual:**
If operating mode of full manual mode is required to be displayed to the operator, then uncheck this option. It is suggested that full manual option should be inhibited unless specifically required.
- **Use Overstroke:**
If anti-surge valve Overstroke is required, then check this box and enter maximum and minimum values. Refer to the operation manual if more information of valve Overstroke is required. Overstroke option is not required in the given project specifications.

Configuration Screen:

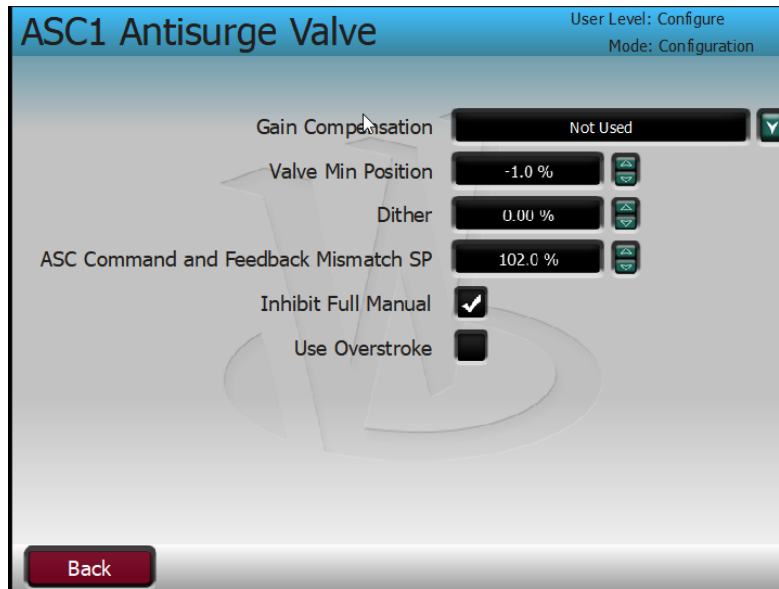


Figure 20-45. ASC1 Antisurge Valve

End of ASC1 Antisurge Valve configuration screen. Press functional key below “Back” button to reach the main configuration screen.

Antisurge Control1

This configuration screen consists of ASC1 control features and configuration options.

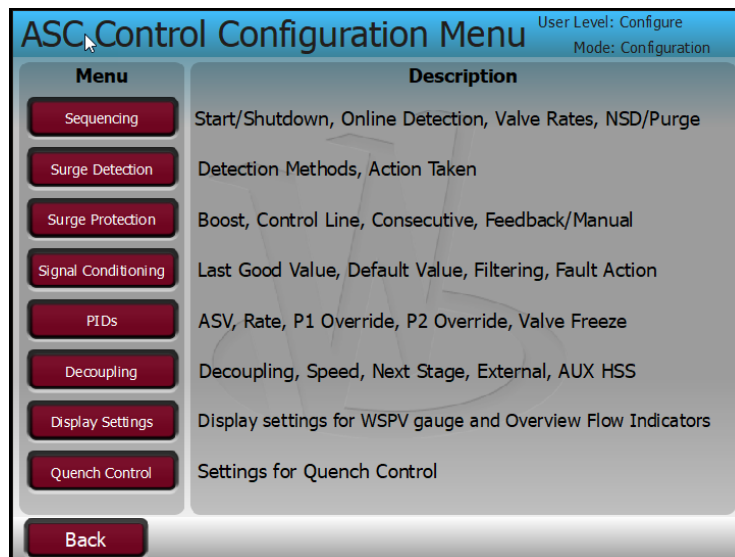


Figure 20-46. ASC1 Control Configuration Menu

Sequencing:

Sequencing configuration is used to set the ASC start /shutdown, online rates. For this page, unless specified differently, use the default values.

- Shutdown Manual Position Enabled:
At shutdown command, when ASC is in manual with backup mode, if ASC position is required to ramp to shut down position, then check this box. Default should be the checked option.
- Position just After Shutdown:
Configured ramp position for shutdown state. Default is 100%
- Position During Startup:
The required position during startup. Default is used. If Purge is selected, then this position is replaced internally by purge position.

Configured Page:

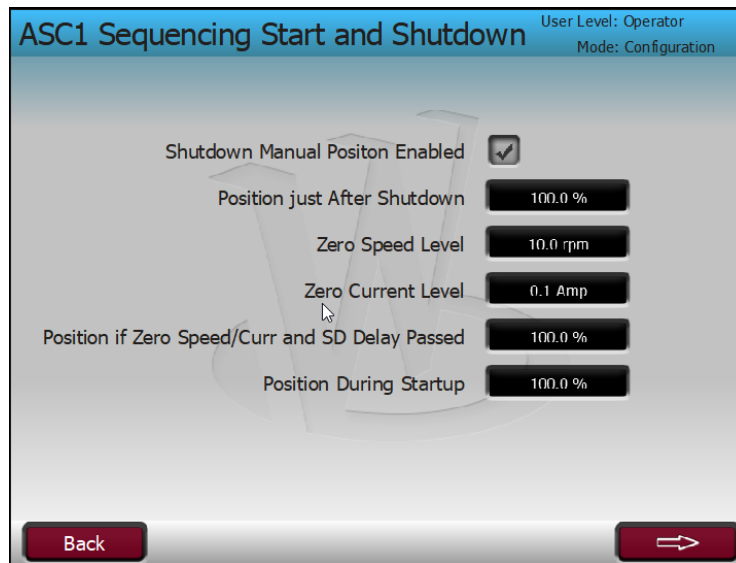


Figure 20-47. ASC1 Sequencing Start and Shutdown

Press function key for next page arrow.

ASC1 Sequencing Online Detection:

This page is used to arm the anti-surge control. At least 1 trigger option must be used for online detection.

Out of speed and current, compressor speed is the preferred variable for online detection. Referencing the compressor map, the minimum speed for compressor operation is 8625 rpm, so, ASC need to be online just before reaching this level of 8625 rpm. Therefore, online detection of speed with threshold value of 8600 rpm has been selected. Note that there is a delay timer for online detection, which is configured to default value of 10 seconds

Configured Page:

Triggers	Levels
Use Minimum Speed Level <input checked="" type="checkbox"/>	8600 rpm
Use Maximum Suction Pressure Level <input type="checkbox"/>	1.0 kPa A
Use Minimum Discharge Pressure Level <input type="checkbox"/>	1.0 kPa A
Use Minimum Flow Level <input type="checkbox"/>	1.000 ACMH
Use Minimum Current Level <input type="checkbox"/>	10.0
Use Minimum Pressure Ratio <input type="checkbox"/>	1.1
Use Minimum IGV Level <input type="checkbox"/>	10.0 %
Use External Contact <input type="checkbox"/>	
Delay Timer for Online Detection	10.0 s

Figure 20-48. ASC1 Sequencing Online Detection

Press the function key on next page arrow key.

ASC1 Sequencing Valve Rates:

This page is used to configure valve operating ranges. For a description of each rate, refer to the operating manual. Unless specified differently, keep the default values.

Configured Screen:

The screenshot displays the 'ASC1 Sequencing Valve Rates' configuration screen. The title bar indicates 'User Level: Configure' and 'Mode: Configuration'. The screen lists the following parameters and their values:

Parameter	Value	Unit
Automatic Close Rate	1.0	% / s
Offline/Start Rate	25.0	% / s
NSD Rate	1.0	% / s
Manual Raise/Lower Slow Rate	0.5	% / s
Delay for Fast Rate	3.0	s
Manual Raise/Lower Fast Rate	1.0	% / s

At the bottom, there is a checkbox for 'Allow use of Remote ASV Valve Demand' which is currently unchecked, with the note '(Must Configure an AI for this function)'. Navigation buttons include a left arrow, a 'Back' button, and a right arrow.

Figure 20-49. ASC1 Sequencing Valve Rates

Press the function key below next page arrow to reach the next configuration page.

- **ASC1 Sequencing NSD/Purge:**
This page is used for set normal shutdown and purge functions.
- **Normal SD State:**
Since the customer has specified a dedicated Train Normal Shutdown command Boolean input, the "NSD on Train NSD request" is selected.
- **Purge Command:**
No purge function is specified; therefore, use default option of "Purge Never Used".
- **Purge Position:** Since no purge function is used, purge position is left at default value.

Configured Screen:

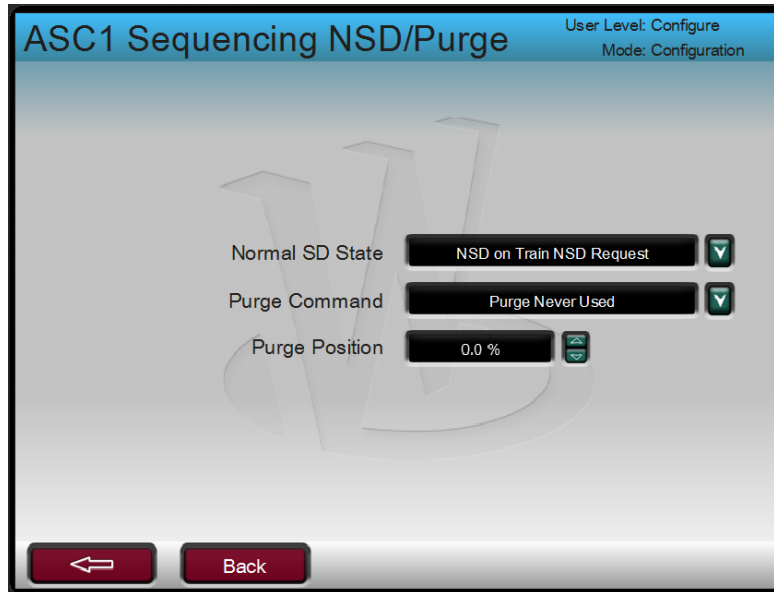


Figure 20-50. ASC1 Sequencing NSD/Purge

The Sequencing configuration is completed. Press the function key below "Back" button to arrive ASC1 Control Configuration menu.

Surge Detection:

On this page, configuration methods related to surge detection and subsequent actions are configured. Highlight "Surge Detection" button and press Enter.

- **ASC1 Surge Detection Method Used:**
Surge detection of cross line is the default selected. Since speed, as well as motor current, has also been provided, surge detection on those parameters can also be configured. However, those selections should be made in Service mode during commissioning.

The operating SP limit should be configured so that no surge should be detected if the operating point is higher than rated conditions. During normal running of compressor, note the WSPV when the compressor is operating right or on the rated conditions. If unsure, leave default values.

Configured Screen:

Surge Detections	Use	Trigger Setpoint	Captured Values
Flow Derivative Detection	<input type="checkbox"/>	80.00 % / s	0.00 % / s
Minimum Flow Detection	<input type="checkbox"/>	1.00 ACMH	
Disch. P. Derivative Detection	<input type="checkbox"/>	-100.00 kPa / s	0.00 kPa / s
Suction P. Derivative Detection	<input type="checkbox"/>	1.00 kPa / s	0.00 kPa / s
Speed Derivative Detection	<input type="checkbox"/>	1.00 rpm / s	0.00 rpm / s
Motor Curr. Derivative Detection	<input type="checkbox"/>	-1.00 / s	0.00 / s
Surge Detection on Cross Line	<input checked="" type="checkbox"/>		
Operating SP Limit To Detect Surge		150.0 %	0.0 %

Back →

Figure 20-51. ASC1 Surge Detection Method Used

Press the function key to reach the next configuration page.

ASC1 Action Taken when Surge Detected:

Loop Period: Configured to default value. To be adjusted during commissioning using service mode.

Use External Surge Detection Contact: No external surge detection contact is specified in Boolean input list; therefore, leave this option unchecked.

Enable Surge Recovery: Keep this option to default.

Enable Surge Recovery in Full Manual: Since full manual option is not provided to operator, uncheck this option.

Amount and minimum amount should be left to default and will be tuned while commissioning.

Surge Minimum Position:

Enable Surge Minimum Position. Configure amount and Reset option to default values. Needs to be tuned during commissioning.

Control Line Shift:

Enable Auto Shift Function. Leave amount and reset type as default. Needs to be tuned during commissioning.

Configured Screen:

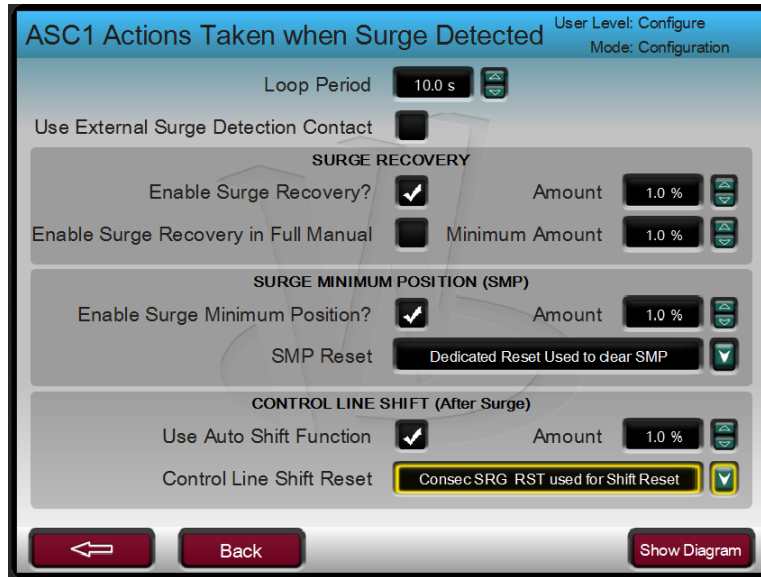


Figure 20-52. ASC1 Actions Taken when Surge Detected

The surge detection configuration is complete. Press the function key below “Back button to arrive” ASC1 Control Configuration menu.

Surge Protection

This configuration page is used to set up protection routines such as Boost, surge lines distances, etc. Select “Surge Protection” button on Control Configuration menu and press enter.

ASC1 Surge Control and Boost Line:

- Surge Control Line Margin:
The current value of surge margin. This value cannot be set lower than Surge Control Margin Minimum value.
- Enable Boost:
Ensure that Boost is enabled and checked.
- Margin:
Keep the margin as initially 5% of value; the final value will be tuned during commissioning.
- Amount:
Keep the margin as initially between 5%-10% of value; the final value will be tuned during commissioning.
- Enable Pre-pack:
Enable at this stage; however, final decision will be taken during commissioning.
- Pre-pack Amount:
Keep the initial value between 1% to 5% of value; the final value will be tuned during commissioning.

Configured Screen:

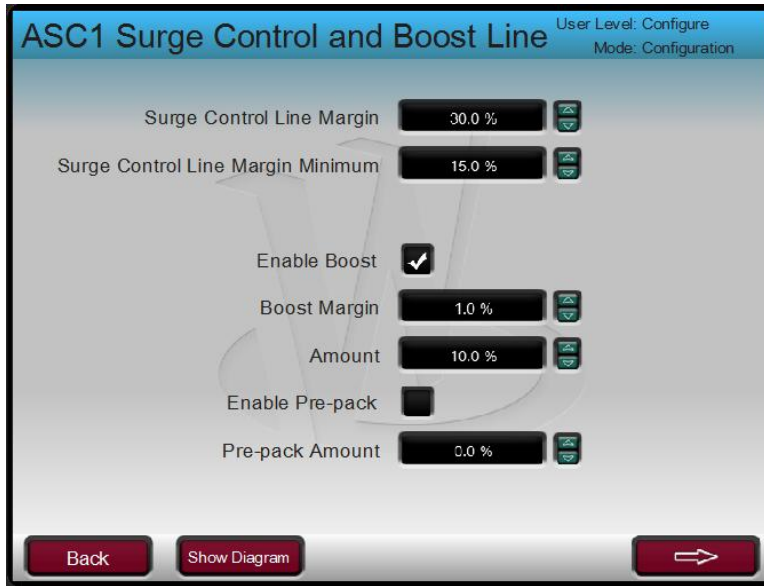


Figure 20-53. ASC1 Surge Control and Boost Line

Press function key below next page arrow button to reach next page.

ASC1 Consecutive Surges Alarm Counter:

Keep the default values under this section. Check the option "Alarm if Consecutive Surges". Since it is not mentioned in control narrative so, uncheck full opening if consecutive surges Alarm detected.

- Consecutive Surges Shutdown Counter:
Since, in IO list there is specific Boolean output for Consecutive Surge detected, therefore, check option "trip if Consecutive Surges SD Detected". Leave other two settings as per the default values.

Configuration Screen:

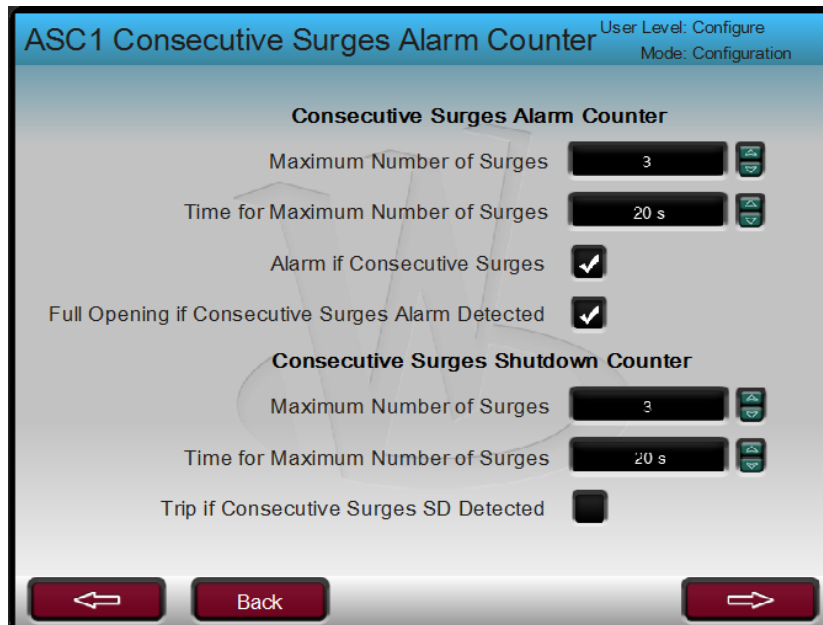


Figure 20-54. ASC1 Consecutive Surge Alarm Counter

Press function key below next screen arrow to reach next configuration screen.

ASC1 AS Valve Feedback Action:

Since, there is no signal list connected to ASV solenoid, therefore, leave all parameters as default.

Configured Screen:

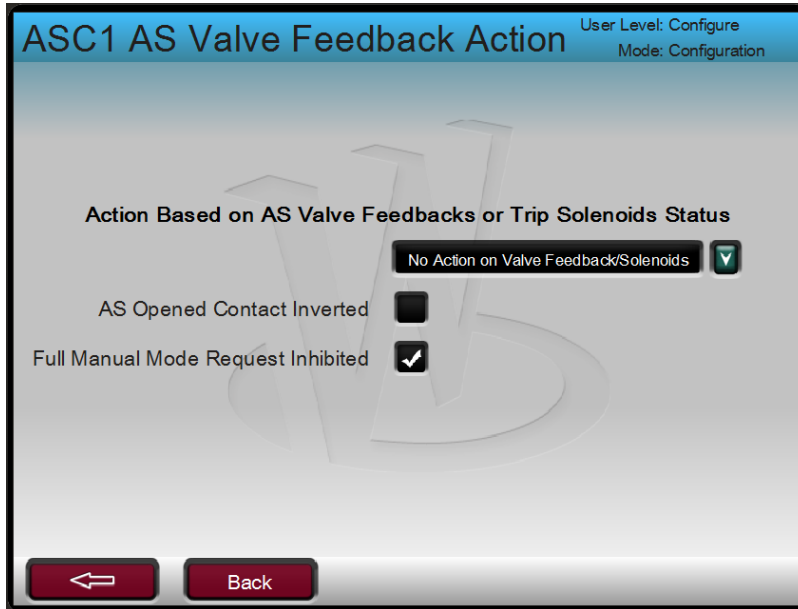


Figure 20-55. ASC1 AS Valve Feedback Action

This concludes ASC1 Surge Protection configuration. Press the Function key below “Back” button to reach ASC1 Control Configuration Menu.

Signal Conditioning:

This configuration page is used for configuring fallback strategies and signal conditioning. Select the Signal Conditioning button and press Enter. Since no specific fallback strategy has been informed, select last good value option.

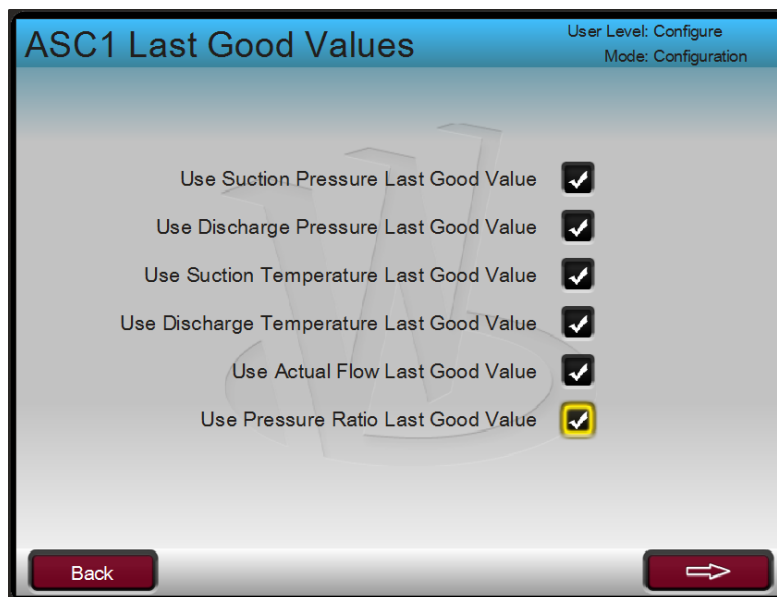


Figure 20-56. ASC1 Last Good Values

Press the function key to reach the next page.

- **ASC1 Smart Calculation Settings:**
ASC internal expected temperature values are used to calculate suction or discharge temperature if either of them fails. Check both options. Press the function key to reach the next page of configuration.
- **ASC1 Default Valve Settings:**
Note: Default values must be set even if fallback method is set to any other method, such as last good value etc.
- **Default Pressure Values:**
Refer to the thermodynamic data sheet. Use rated condition values unless specified different options to configured default pressure and temperatures.

Table 20-4. Thermodynamic Rated Condition Values

Pressure at Suction:	41.0 kg/cm ² A
Pressure at Discharge:	50.5 kg/cm ² A
Temperature Suction:	15.0 °C
Temperature at Discharge:	32.4 °C
The default actual flow should be set as highest flow on surge line map, multiplied by 1.2 (20% surge margin)	
Default Actual Flow:	$1.084 * 1.2 = 1.3 \text{ ACMH} * 10^3$

Default pressure ratio should be taken from the rated condition pressure ratio unless specified by the customer. Based upon provided data, at rated conditions pressure ratio = $50.5/41 = 1.232$

If specified by the customer, use Pressure ration in case of P1 or P2 failure. Otherwise, those fields may be left unchecked.

Press the function key for next page.

ASC1 Field Signal Filtering:

This page is used to configure signal filters for DP, Pressure (Suction and Discharge), and temperature signals (Suction and Discharge). Final values will be set during commissioning (if significant noise is detected on sensors); however, set the initial values as in Table 19-5.

Table 20-5. Initial ASC1 Field Signal Filtering Values

Flow Filter (ARMA):	(between 0.1 to 0.2) = 0.1
Pressure Filter:	(between 0.5 to 2) = 1.5
Temperature Filter	(between 1 to 5) = 4

Press the function key to reach the next page.

ASC1 Field Signal Fault Action on Control:

Added Man Amount on Flow Fail: At this stage, leave at default value of 10% unless specified by the customer. This will be tuned during commissioning. Verify during commissioning how much ASV opening keeps the Wspv >100 at peak load. Configure that ASV opening value.

Full Manual on Flow Sensor Fault: Unless specified by the customer, avoid implementing this option since full manual mode is discouraged.

Full Manual mode selected on Any Fault: Unless specified by the customer, avoid implementing this option since full manual mode is discouraged.

Min. AS valve Demand if Flow or Press@ Flow fail: Enable this option unless not required specifically by the customer.

Min AS Valve Demand on Fault: To be tuned during commissioning. Verify during commissioning how much ASV opening keeps the WSPV >100 at peak load. Configure that ASV opening value. Configure the initial value of 10%.

Flow Fail Position Delay: Keep the default value of 2.0 seconds.

End of fallback configuration.

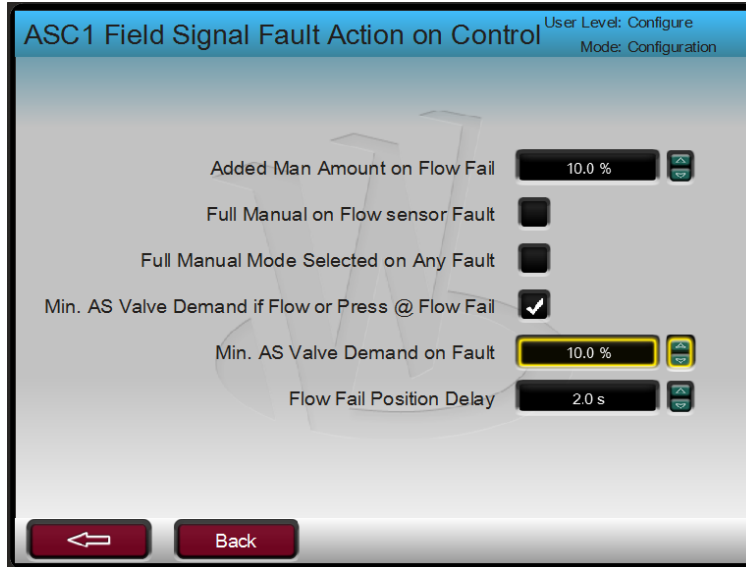


Figure 20-57. ASC1 Field Signal Fault Action on Control

Press the Function key below the “Back” button to arrive to the main configuration page.

PIDs

This configuration sheet is to set PIDs configurations

ASC1 Normal Surge Controller Settings:

Use Compensation on Normal PID: Uncheck since gain compensation is not used.

Leave the default value of Proportional, Integral, and SDR (equivalent to derivative) parameters. Final tunings will be done while commissioning.

- **ASC1 Rate PID Controller Settings:**
Leave all settings to default, uncheck rate PID usages. The final selection will be done during commissioning.
- **ASC1 Valve Freeze Option:**
Leave all configuration at the default values. Final settings will be done during commissioning.
- **ASC1 Suction Pressure Override Controller:**
If not specified by the customer, collect information from the customer for low value of suction pressure, below which compressor is configured to trip or process upset.

The trip on suction pressure value that has been obtained from the customer is 25 kg/cm² A. Therefore, Suction pressure override set point should be configured with addition of initial (20% margin). Initial setpoint = 25 + 5 = 30 kg/cm² A.

Select controller function as “Used with Actual P1”. Leave all other parameters to default values.

Configuration Sheet:

ASC1 Suction Pressure Override Controller User Level: Configure
Mode: Configuration

Tag Name: PIC00X

Description: Suction pressure override

Controller Function Selection: Used With Actual P1

Use Pressure Compensation:

Proportional Gain: 0.30

Integral Gain: 0.30 rpt / s

Speed Derivative Ratio: 100.00

Initial Setpoint: 0.00 psl A

SP Rate of Change: 0.10 psl A / s

Auto Enable on Power-up:

Navigation: Back

Figure 20-58. ASC1 Suction Pressure Override Controller

ASC1 Discharge Pressure Override Controller:

If not specified by the customer, collect information from the customer for low value of discharge pressure, above which the compressor is configured to trip or process upset. The trip on discharge pressure value that has been obtained from the customer is 70 kg/cm² A. Therefore, Suction pressure override set point should be configured with offset of initial (10% margin). Initial setpoint = 70 - 7 = 63 kg/cm² A.

Select controller function as “Used with Actual P2”. Leave all other parameters to default values.

Configured Screen:

ASC1 Discharge Pressure Override Controller User Level: Configure
Mode: Configuration

Tag Name: PIC00X

Description: Discharge pressure override

Controller Function Selection: Used With Actual P2

Use Pressure Compensation:

Proportional Gain: 0.30

Integral Gain: 0.30 rpt / s

Speed Derivative Ratio: 100.00

Initial Setpoint: 0.00 psl A

SP Rate of Change: 0.10 psl A / s

Auto Enable on Power-up:

Navigation: Back

Figure 20-59. ASC1 Discharge Pressure Override Controller

End of the PID configuration. Press the function key below the “Back” button to reach main configuration screen.

Decoupling:

This screen is used to configure loop decoupling and auxiliary signals for HSS bus. The decoupling feature is done based upon the interaction level of anti-surge loop with other control loops. It is preferred to configure this during commissioning using the service menu. Therefore, set all values in Decoupling section to the default settings.

- **ASC1 Auxiliary Control:**
There is not external high signal selection defined in the IO list; therefore, HSS1 is not selected.

During commissioning, external control in auto mode may be required; therefore, check the box for Use Auxiliary HSS2 and keep the signal value as default -1%.

Configured Screen:

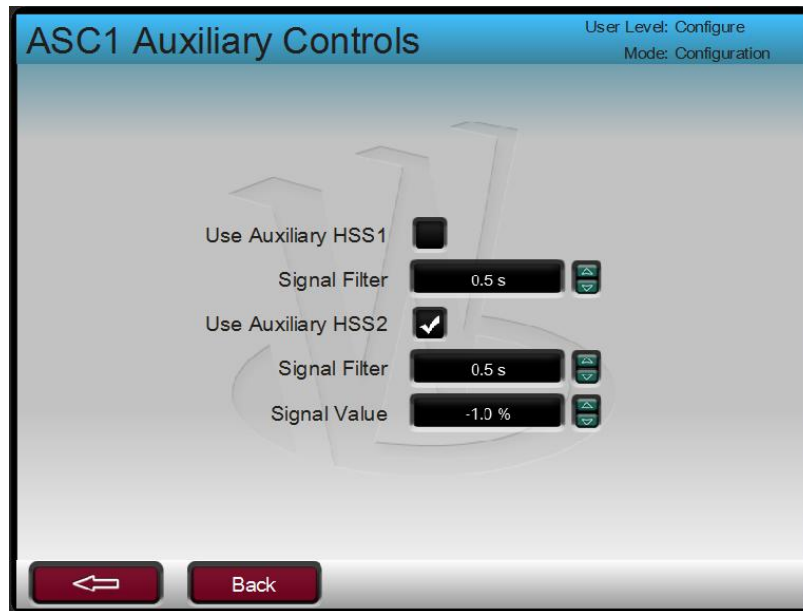


Figure 20-60. ASC1 Auxiliary Controls

End of Decoupling and Aux controls configuration. Press the function key below “Back” button to reach the main configuration screen.

- **ASC1 Control Configuration Menu:**
This screen is used for WSPV display settings, flow type display on overview screen. Unless specified by the customer, leave the settings as the default conditions.

This concludes the ASC1 control configuration menu.

Press the function key below the “Back” button to arrive on the main screen.

ASC1 Main Configuration Screen:

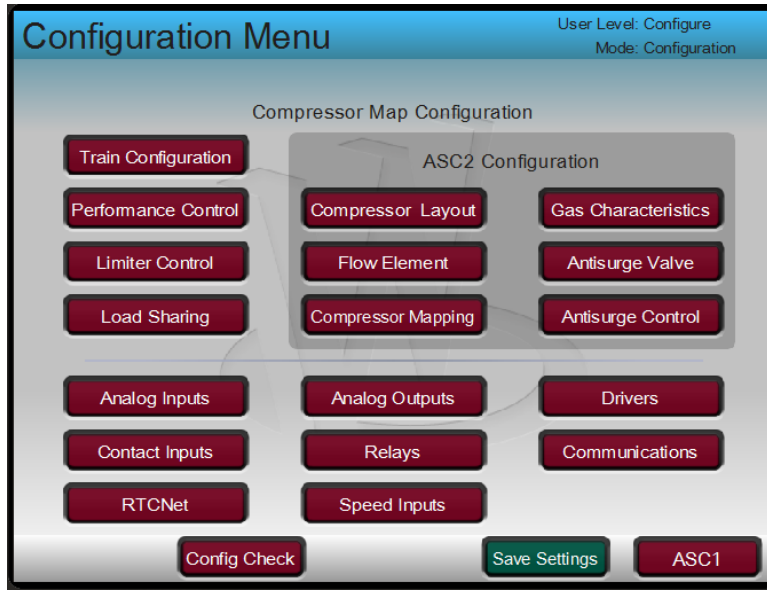


Figure 20-61. Main Configuration Menu

The next step is to check any configuration errors. Press the function key below “Config Check” button to verify no configuration error exists.

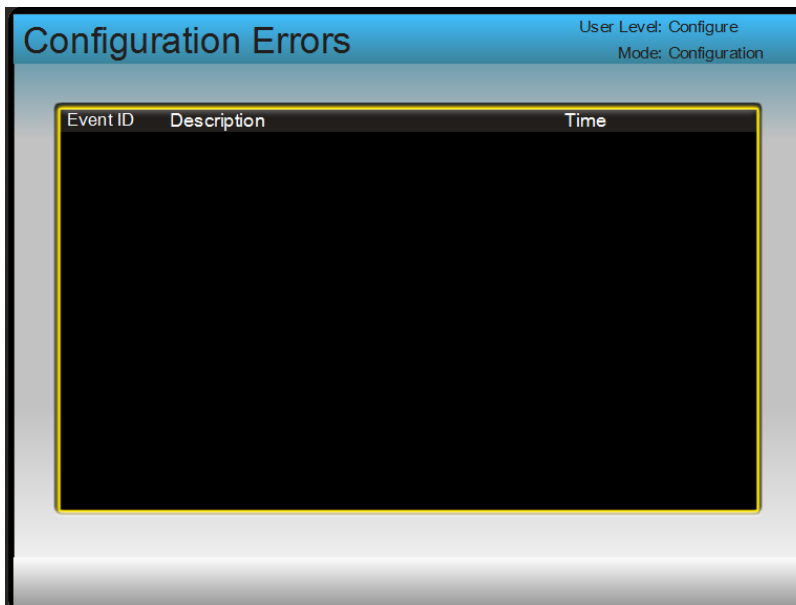


Figure 20-62. Configuration Errors Screen

Press “HOME” button to reach the Configuration menu. If no configuration error exists, then press the function key below the “Save Settings” button to save the settings.

Press the “HOME” button to reach the Main Menu screen.



Figure 20-63. Operation Main Menu

Press the function key below the “Site Info” button to enter site related information.

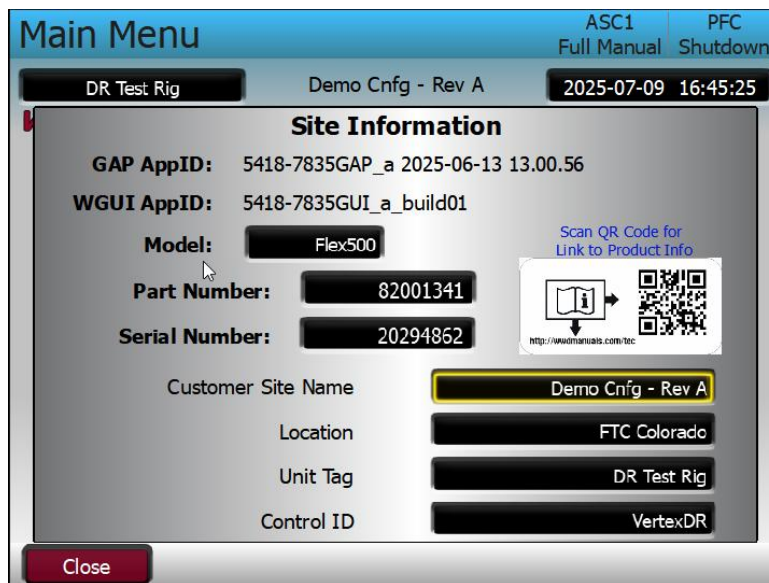


Figure 20-64. Site Configuration Screen

Exit configuration by accessing User Login and Mode Selection and then exiting configuration.

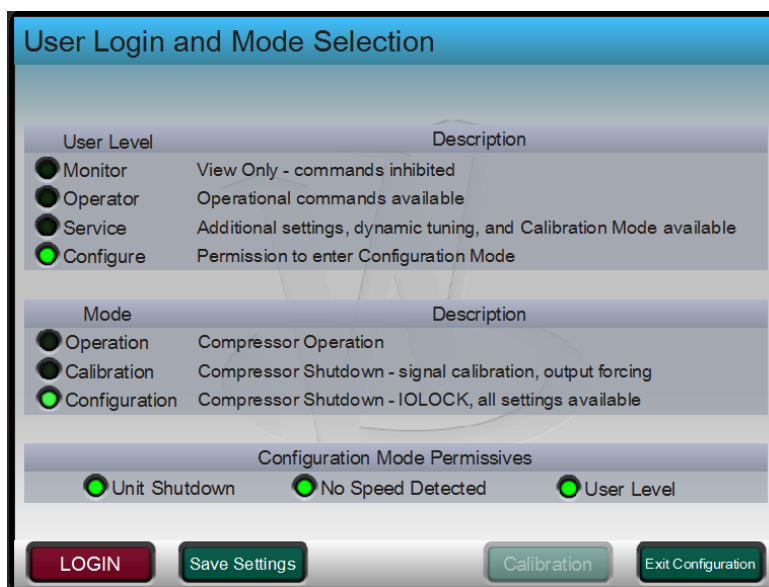


Figure 20-65. User Login and Mode Selection

Press the “HOME” button to reach the Main Menu screen. Unit preliminary configuration is completed.

Chapter 21.

Driver (Motor) Solo Run

Solo Run

Preparations for Solo Run

Reference the control narrative section.

General Summary: The Motor first start of Solo-Run-Function will be operated from the Motor Control Center (MCC) without Vertex control. Compressor shaft is uncoupled from Motor shaft.

1. All Motor input and output signals related to the unit have been tested for calibration and accuracy.
2. Motor shaft is decoupled from the compressor for solo run purpose.

Pre check before startup:

1. Closest Emergency Shut Down push button has been located.
2. Must have a clearance from site operation team and all safety lock out tags related to unit must be cleared.
3. Anti-Surge Control consecutive surge detection option under Service section->Surge Protection->ASC1 Consecutive Surges Alarm Counter-> Uncheck option Trip if Consecutive Surges SD Detected.
4. ESD system and MCC drive related to unit healthiness.
5. No critical alarm exists on the control panel.
6. Performance Controller should be disabled.
7. Vertex is ready for Motor solo run.

Chapter 22.

Train Sequence Control (Coupled Run)

Motor

Preparations for Motor Coupled Run

In this section it is assumed that Motor shaft is coupled with compressor shaft.

The Motor start will be operated from the Motor Control Center (MCC).

1. The entire compressor input and output signals related to the machine have been tested for calibration and accuracy.
2. Anti-surge valve functionality and calibration have been done.
3. Motor is coupled with compressor for coupled run purpose.

Pre check before startup:

1. Must have a clearance from site operation team and all safety lock out tags related to unit must be cleared.
2. ESD system and MCC drive related to unit healthiness.
3. No critical alarm exists on the control panel.
4. All auxiliaries and safety systems related to the unit must be healthy and online.
5. Performance Controller should be should have no inhibit conditions except trip or Normal SD
6. Anti-Surge Valves is preferred to be in Manual with backup mode and initially at shutdown position (~100%).
7. No Configuration error exists.
8. Reset the Vertex. Ensure Performance controller ramps to reset position.

Start-up Sequence

1. After receiving clearance from operation side, check for the availability of ready to start permissive at Vertex Main Menu-> Sequencing->Ready to Start Green LED
2. Operator starts the motor, which also issues Train Start Command. Verify that at Sequence control page, Performance controller ramps to startup position of 20%.
3. Verify that motor speed and current reaches to startup level. Speed=8625 rpm.
4. Verify that when Motor start "Driver Start Complete Feedback" gets active, the sequence status LED displays start complete and PFC started.
5. Verify that on Main Menu-> Compressor 1Control->Inhibit Conditions, no condition is active.
6. Verify on same page that, no surge event is active and wspv >100%.
7. Access Main Menu-> Performance Control page. Change the performance controller operating mode to manual at stable throughput, so that Anti-surge Controller tuning can be carried out at given operating conditions (Ps= 41 kg/cm² A, TS= 15 Deg C, N=8625 rpm).

Note1: It is the operator responsibility to observe the turbine's:-

- 11.1. Bearing temperature. Ensure no alarm exists.
- 11.2. Axial/Radial vibration alarms. Ensure no alarm exists.
- 11.3. Any other dangerous situation. Mention if any.

The field operator shall be prepared to trip the Motor by using the closest Emergency Stop Button, when observing any problem.

ASC MIN SPEED Tuning

1. Verify that Performance controller is in manual mode and holding process parameters (Ps, Ts and Speed) .Verify that actual speed is stable condition, fluctuating from set point less than ~5-10 rpm.
2. Increase the Performance controller out such that speed should be 5% higher than minimum speed of 8625 rpm. Verify that current speed is at 9056 rpm and stable.
3. Access Service Menu-> Compressor Control 1. Press function key on right hand side bottom of screen, labeled as "Tuning (Off)". Verify that status of the key changes to "Tuning (On)".
4. Access the Main Menu, press 3 and followed by 0 on key pad to arrive on tuning screen.
5. Press function key below label "Data/Control". Adjust manual demand such that wspv is on surge control line (wspv~100) in steps of 1 %.
6. Verify that wspv ~ 100, and no abnormal vibration or process conditions exists.
7. Verify that Trend with antisurge wspv, PID output and Surge margin, tuning P, I, D parameters are visible.
8. Verify the current average value of wspv , ASC PID output,
9. Average WSPV=..... PID Out =..... Surge Margin=.....Boost margin (Initially ~30% to 50% of Surge Margin) = _____
10. P= _____ I= _____ D= _____
11. Step Increase the surge margin by five (for example from 25 to 30), observe the behavior of the loop and carry out tuning to get desired response.
12. Bring back the surge margin to original value. Repeat the step 7, and observe the behavior of the loop and carry out tuning.
13. After initial tuning finished, normalized the surge margin to original value.
14. Note down the final values of speed controller's PID values:

Average. WSPV= _____ PID Out = _____ Surge Margin= _____ Boost margin = _____

P= _____ I= _____ D= _____

Signal Filtering

1. This aids in reverting false surge detections, prevents unnecessary response to noise, and stabilizes the control routines. Check the Flow, Pressure, Temperature transmitter's fluctuations. A typical noise effect is mentioned below.

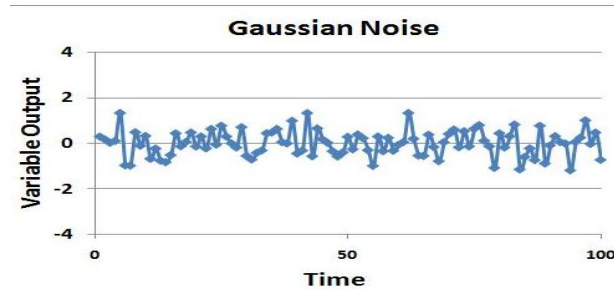


Figure 22-1. Noise Example

2. If process measurements are clean enough to provide adequate control without filtering, configuring filter time constants of zero seconds would optimize the controller's speed of response.
3. In any case, if filtering is deemed necessary, it is recommended to enable it in the control, not in the field device—disable or minimize any transmitter filtering. Write down whether filtering is enabled on the control side.
4. Temperature and pressure measurements can be filtered with a high level of accuracy due to the expected responsiveness of these process signals. The filter is a simple first-order lag with configurable time constant. For this go to the Main Menu->Service Function key->Compressor Control 1-> Signal Conditioning-> Page ASC1 Field Signal Filtering
5. Since it is a time constant, a high value is required if the noise is of low frequency or high amplitude. Typical defaults are 3.0 seconds for temperature inputs and 0.2 seconds for pressure signals.
6. Mention the configured value inside control: T: _____ P: _____
7. In contrast, the flow sensor requires careful consideration as it is typically noisy, but it is the primary surge detection signature. Flow signals require much faster filtering as compared to pressures and temperatures. Lag time constants are typically less than 100 milliseconds. A typical default value is 0.05.
Mention the configured value inside control F: _____

To configure these values, go to the Compressor Service Main Menu->Service Function key->Compressor Control 1-> Signal Conditioning-> Page ASC1 Field Signal Filtering

Open Loop Response Tuning

Under this response, compressor boost line control and Surge Control Line Shifting need to be tuned. Before coming to this section, it is assumed that Anti-surge Controller has been tuned for Min Speed, See Sections above.

Surge Control Line Shifting / Control Margin Bias

The anti-surge control offers automatic biasing of the control margin to shift the Surge Control Line when surges are detected. This feature is a temporary solution to a surge event. If enabled, the control margin will shift to the right a configured amount for each surge detected, as enumerated by the surge counter.

For example, if the control margin is at 10% and a surge event records three individual surges, a configured SCL Shift Amount of 1% would bias the control margin to 13% from 10%, or 1% for every surge detected. When the surge counter is reset, the shift amount ramps slowly back to zero, gradually returning the SCL to its original location determined by the configured base control margin.

If the process change that initiated the surge event is deemed chronic, (NOT due to Anti-surge Controller), the base control margin should be increased to permanently move the SCL. To access the control line shift value, refer Service Menu->Compressor Control 1->Surge Detection->Page ASC1 Actions Taken when Surge Detected-> section Control Line Shift.

Boost line tuning for Anti-Surge Valve 1st Stage

1. Keep the performance controller in manual mode. Observe the behavior of speed, speed variations should be at stable conditions.
2. Close the first stage Anti-surge Valve manually, in steps of 1%, unless the WSPV ~103%. Recommend not closing Anti-surge Valve below 30%.
3. During this valve closing, observe all the relevant process parameters such as speed, suction/discharge pressure or temperature.
4. Go to the Vertex Main Menu->Press 3 and then zero to reach ASC1 Compressor MAP with tuning enable. Move the *Boost margin* to almost 0.5, so that Boost line almost overlaps on the SCL line. Check the *Enable boost button* and initially choose the value 5%. Ensure that Rate PID is disabled (Service Menu->PID->Rate PID), and *detune Anti-surge Valve PID* with low P (1/5) and increase integral time (5 times) (Service Menu->PID->Normal Surge Controller Settings).
5. Now, refer Main Menu-> Press three and then zero to reach ASC1 Compressor MAP, gradually close the Anti-Surge Valve, till WSPV reaches almost 101.0. Keep observing the trend of Wspv versus valve opening. Close the valve further and the moment WSPV reaches below (100-boost protection margin), boost will be triggered.

Tune the Boost line response (Boost amount) such that it should increase the WSPV, by 5%-8% of its existing value.

Set the boost line as half of the distance between SCL and SLL.
 For example, if distance between SCL and SLL is 20%, then configure Boost line distance from SCL as ~10%. This distance can be varied based upon experience of speed of unit disturbance, causing surge, delay time in the process pipeline. Reinstate the rate controller and Anti-Surge Controller PID values.

Write down the Final Boost line distance _____ %
 Write down the Final Boost line response _____ %

Chapter 23.

Rated Speed Tuning

ASC Intermediate Speed Tuning

1. Verify that Performance controller is in manual mode and holding process parameters (Ps, Ts and Speed) .Verify that actual speed is stable condition, fluctuating from set point less than ~5-10 rpm.
2. Increase the Performance controller out such that speed should be at mid-point of speed range which is rated condition speed of 11200 rpm. Verify that current speed is stable at 11200 rpm.
3. Access Main Menu-> Press 3 and 0 on key pad to reach ASC1 Compressor Map. Adjust manual demand such that WSPV is on surge control line (wspv~100) in steps of 1 % .
4. Verify that WSPV ~ 100, and no abnormal vibration or process conditions exists.
5. Verify that antisurge WSPV, PID output and Surge margin, tuning P, I, D parameters are visible. If required, separate trend can be configured using control assistant or Vertex trends.
6. Verify the current average value of WSPV , ASC PID output,
7. Average WSPV=_____ PID Out =_____ Surge Margin=_____ Boost margin (Initially ~30% to 50% of Surge Margin) = _____
8. P=_____ I=_____ D= _____
9. Step Increase the surge margin by five (for example from 25 to 30), observe the behavior of the loop, and carry out tuning.
10. Bring back the surge margin to original value. Repeat the step 7, and observe the behavior of the loop and carry out tuning.
11. After initial tuning finished, normalized the surge margin to original value.
12. Note down the final values of speed controller's PID values:

Average. WSPV=_____ PID Out =_____ Surge Margin=_____ Boost margin = _____

P=_____ I=_____ D= _____

Suction & Discharge Pressure Limit Tuning

The Suction Pressure Override Routine

This routine monitors the difference between the suction pressure set-point and the compressor suction pressure. If enabled, the override controller will open the valve to limit the suction pressure as needed.

1. Recommend carrying out this tuning at Rated speed/Guarantee point. The performance controller should be in manual mode for this tuning. Monitor the process parameters such as suction/discharge temperature or pressure, WSPV, speed during this tuning.
2. Refer Vertex Main Menu->Compressor 1 Control->Controllers-> P1 Override. Ensure that Controller status is enabled and no inhibit conditions exist. Ensure that set point ramp rate is >10 units/sec.
3. To carry out this tuning, increase the set point of the Suction pressure override controller near the actual PV (suction pressure).Keep initial settings of P=,I and SDR under compressor *To Vertex* P1 Override page-> Commands->More->Dynamics

4. Now increase the set point ~three units and observe the suction pressure control by the Anti-Surge Valve. Accordingly tune the controller.
5. When tuning finishes, put back the suction pressure override controller's original set point.

Write down the final value of the set point _____

Write down the final values of tuning parameters. P= _____ I= _____ SDR= _____

The Discharge Pressure Override

1. This routine monitors the difference between the compressor discharge pressure and the discharge pressure set-point. The override controller will open the valve to help reduce the discharge pressure.
2. It is recommended to carry out this tuning at Rated speed/Guarantee point. The performance controller should be deactivated for this tuning. The discharge temperature should be monitored during this tuning.
3. Refer Vertex Main Menu->Compressor 1 Control->Controllers-> P2 Override. Ensure that Controller status is enabled and no inhibit conditions exist. Ensure that set point ramp rate is >10 units/sec.
4. To carry out this tuning, increase the set point of the Suction pressure override controller near the actual PV (discharge pressure). Keep initial settings of P=, I and SDR under compressor *To Vertex* P2 Override page-> Commands->More->Dynamics
5. Now increase the set point ~three units and observe the suction pressure control by the Anti-Surge Valve. Accordingly tune the controller.
6. When tuning finishes, put back the discharge pressure override controller's original set point.

Write down the final value of the set point _____

Write down the final values of tuning parameters. P= _____ I= _____, SDR= _____

Loop Decoupling tuning

Each decoupling input has a "Delay Time" and an "Amount" to configure (as with speed decoupling). The larger the filter time constant, the longer the decoupling lasts before it is removed. The "Amount" value is the relationship of input change to decoupling output; a larger amount value translates into a higher impact of anti-surge valve movement to input change. And, the amount should be positive if the process variable is inversely proportional to compressor flow and negative if the relationship is directly proportional. These decoupling routines are disabled if their respective input signals fail.

There are five separate Decoupling routines: two based on speed and three inputs from separate processes.

Decoupling is enabled as a whole—disabling any of the five routines individually is done by configuring its respective "Amount" to 0.0. In addition, the action is not allowed to influence the anti-surge valve until the compressor is on-line and in Automatic Mode.

Note1: In this project, decoupling from Speed/Performance controller to first stage ASC may be implemented based upon the requirements mentioned in below section.

Also, since there is no need to manipulate the anti-surge valve if the compressor is operating far from the Surge Control Line, Decoupling is inhibited if the current S_PV value is greater than 110% (adjustable in Service Menu). And, since Decoupling is a supplemental function, not a primary control, its output is limited to 10 % (adjustable in the Service Menu)—In other words, the sum of all five decoupling responses may not open the valve more than 10% of the current Anti-surge Controller value.

Speed decoupling can be performed in two cases, one to prevent a surge and the other to stabilize the process. Once the compressor is stable at an operating point, a decrease in speed would move the operating point towards surge. The first form of speed decoupling uses a direct relationship from change in speed to generate the appropriate valve movement. This form is called “dynamic” and is fast acting and momentary. It is configured as the “Fast Speed Amount” in percent per rpm.

The second form of speed decoupling uses knowledge of the relationship between speed and flow to anticipate the necessary movement of the anti-surge valve. The change in speed is related to a change in flow, and the anti-surge valve moves to maintain the previous flow. This type of decoupling is also quick to initiate, however, it lasts for a much longer period of time and is removed slowly.

To enable general decoupling configuration, refer Service Menu-> Decoupling-> Main Settings. On this page, verify below settings:

- Decoupling Selection: Compressor Decoupling used
- Min Decoupling Level: 0
- Max Decoupling Level: 5%
- Surge Process Value Range= 110%
- Rate Limit on Enable/Disable Decoupling= Yes

This slower acting decoupling is configured as “Slow Speed Amount” and is usually greater than zero. The time constant is set at “Slow Speed Delay Time.”

1. Field-testing is the only method to determine the relationship between the changes. Also the need to configure decoupling should also be determined. To test the speed decoupling requirement, enable 1st stage Anti-surge Controller in auto mode. Drop the speed up to 5% of its existing value, and if the operating point is crossing the SCL line or the valve has some significant dead band, then Loop decoupling is recommended.
2. Start with small “AMOUNT” ~0.5% and gradually increase in such a way that changes in the Speed of 10% -20% should be able to open the ANTI SURGE VALVE actually in the field ~2%-3%. And starts affecting the WSPV.

Both speed-decoupling routines are disabled in the event of a speed signal failure.

Write down all configured decoupling values:

From Speed/Performance Controller to ASC1: Amount_____ Delay Time_____

Surge Detection Tuning

Seven robust surge detection routines detect a surge within 50 milliseconds. To access refer Service Menu-> Compressor Control 1->Surge Detection->Surge Detection Methods Used. These user-configurable surge detection routines are

1. Flow derivative (rate of change), (dp)
2. Speed derivative (rate of change), (N)
3. Suction pressure derivative (rate of change),(Ps) and
4. Discharge pressure derivative (rate of change) (Pd).
5. Minimum flow
6. Motor Current Derivative
7. SLL Crossing

Surge Detection

The Surge Detection routines are configured to determine when a surge event has occurred, capture the surge signature, and maintain a surge counter.

To set the set point for detection based upon dP, N, Ps or Pd. Refer to the Service Menu-> Surge Detection->Surge Detection Methods Used. When surge has occurred, trigger levels are automatically recorded in section Captured Values.

Note: The two routines, Minimum Flow and Surge Limit Line Flow, may not detect an actual surge. They initiate a surge response if the calculated flow reaches the respective set-point. Values are already configured and usually minimum flow is set to the minimum flow on the SLL.

Surge Recovery

Once the controller detects a surge, Surge Recovery is programmed to open the anti-surge valve a fixed amount above the current position. To configure access Service Menu->Compressor Control 1->Surge Detection-> ASC1 Actions Taken when Surge Detected, Surge Recovery section.

As per the field commissioning experience, it is configured to add the WSPV value by 5%-8% to the existing value (Similar to the Boost Line response). During Boost line /Anti-surge Control tuning, determine the required valve opening, which increases WSPV to 5%-8%. Usually, it is the same as Boost line response value.

Write down the final Surge Recovery Value . _____ %

Surge Minimum Position (SMP)

When the control detects that a surge event has occurred, the Surge Minimum Position (SMP) function will be activated. After the surge recovery routine breaks the surge cycle, the SMP routine will be enabled to prevent subsequent surges.

This routine captures the valve position when the compressor surges and then adds a small amount (SMP Amount) to that position. To configure access Service Menu->Compressor Control 1->Surge Detection-> ASC1 Actions Taken when Surge Detected, Surge Minimum Position section.

For commissioning point of view, this amount is kept similar to the Boost line action response. After the surge recovery decays to zero this routine will not allow the anti-surge valve to close beyond the SMP value (value at surge plus SMP Amount). Once process conditions are stabilized the operator can reset SMP and return to normal operation.

Control Line Shift after surge detection settings are recommended such that it should be < Safety margin/4 and > Safety margin/8.

Write down the values. _____ %

Rate Control Tuning

Rate Controller PID

The rate controller monitors the time derivative of S_PV and acts to open the anti-surge valve if this rate of operating point is too fast for the system to respond.

This action will take place before the operating point reaches the Surge Control Line. It is a proactive routine that takes the place of derivative action in the Anti-Surge PID. Keep in mind that Rate PID is automatically disabled if any input signal is failed. To access Rate PID page refer Service Menu-> Compressor Control1-> PID's-> ASC1 Rate PID Controller Settings

The setpoint for the Rate Controller PID is a percentage of the maximum safe rate of approach to the Surge Control Line. The allowable rate of approach to the SCL is dynamically calculated from the proximity to the SCL and the system response time (loop period), as shown below.

$(WS_PV - 100) / \text{Loop period}$

This means that the further the operating point is from the SCL ($WS_PV > 100$), the greater the allowable rate. Likewise, the faster the system can respond to changes (shorter Loop Period), the greater the allowable rate. As the operating point moves closer to the SCL, the rate set-point is reduced.

1. Initially keep the rate controller PID values similar to the Anti-Surge Controller PID values. To ensure the controller has time to react, the actual rate set-point is a percentage, typically 60%-80%, of this maximum allowed rate. Therefore, if the system dynamics require that the controller act sooner when the anti-surge valve is closing prior to reaching the SCL, reduce this Rate Set point. As this value approaches 100%, the Rate Controller set-point approaches the calculated maximum allowable rate.

2. To tune this controller, keep the boost line response double of its existing value, so that in worst case this will save the compressor from surge event. Change the Boost line distance to double of its existing value (for example if Boost line distance was 5%, configure it to 10%) Keep the trend of operating point and flow, pressure, speed, valve command. Ensure that WSPV is nearby ~102% and Anti-Surge Controller of existing stage is in Auto mode. Enable rate control PID and keep PID values similar to the ASC PID values.
3. From the *Service Menu-> Surge Protection*, abruptly increase the Safety margin to 1.5 times (for example, if it was 20%, make it 35%). See the operating point is well controlled by Rate PID and does not allow hitting the Boost line.

Note: To enable Rate PID controller fast to catch the approach of operating point, reduction in percentage of maximum allowed rate AND/OR configuring the rate PID values faster.

It should be preferred to keep the percentage value within 30%-50% of maximum allowed rate. If even this is not helping and the operating point is hitting BOOST Line while tuning, make the PID values of rate controller more aggressive.

While tuning on one stage anti-surge controller, make sure that if applicable, another stage anti-surge controller is in manual with back up, and opening should be in such a way that WSPV of that stage must be ~120%.

For Stage 1:

Write down the final value of percentage value of Rate Controller

Write down the final values of tuning parameters of the Rate Controller: P= _____ I= _____, SDR= _____

ASC Upper Level SPEED Tuning

1. Verify that Performance controller is in manual mode and holding process parameters (Ps, Ts and Speed). Verify that actual speed is in stable condition, fluctuating from set point less than ~5-10 rp
2. Increase the Performance controller such that speed should be at high-point of speed range between 12321 to 12937 rpm. The mid-point of 12321 and 12937 is 12629. Verify that current speed is stable at 12629 rpm.

Note: It is the operators responsibility to observe the turbines:

11.1. Bearing temperature: Ensure no alarm exists.

11.2. Axial/Radial vibration alarms: Ensure no alarm exists.

11.3. Any other dangerous situation: Mention if any.

Note: The field operator shall be prepared to trip the Motor by using the closest Emergency Stop Button when observing any problem.

3. Access Main Menu-> Press 3 and then 0 on key pad to access ASC1 Compressor MAP screen. Adjust manual demand such that WSPV is on surge control line (wspv~100) in steps of 1 %.
4. Verify that WSPV ~ 100, and no abnormal vibration or process conditions exists.
5. ASC1 control screen, verify that Trend with antisurge WSPV, PID output and Surge margin, tuning P, I, and D parameters are visible.
6. Verify the current average value of WSPV , ASC PID output,

Average WSPV= _____ PID Out = _____ Surge Margin= _____ Boost margin (Initially ~30% to 50% of Surge Margin) = _____

P= _____ I= _____ D= _____

7. Step Increase the surge margin by five (for example from 25 to 30), observe the behavior of the loop and carry out tuning.

8. Bring back the surge margin to original value. Repeat step 7, and observe the behavior of the loop and carry out tuning.
9. After initial tuning is finished, normalized the surge margin to original value.
10. Note the final values of speed controller's PID values:

Average. WSPV=_____ PID Out =_____ Surge Margin=_____ Boost margin =_____

P=_____ I=_____ D=_____

Performance CONTROLLER UPPER Level SPEED Tuning

1. Verify the following assumption at this stage:
 Driver control PID is tuned already by the customer (Cascade loop driver control such as speed control, VFD control etc.)
 Anti-Surge controller tuning is carried out.
 No fault alarms exist, no limiter condition exists.
2. Access Main Menu-> Compressor Control. Adjust manual demand such that WSPV is at least 10% away from surge control line (wspv~110) in steps of 1%.
3. Access Main Menu->Performance Control, place Performance controller in Auto mode.
4. Access Main Menu-> Performance Control-> Commands->More->Dynamics. Note down initial values of below parameters

Performance PV=_____ Performance SP =_____

P=_____ I=_____ D=_____

5. Create a PID disturbance by increasing the Performance controller's SP by two units from current SP. Observe the behavior of the loop and carry out tuning.
6. Create a PID disturbance by decreasing the Performance controller's SP by two units from current SP. Observe the behavior of the loop and carry out tuning.
7. Repeat above steps, increasing and decreasing both direction.
8. Note down the final values of speed controller's PID values:

Performance PV=_____ Performance SP =_____

P=_____ I=_____ D=_____

Chapter 24. Tests

Surge Test

This section describes compressor specific procedures for carrying out anti-surge control tests. It is advisable to only perform these tests once the Speed Controller and Anti-surge controller have both been tuned.

Verification for the compressor first stage is driven by a variable-speed driver. It is highly recommended to carry out Surge Line Validation. Perform the test using either of the two methods described below.

1. Compressor is actually driven into surge conditions to obtain process data representing the actual surge point. The number of surge cycles is kept to the minimum possible, 1 or at the most 2 surge cycles.
2. Compressor is brought close to surge conditions to validate the as-tested surge limit line. Compressor surge will be prevented as long as the operating point is to the right of surge limit line.

Note: In case of new surge line configurations, the machine shutdown is required to fit the surge points inside the controller. It is recommended to carry out the surge test followed by surge point's fittings inside the controller.

IMPORTANT

Although the surge test is performed in a controlled manner, there are still possibilities of machine trip and/or mechanical impacts due to actual surge events during the surge test, as well as on other machinery/process parameters such as overspeed/vibrations.

Preparation & Guidelines

Before the surge test, the commissioning engineer will gather the latest available compressor and process data for project. The preparation involves the following activities.

- Review the latest tested compressor surge Map; review the Engineering manual to verify calculations and surge limit line configuration in the controller.
- Check calibration ranges for all transmitters. Flow transmitter must be set up for linear output with no damping.
- Normal operating pressure and temperatures. If possible, the surge test is done with normal inlet conditions.
- Gas composition. It is important that the composition of the gas at the compressor inlet is approximately the same as during normal production. Gas of a different composition will have an effect on the surge test data. The customer should arrange gas sample analysis for molecular weight at adequate intervals during the surge test.
- Set the PID values of anti-surge controller in very slow tuning, so that Anti-surge Valve should not move back and forth frequently when a surge event is detected. Understand the transmitter fallback strategies. Keep performance controller in manual mode to achieve fixed compressor speed. Change boost amount to higher value between 15%-25%.
- After discussion with OEM/end user, no limiting conditions have been set at present or the surge test. Limiting conditions can be set for suction or discharge pressure if required by the customer. Limit set-

points might have to be revised for the surge test; the new values should be mutually approved by relevant parties.

- The surge test will be carried out by blocking the compressor suction valve, which allows operating the compressor in close loop and bringing the operating point near surge limit line. The suction valve will remain in this condition until the surge test and anti-surge control tuning is completed.
- During the surge-test, flow through the compressor stage will be reduced in controlled manner by pinching the recycle valve through anti-surge controller. The controller will fully open the recycle valve on detecting surge or incipient surge.
- Access Service Menu screen-> Compressor Control 1. Ensure that bottom right side corner function key text displays "Tuning (ON)".
- Configure the Trends of Compressor in Control Assistant for both 1st and 2nd stages.

Suction Flow (U__FLOW_ACTUAL->QA->A_NAME)	<input type="checkbox"/>
Suction Pressure (U__INPUT_P1->P1->A_NAME)	<input type="checkbox"/>
Suction Temperature (U__INPUT_T1->T1->A_NAME)	<input type="checkbox"/>
Discharge Pressure (U__INPUT_P2->P2->A_NAME)	<input type="checkbox"/>
Discharge Temperature (U__INPUT_T2->T2->A_NAME)	<input type="checkbox"/>
Polytropic Head (U__POLYTROPIC_HEAD->HEAD_POLY->A_NAME)	<input type="checkbox"/>
Anti-surge valve opening (T1__VLV->ASV_DRV_FLT->A_SW)	<input type="checkbox"/>
Speed (SPD->DRV_SPD->A_NAME)	<input type="checkbox"/>
WSPV (T1__CTRL->WSPV->A_NAME)	<input type="checkbox"/>
ESD Shutdown (T2__STG_BI->SD_ACTIVE->B_NAME)	<input type="checkbox"/>
Surge Detected (U__SURGE_DETECTION->S_DET->B_NAME)	<input type="checkbox"/>

Surge Verification for Anti-Surge Controller (ASC1)

The Hi-Speed recorder/data logger should be turned on during the surge-test. The compressor should be running, and the discharge valve should be in closed position. Before commencing surge test, it is mandatory to ensure that pressures, temperatures, and the Molecular weights are close to normal production conditions.

Step 1: The controller is prepared for the surge test. Anti-surge controller parameters are suitably changed to ensure stable operation. The safety margin for ASC is initially at 20%. To view these settings, return to Main Menu-> Press 3 and then 0 on keypad to access the Compressor Map screen. Set the Min Surge Margin to 5%.

Step 2: The compressor speed is held steady at 10% of (Min Gov-Max Gov) above the min governor speed by manually increasing the speed set point of driver.

For example: If min Gov speed is 8625 rpm and max Gov speed is 12937. So total operating range is $12937-8625=4312$.

10% of 4312 ~ 431. So the first surge test point speed should be $8625+431=9056$ rpm. Next point will be 40% ($8625+1725=10350$). If process parameters allow then move to 80%.

Write down this step compressor Speed _____ rpm.

Step 3: ASC is online and controller will be in manual mode. Access Compressor Map page. Close the valve slowly in 2%-3% steps, until WSPV reaches to ~100%.

Step 4: If Boost line test has not been done, then a few Boost tests should be performed to verify the necessary valve step opening and the dead time of the process. To perform these tests, change the boost amount to a higher value between 15%-25% to verify it takes proper action to move the operation point.

Step 5: With operating point on the surge control line, the safety margin for anti-surge Controller will gradually be reduced. Anti-surge controller will be further throttled by 1% each time and the operating point will move towards the SCL.

Step 6: Reduce the surge margin setting to 10%.

Process and machinery performance parameters like vibration alarms, excessive noise on flow signal, or speed fluctuations should be observed carefully for changes. If these issues are witnessed, the entered surge map should be reviewed for accuracy.

Step 7: Reduce the surge margin setting to 5%. Verify that there is no surge detected on this stage; this operating point is deemed as a verified surge point per the surge test procedure as per method 2 (at the beginning of this chapter).

For surge test procedure point 1, the operator needs to configure the following settings

- Disable Surge detection method for this particular compressor stage. Go to the Service Menu -> Compressor Control 1 -> Surge Detection, and uncheck the Min Flow, Cross line options flow derivative. Ensure at least one of the methods of surge detection between speed and current should be checked if set points are already configured.

- Reduce the Boost line distance to ~5%.

- Set the Surge control line minimum margin to -5% so that operating point can be moved further left to the surge line. For this particular setting, go to the Service Menu -> Compressor Control 1 -> Surge Protection. Changing this value requires Configure User Level permissions.

Step 8: Reduce surge margin and continue pinching the Anti-Surge Valve, until unit surges. If unit does not surge even going left of surge line by 5%, refer to step 3 above and reduce surge minimum margin to another -5% . The recycle valve will be opened by one of the open loop responses (example Boost line). Quickly raise the manual position of ASV by an additional 10%-15%. Once the open response triggers, then bring back the pre-surge test conditions with the following settings:

- Ensure the safety margin configuration again as it was before the test. Start by slowly increasing the margin followed by valve opening in such a way that WSPV should not fall below ~110 % and margin is again~ 20%-25%.
- Reset the Surge Event.
- Reconfigure the Boost line distance the same as before start of test. (~half of safety margin).
- Enable the Surge detection methods of Min flow (if required) and Cross Line option.
- Configure the Anti-Surge Controller tuning parameters same as it was before the start of the test.
- Restore the surge minimum margin configuration using the service menu.
- Save the trends of the Surge Test event for mentioned process tags.
- Ensure that Anti-surge Controller is in Manual with Back up mode such that WSPV=~105.
- Write down the final value of safety margin _____ %

In case a surge is detected before the operating point touches the predicted surge limit line, the boost response will immediately step open recycle valve. Anti-Surge Control stage 1 may be opened further in manual control to keep operating point >100%. The recorded surge data is examined.

Step 9: The compressor speed will be increased to 40% by giving manual set point to the variable–speed-drive controller. Step 6-to-Step 8 will be repeated at this speed for carrying out surge verification.

Step 10: The compressor speed is increased to 80% by giving manual set point to the variable–speed-drive controller. Step 6-to-Step 8 will be repeated at this speed for carrying out surge verification.

Step 11: The commissioning engineer will analyze the results; the machine will be re-tested in case of re-confirmation or doubt. A conservative safety margin will be set for Anti-Surge Controller. Fallbacks for transmitter-failure will be set after explaining to the customer and Anti-Surge Controller tuning will be done for normal operation.

Step 12: The commissioning engineer will analyze the results; the machine will be re-tested in case of re-confirmation or doubt. After completion of surge-test with Feed Gas, the safety margin for Anti-Surge Controller will be reduced to an optimum value.

Complete Table 24-1.

Table 24-1. Surge Test Table

Property	Unit	Unit	Unit		
Date	dd/mm/yy	dd/mm/yy	dd/mm/yy		
Time	h:mm:ss.0	h:mm:ss.0	h:mm:ss.0		
Head.[Hp]					
Flow [Δp_0]/Vol. Flow Qa or dP					
Discharge pressure Pd					
Suction pressure Ps					
Speed (Compressor/Driver) [N]					
Discharge Temperature T _D					
Suction temperature [T _{SUCTION}]					
Anti-SURGE VALVE Out					
Mol weight [MW]	-				
Max. flow rate of change	-				
Max. Pressure rate of change	-				
Max. Speed rate of change (if app.)					
Max. Current rate of change (if app.)					

Unit Unload Tuning

When the Operator performs the normal unload command, the Anti-surge controller ramps the respective Anti-surge Valve to Anti-surge controller shutdown position level. Once shutdown position is achieved, the performance controller ramps down the demand to 0% in manual mode.

The objective of tuning both Anti-surge and speed controller under UNLOAD action, is such that, while the unit is ramping down to Min Governor Speed, there should not be any Boost Line response in either stages Anti-surge Controllers.

1. Before carrying out unload tuning for both compressor stages, the surge line verification test, Anti-Surge controllers tuning, Speed Controller tuning, and preferably performance controller tuning must

have been done.

2. To prepare the unload command tuning, initially pre tune the performance controller ramp rate of unload. Go to the Service Menu-> Performance Control-> Rates screen, *NSD rate*, and set the initial value as 1 % /sec.
3. Initially pre-tune the Anti-surge for both the 1st and 2nd stage Anti-surge Controllers for Unload ramp rate. Service Menu->Compressor Control1-> Sequencing-> ASC1 Sequencing Valves Rates->*NSD Rate when*. Make it 1% initially.
4. After clearance from End user /OEM, bring the operating speed of compressor preferably up to rated speed by slowly increasing the performance controller's output (~1-5 %/sec). Watch out for the process parameters (vibrations, trip limits), discharge temperature.
5. When machine is stable at desired speed, press the unload button; this should cause the performance controller to change into manual mode and Anti-surge Controller to open the valve as per defined NSD ramp rate. If during this process at any compressor stage Boost line response occurs, then increase the Anti-surge Controller unload ramp rate by 2 times the existing one.
6. If the above mentioned ramp rate needs to be changed, it is recommended to carry out the test again.

At the end of tuning, note the final ramp rate of:

Performance controller_____

1st Stage Anti-surge controller_____

Chapter 25. Load Sharing Configuration

This section describes parallel load sharing configuration and commissioning with the example of two trains. The example uses two stages compressors for each train. It has been assumed that at this stage the user is aware of anti-surge and performance control configuration and commissioning.

Layout of the load sharing scheme:

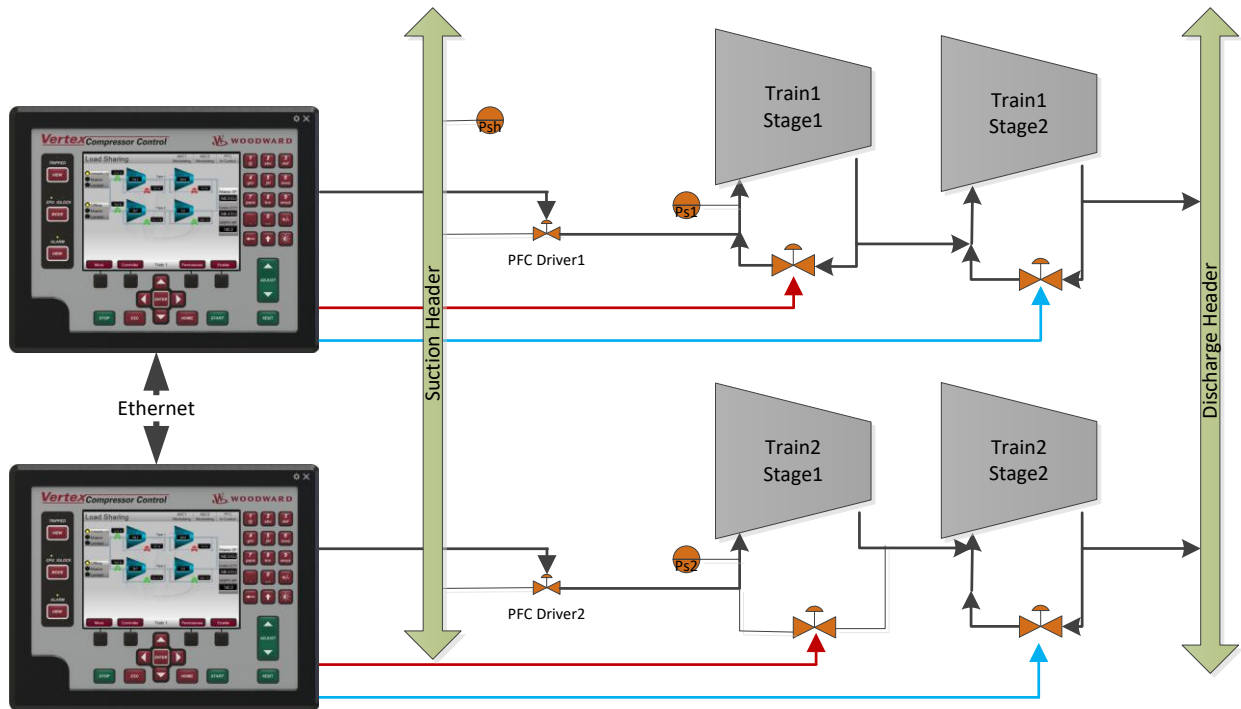


Figure 25-1. Load Sharing Layout

Psh- Suction header transmitter. Connected to Train -1 Vertex as Load sharing PV.

Ps1- Train 1 suction pressure transmitter, which is also configured as Train1, performance controller's PV.

Ps2- Train 2 suction pressure transmitter, which is also configured as Train2, Performance controller' PV.

Input /Output Configuration:

Table 25-1. Load Sharing Analog Inputs

Analog Inputs					
Channel	Function	Train 1		Train 2	
1	Stage 1 Suction Flow	0-100	InH2O	0-100	InH2O
2	Stage 1 Suction Pressure (Ps1)	0-800	psi A	0-800	psi A
3	Stage 1 Discharge Pressure	0-1000	psi A	0-1000	psi A
4	Stage 1 Suction Temperature	0-300	Deg F	0-300	Deg F
5	Stage 1 Discharge Temperature	0-300	Deg F	0-300	Deg F
6	Load sharing input (Psh)	0-700	psia	Not Used	
7	Not Used				
8	Not Used				
9	Stage 2 Suction Flow	0-150	InH2O	0-150	InH2O
10	Stage 2 Suction Pressure	0-1000	psi A	0-1000	psi A
11	Stage 2 Discharge Pressure	0-2000	psi A	0-2000	psi A
12	Stage 2 Suction Temperature	0-300	Deg F	0-300	Deg F
13	Stage 2 Discharge Temperature	0-450	Deg F	0-450	Deg F
14	Not Used				
15	Speed Signal	0-10000	rpm	0-10000	rpm
16	Motor Current	0-2000	amp	0-2000	amp

Table 25-2. Load Sharing Analog Outputs

Analog Outputs			
		Train 1	Train 2
1	Stage 1 AS valve demand	0-100%	0-100%
2	Performance Valve Output	0-100%	0-100%
3	Stage 2 AS valve demand	0-100%	0-100%

Table 25-3. Load Sharing Boolean Inputs

Boolean Inputs	
1	Emergency Stop
2	Train Start command
3	Startup complete feedback
4	Start inhibit
5	Normal SD request
6	Quit Normal SD
7	Enable Load sharing
8	Disable Load sharing

Control Narrative for Load Sharing

The operator issues Train startup command, which initiates startup sequence to Train 1. When the driver speed gets stable, train startup is completed. The performance controller controls its PV (suction pressure of the train) by modulating suction control valve.

Train 2 startup is also completed and Performance controller controls train two suction pressure, by modulating suction valve.

When Train -1 and Train -2 are ready for load sharing, the operator issues Enable load sharing command, and both trains start functioning in Load sharing mode. The process variable of Load sharing is Suction header pressure (Psh). The initial set point for suction header is 342 psia.

Configuration

At this stage, it is assumed that the user has configured inputs and outputs as mentioned in the IO table.

Configuring Load Sharing for Train 1

Bring Train 1 Vertex into configuration mode.

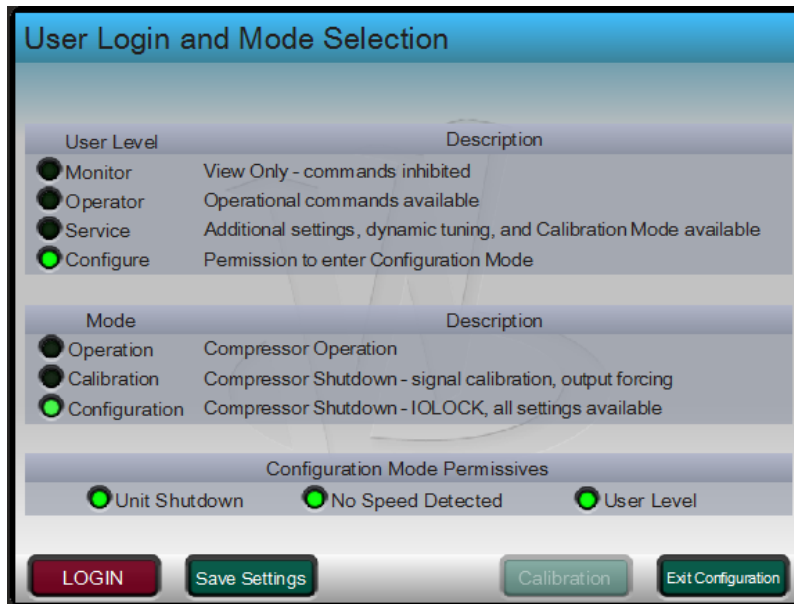


Figure 25-2. User Login and Mode Selection

Go to the configuration screen:

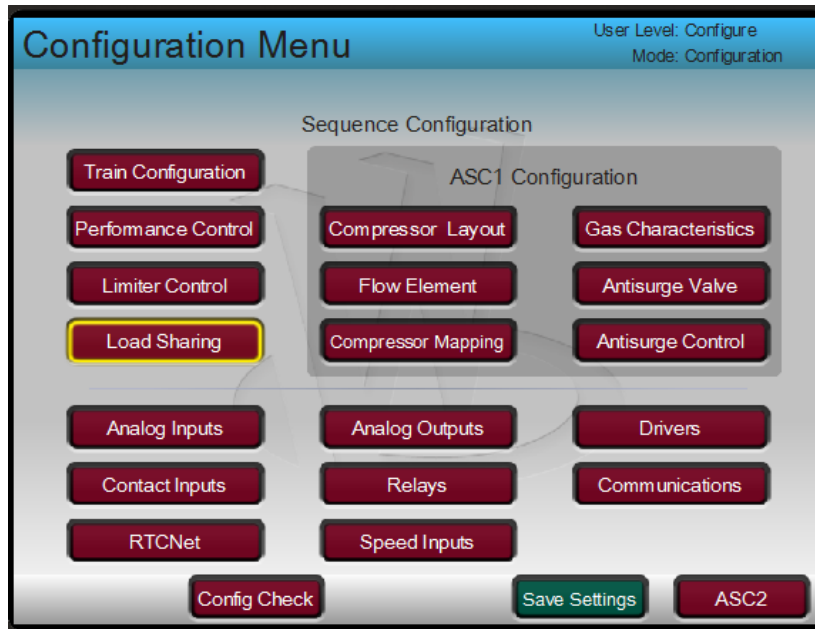


Figure 25-3. Main Configuration Menu

Select Load Sharing button and open the screen for Load sharing configuration

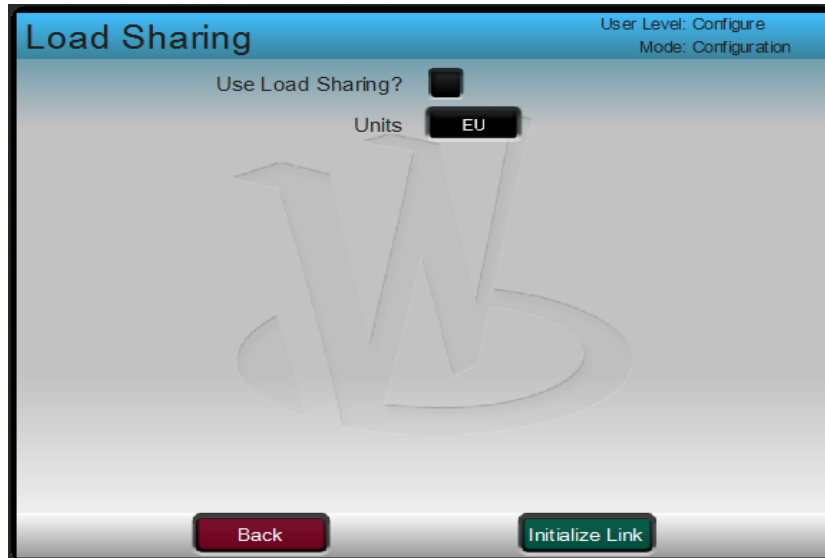


Figure 25-4. Load Sharing Configuration

Check the Load sharing Option.

Enter the units for load sharing PV and SP (psia in this example).

Figure 25-5. Load Sharing Configuration Screen

Number of trains in Load sharing:

Since there are two trains which will participate in Load sharing, the total number of trains are two. The Vertex can handle a maximum of five trains in load sharing.

Train ID: This is the unique identification of each train on load sharing network. Each participating load sharing Vertex must have a unique load sharing ID. Maximum 5 train IDs can be used. Assign Train ID 1 for Train 1. Similarly for configuration in Train 2, the train ID must be set to something other than 1.

Load sharing Parameter: This the parameter used for balancing two trains, a common variable which is used to keep participating trains at equal level of balancing variable. The most common load sharing variable is wspv. Therefore, opt for wspv.

Inverted Control: In the control schematic, if process variable (Psh) gets higher than set point, then the suction valve needs to be opened more. That means if $PV > SP$ for the control, the demand should increase. This is defined as "Invert Control". Therefore, check the option of Inverted Control.

Inverted Bias: Each train receives load sharing distributed setpoint (average wspv in this example). If each train's load sharing parameter (wspv) gets higher than the required distributed load sharing set point (Average WSPV), then the load sharing demand should reduce demand for suction valve opening. This is invert control for load sharing bias.

A general behaviour can be noted that, if Inverted Control is checked, then check the Inverted Bias as well.

In the above example, the error ($wspv - bias - SP$) is added to Load sharing controller's SP. For example, if bias SP is 120 and the current train's wspv is 125, then based upon the above example, an error ($125 - 120 = 5$) is added to load sharing SP. This addition of set point will tend to close the suction valve since the Load sharing controller is inverted.

Load sharing parameter location: This parameter is for indication purposes only. Since load sharing PV is suction header pressure, select option as suction header.

Minimum Setpoint: The lowest value of the set point related to load sharing controller.

Maximum Setpoint: the maximum value of the set point of the load sharing controller (700 psia).

Initial Setpoint: This is the setpoint which is used when Vertex boots up (342 psia).

Units: Engineering units of the load sharing PV and SP (psia).

Initialize link function key: This function key should be used when another Vertex unit is enabled and appears on load sharing EGD network. This function key initializes the EGD communication.

Final configuration page of Train 1:

Load Sharing User Level: Configure
Mode: Configuration

Use Load Sharing?

Number of Trains in Load Sharing: 2

Train ID: 1 *Must be unique for each Vertex in Load Sharing*

Load Sharing Parameter: WSPV

Inverted Control?

Inverted Bias?

Load Sharing Parameter Location: Suction Header

Minimum Setpoint: 0.00 psia

Maximum Setpoint: 700.00 psia

Initial Setpoint: 342.00 psia

Units: psia

Back Initialize Link

Figure 25-6. Load Sharing Configuration

Configuration of Load sharing for Train 2:

Similar steps should be carried out as in configuration for Train 1 except that the Train ID of Train 2 must be different than 1. Configured Train ID of Train 2 as 2.

Final configured page of Load sharing for Train 2

Figure 25-7. Load Sharing Configuration Screen

Press “Initialize Link” function key and that will complete Load sharing configuration tasks for Train 1 and Train 2.

Commissioning Load Sharing Control

At this stage the following is assumed:

- The related Anti-surge and performance controllers configurations have been carried out and no configuration error exists.
- Field connections and wiring to Vertex units have been done, including EGD links for Load sharing network among participating trains.

Field instruments including valves have been verified for correct configuration and ranges.

Service Menu Configuration:

Access the Train 1 service screen:

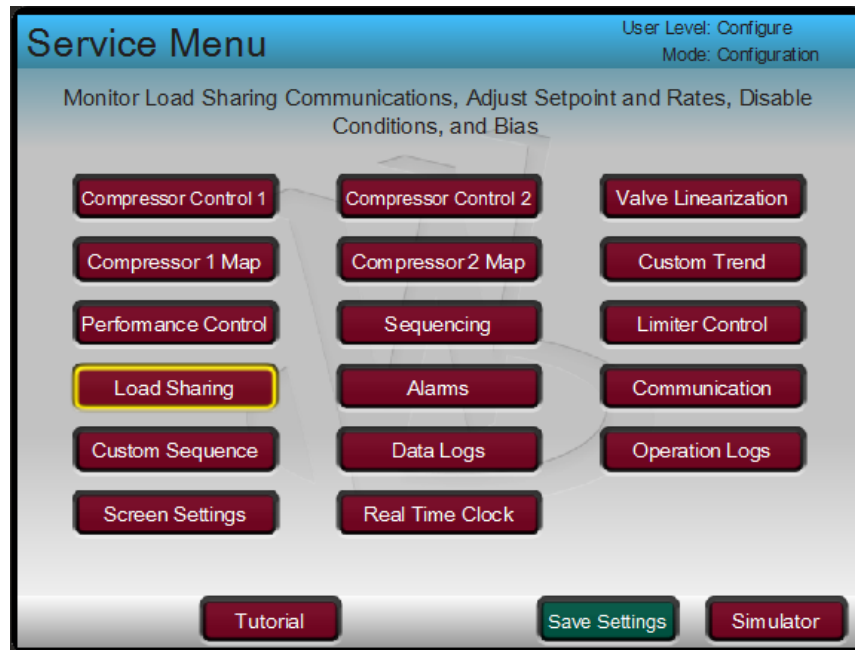


Figure 25-8. Service Screen Menu

Ensure that Train 1 and Train 2 EGD links shows healthy. If not then, Initialize links by using “Initialize Link” function key. If the problem persists, check for general communication troubleshooting steps.



Figure 25-9. Service Screen Load Sharing-Communications



Press function key for next page arrow

Load Sharing Control:

This page is left for default values. For the last option on this page, “Disable ASC Auto Permissive”, means that if anti-surge controller is not in auto mode, then Load sharing cannot be activated. If the plant control operator wants to control the compressor with manual mode of ASC, then this option should be checked, otherwise it is not required.



Figure 25-10. Service Menu Load Sharing-Control

Press function key for next page arrow

Load Sharing–Disable Conditions:

On this screen, there are a selection of conditions related to load sharing kick out. All available options are described below. The actual option availability depends upon user configuration of the function. For example, if limiter 1 function has not been configured in Performance configuration, then there is no need to configure Load sharing kick out (disable) based upon performance limiter 1 activation.

Disable on PFC Limite1: Since Performance controller’s limiter 1 is configured in the control loop, this option is chosen.

PFC Limiter 1 Disable Delay: If the Limiter1 activates/deactivates frequently, then this timer should be kept at default settings. If limiter loop activation is very infrequent then this timer can be shortened. A similar concept may be applied to PFC Limiter2 loop.

Disable on ASV Deviation:

If any train’s ASV1 demand deviates more than the configured value from average ASV1 demands from all participating trains, then LS kicks out. If in the process, the operating point (wspv) remains mostly at surge line (wspv ~100), then the ASV kickout window should be set between 10%-20% with delay timer > 5 seconds.

Disable on Load Share Parameter Deviation:

If any train's lowest WSPV (lowest between ASC1 and ASC2), get higher than all trains average WSPV from configured kickout window then Load sharing kick out.

Similar concepts from ASV deviation can be applied here. Avoid configuring the kickout window value higher than surge margin value.

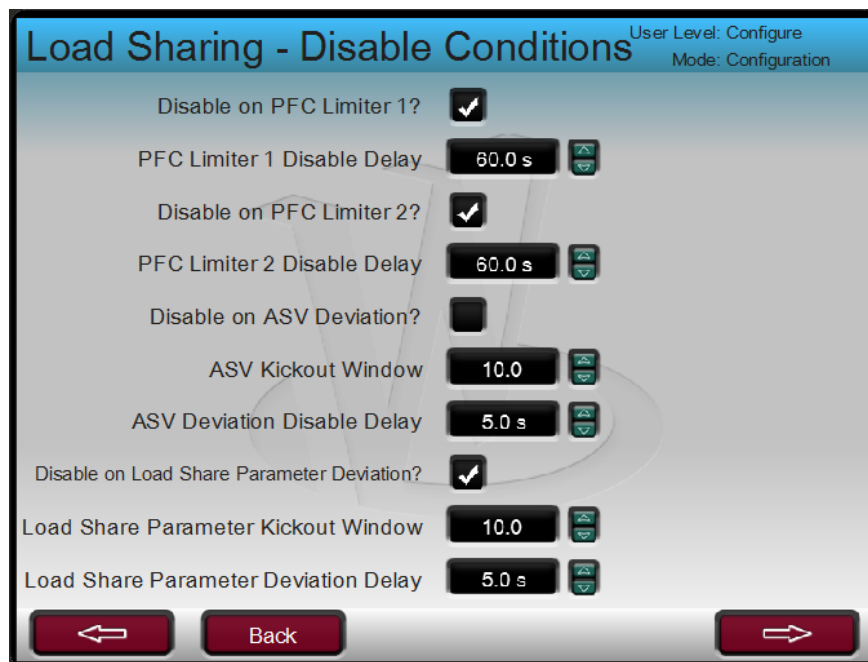


Figure 25-11. Service Screen- Load Sharing Disable Conditions

Press the function key for next page arrow.

Load Sharing Disable Conditions:

On this screen, all mentioned conditions should be used for Load sharing kick out conditions.

Auto Rejoin after Disable clears: If this option is checked, then the controller will try to join load sharing after the kick out conditions are cleared (with time delay).

Auto rejoin option should be utilized if operator intervention is required in the process (such as single stage, air compressors with automated startup sequences).



Figure 25-12. Service Screen- Load Sharing Disable Conditions Continued

Press the function key for next page arrow.

Load Sharing-Performance Bias:

On this screen, the user can configure the gain and lag on the error created from individual Vertex due to load sharing. Higher gains will make individual Train aggressive towards load sharing control. Higher bias lag refers to the lag in error response.

Bias Lag: In general, the default value of 5 should be the initial value. If frequent wspv variation is observed, then bias lag may be increased > 5 sec.

Joining Window: This window is used to check if participating train's load sharing variable (wspv) is in sync with the current load sharing set point with joining window margin. If any train Load sharing is enabled, its load sharing variable is checked with current load sharing variable set point. If joining train's load sharing variable (wspv) value falls in between the Load sharing set point range+/- window then current train changed its status from Joining to LS active status.

Performance Error Gain: Default value should be 1, if user wants to make any individual train more aggressive towards load balancing, then this value may be increased. If frequent oscillation occurs in load balancing, then gain value may be reduced lower than 1.

Performance Error Authority: Maximum value of the error after gain that can be added with load sharing controller. If user wants to make an individual train more aggressive / loaded, then this value may be increased higher than 10.

Load Sharing Parameter Rate Limit: This is the rate of change of Load sharing target set point for the joining load sharing train. If the user wants incoming trains to join fast, without getting stable state, rate limit may be increased higher than 0.5.



Figure 25-13. Service Screen- Load Sharing Performance Bias

Press the function key for next page arrow.

Load Sharing –PV Redundancy:

If Load sharing process variable is connected to more than one Vertex unit, then user has options to select the final Load sharing variable (high, low, median, average).

All Signals Good Equation:

Since in the example case, load sharing PV (Psh) is connected to Train1, this option is not applicable here. The default option of “Median” is used.

Two Signals Good Equation:

This option is applicable when only two trains are participating in load sharing. Since in the example case load sharing PV (Psh) is connected to Train1, this option is not applicable here. The default option of “High Signal Select” is used.

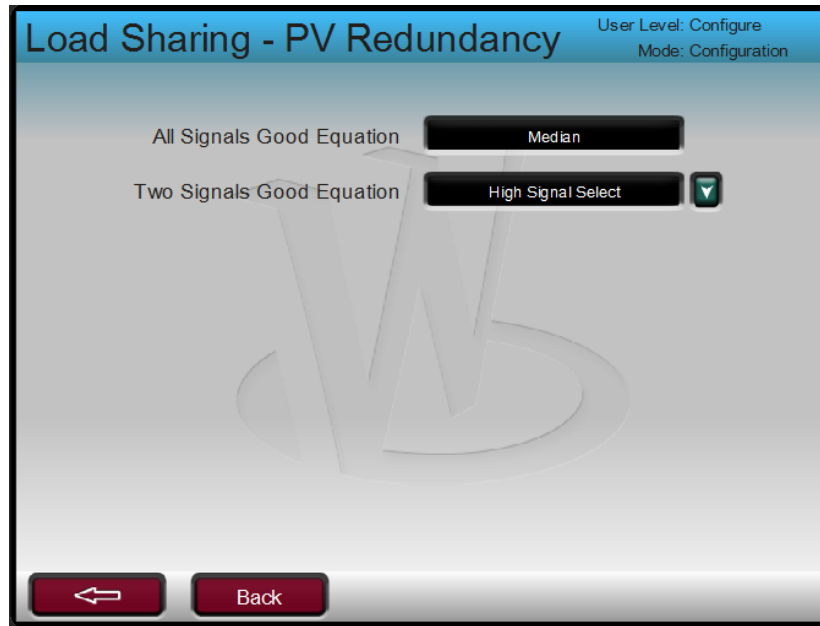


Figure 25-14. Service Screen- Load Sharing - PV Redundancy

Initial service configuration is complete. The service screen variables may be tuned further during commissioning.

Chapter 26.

Load Sharing Commissioning

Train-1 Load Sharing Startup and Tuning

At this stage verify that:

- Train-1 and Train 2, control tuning of Performance and Anti-surge controllers have been carried out.
- Train- 1 (Train ID1) has started; Performance controller and anti-surge controllers have started and in control. Preferably no recycling (ASV ~0%).

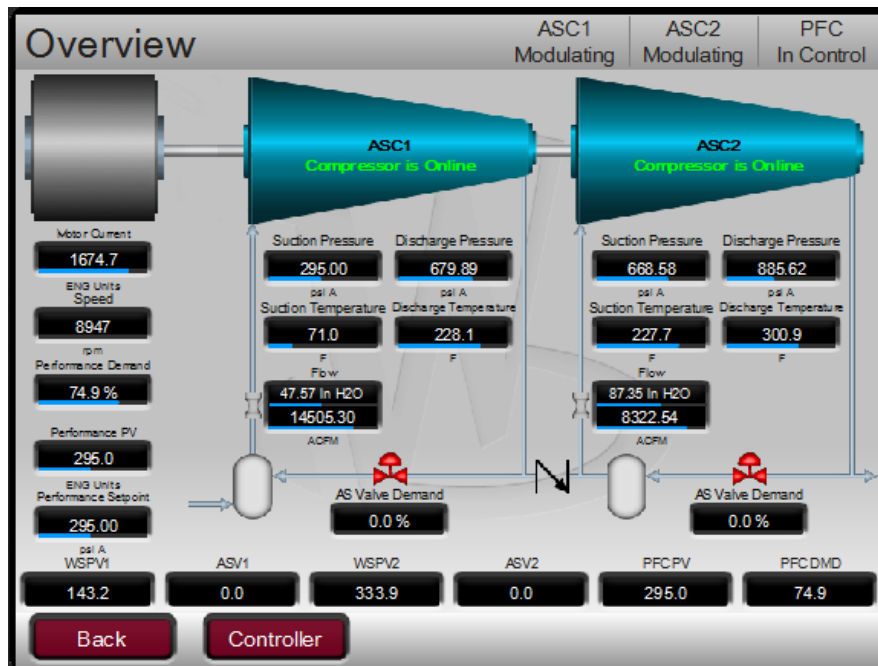


Figure 26-1. Main Overview Screen

Train-1 Load sharing link is healthy. Refer to service screen, Load Sharing, Train 1 and Train 2 Link Healthy.



Figure 26-2. Service Screen- Load Sharing Communication

Access the main screen, Load Sharing run screen, by navigating to button “Load Sharing”, and press Enter.

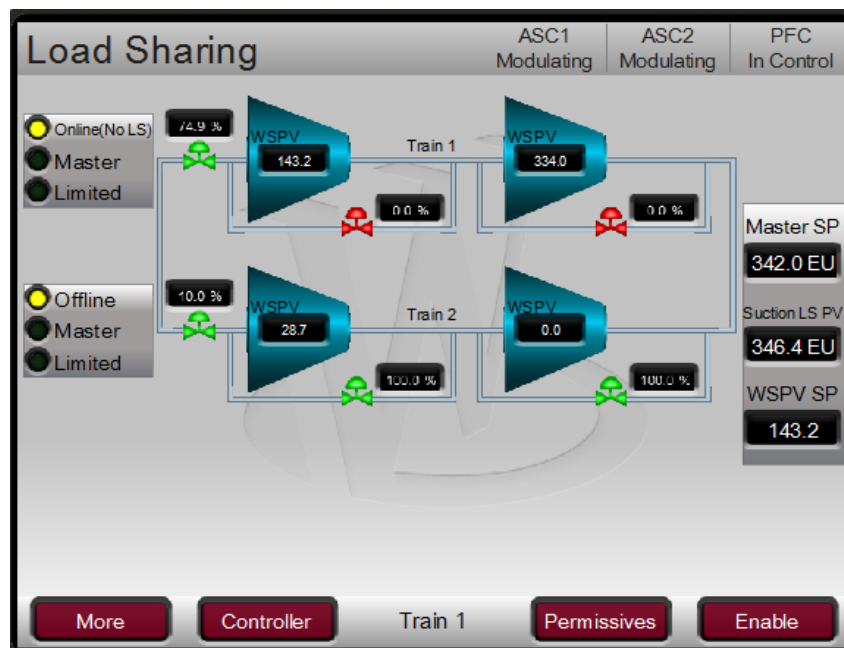


Figure 26-3. Main Menu- Load Sharing Screen

Verify that:

- For current Train 1, the Master set point is the initial Set point as shown.
- For Train 1, the left side top corner status LED shows Online (No LS).
- Status text on right side top displays PFC in Control.

On the same screen, press the function key underneath title “Permissive:

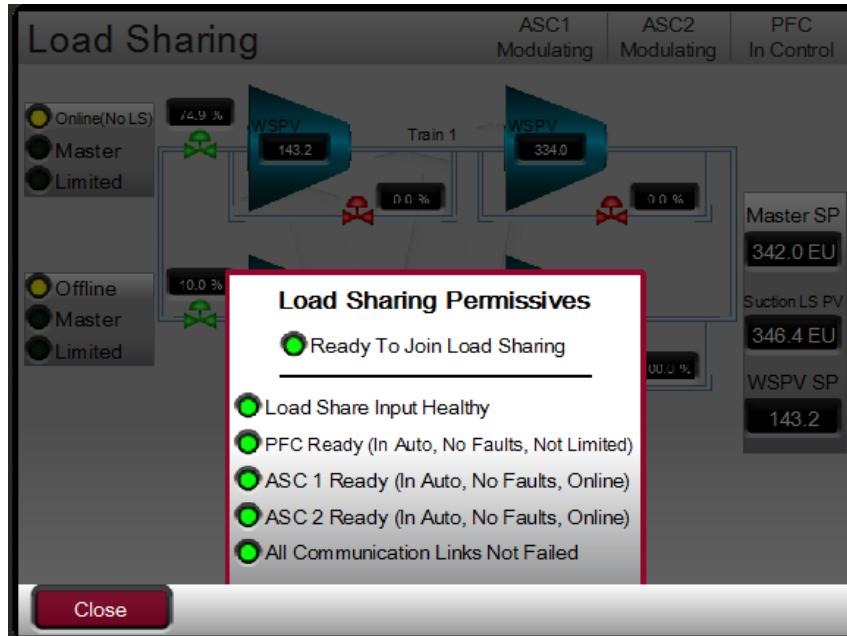


Figure 26-4 Main Menu- Load Sharing Permissive

Verify on this screen that “ready to join Load sharing” status is green. □

Close the pop-up window and reach to Load sharing main page.

Press the function key underneath Enable button.

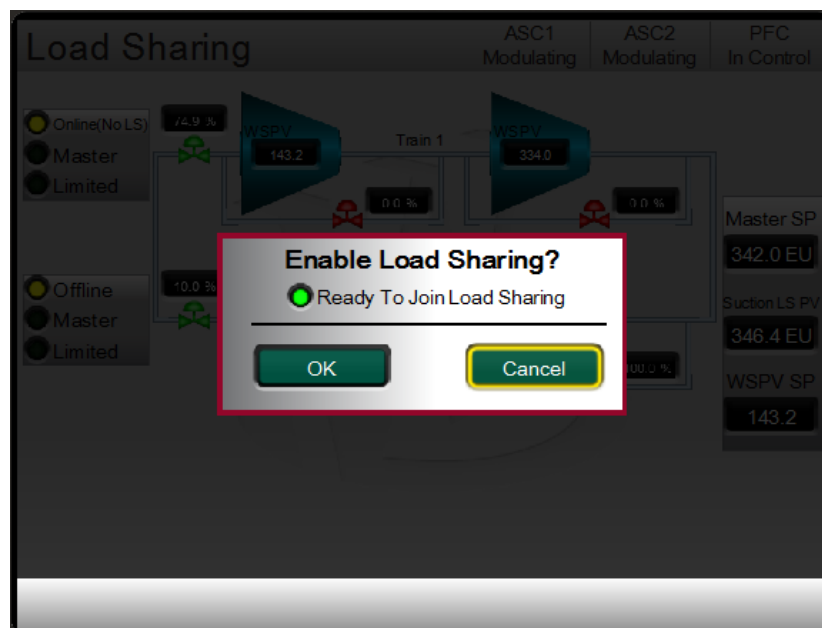


Figure 26-5. Main Menu- Enable Load Sharing

Navigate to OK button and press the Enter key. The load-sharing controller starts joining the load sharing control. Since this is the first train to start, Train -1 immediately gets status of Master controller from LS active status.

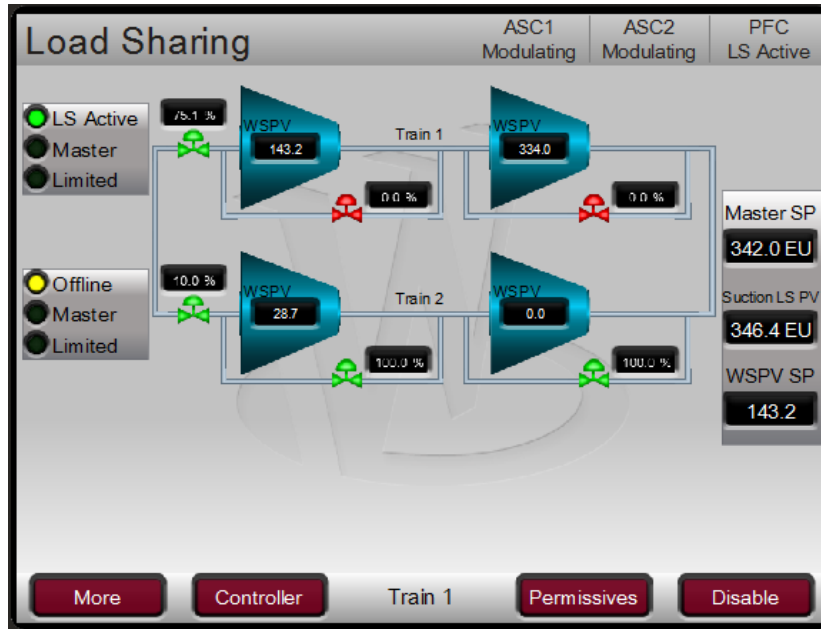


Figure 26-6. Main Menu Load Sharing Screen

Almost immediately, the status changes to Master controller.

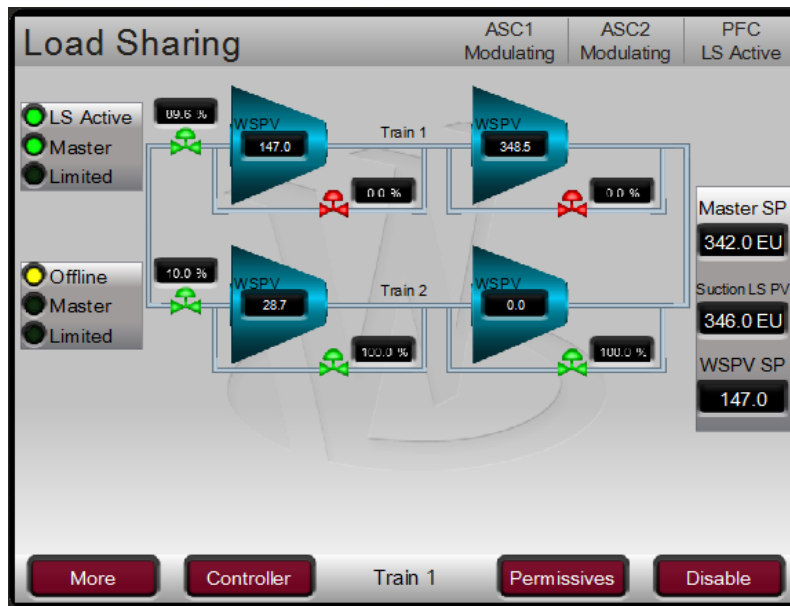


Figure 26-7. Main Menu Load Sharing Screen

Verify that Load sharing controller started modulating the driver to achieve the master controller set point.

Verify the direction of control loop for Load sharing controller. In the example the suction header pressure is controlled by manipulating the suction valve, so if Suction header PV > Master SP then output of controller is increasing (invert action).

If at this stage, the Load sharing controller's tuning may be carried out. If tuning is required, then access the tuning page by selecting function key below "More" button, then pressing the key under "Dynamics" button.

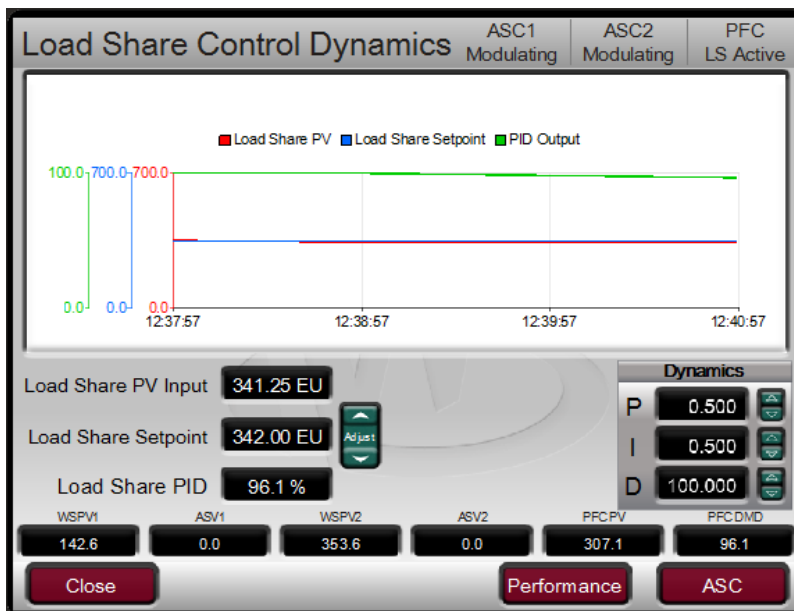


Figure 26-8. Load Sharing Control Dynamics

For basic tuning, create the disturbance by changing set point values of the controller followed by changing P,I, D values. The load sharing master controller should not be tuned aggressively. During tuning caution should be paid to the both stages WSPV (WSPV1 and WSPV2) of compressors.

Once basic tuning is carried out, close the screen and observe the behavior of Train-1.

9.2 Train-2 Load Sharing Startup and Tuning

At this stage verify that:

Train- 2 (Train ID2) has started; performance controller and anti-surge controllers have started and are in control. Preferably no recycling (ASV ~0%).

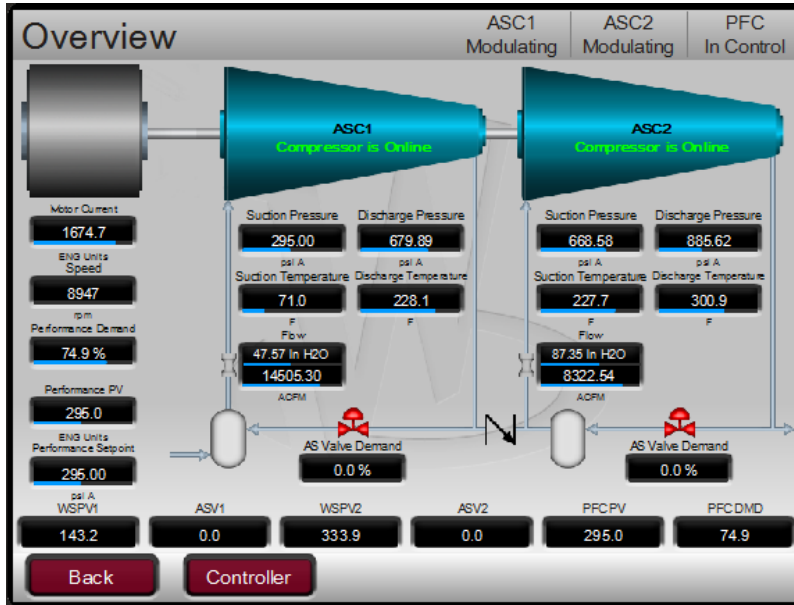


Figure 26-9. Train 2 Main Overview Screen

Train-1 Load sharing link is healthy. Refer to service screen, Load Sharing, Train 1 and Train 2 Link Healthy.

If required, increase the suction header load, since two trains will be extracting suction feed from the same suction header.

When the process is stabilised, access load sharing screen of Train2 (Train ID2)

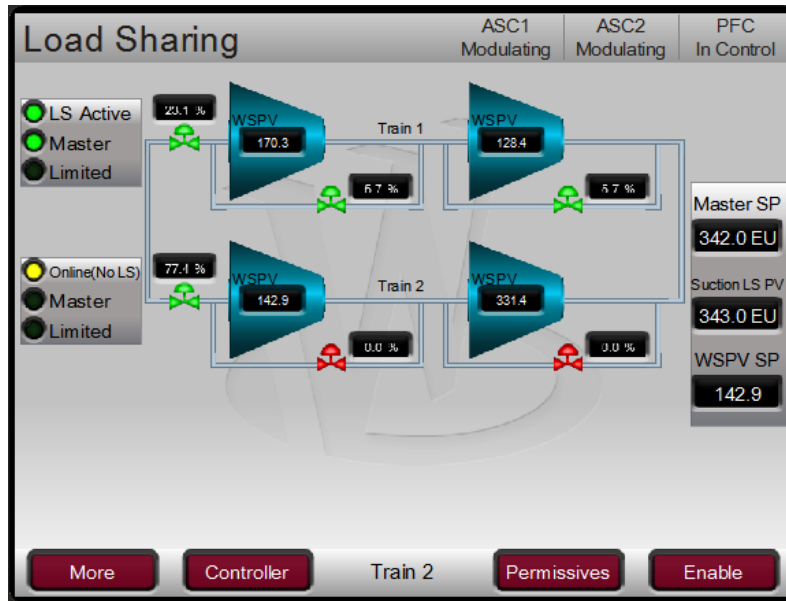


Figure 26-10. Train 2 Load Sharing Screen

Verify that for train 2, the status “Online (No LS)” is active.

Press the function key underneath the “Permissive” label to verify the required permissive exists to enable load sharing.

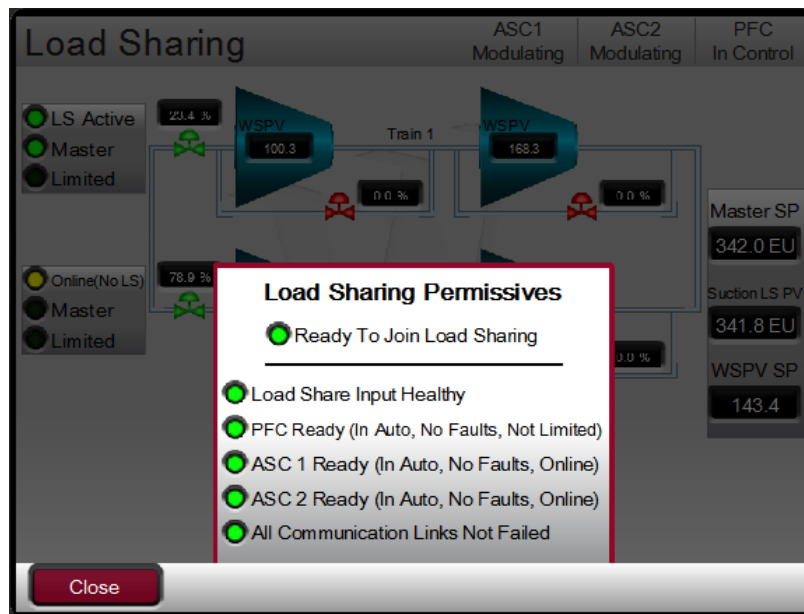


Figure 26-11. Train 2 Load Sharing Permissive

Now Train 2 is ready for load sharing.

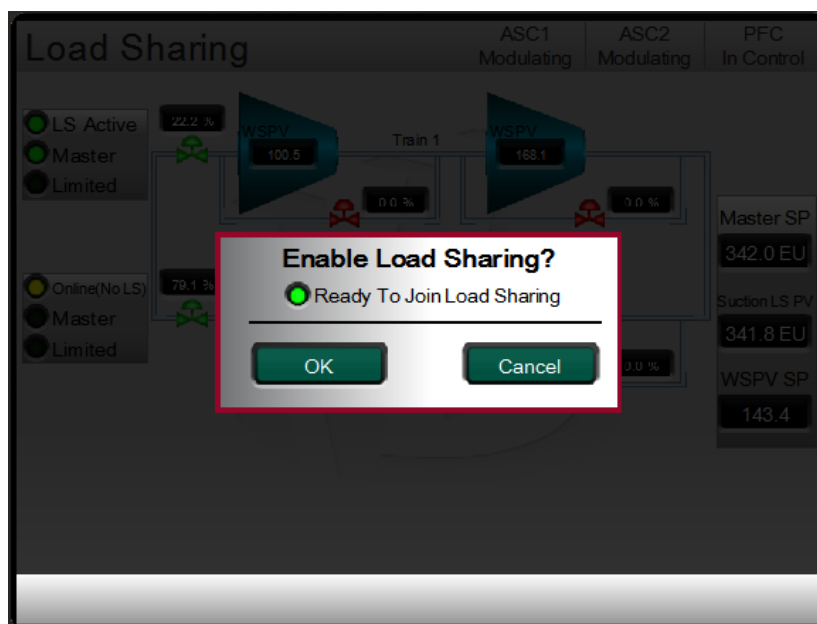


Figure 26-12. Train 2 Load Sharing Enable

When load sharing is enabled, the Train 2 load sharing controller starts “joining” the load share with other trains on the load sharing network (in this example, it is train 1 which is already in Load sharing network). Train 2 WSPV (lowest of stage 1 and stage 2) lies in the band of average of Train 1 and Train 2 WSPV +/- joining window.

The joining window is set in this example as nine. To alter this, access the service menu load sharing.

Press the function key to enable the load sharing.

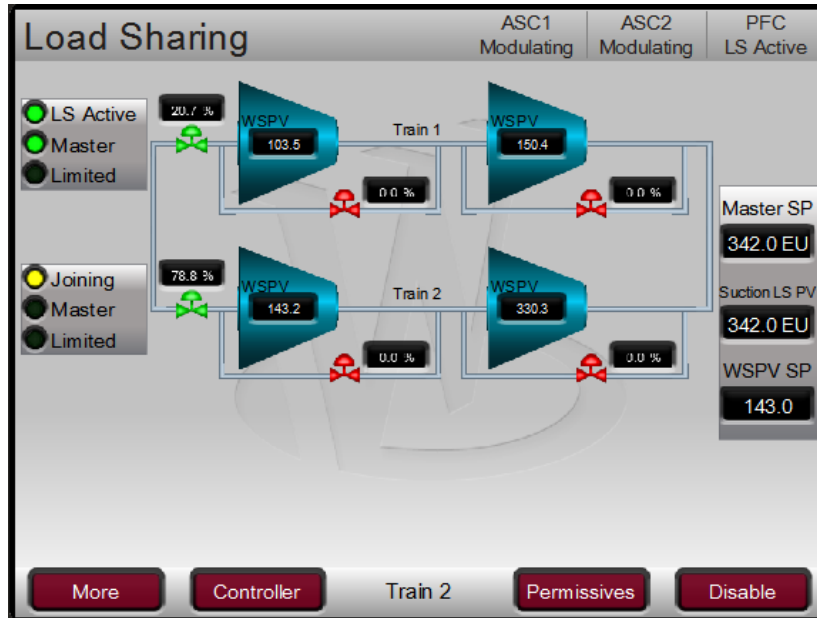


Figure 26-13. Train 2 Load Sharing Main Screen

When Train 2 WSPV gets in the joining range, the train 2 status changed to “LS Active”.

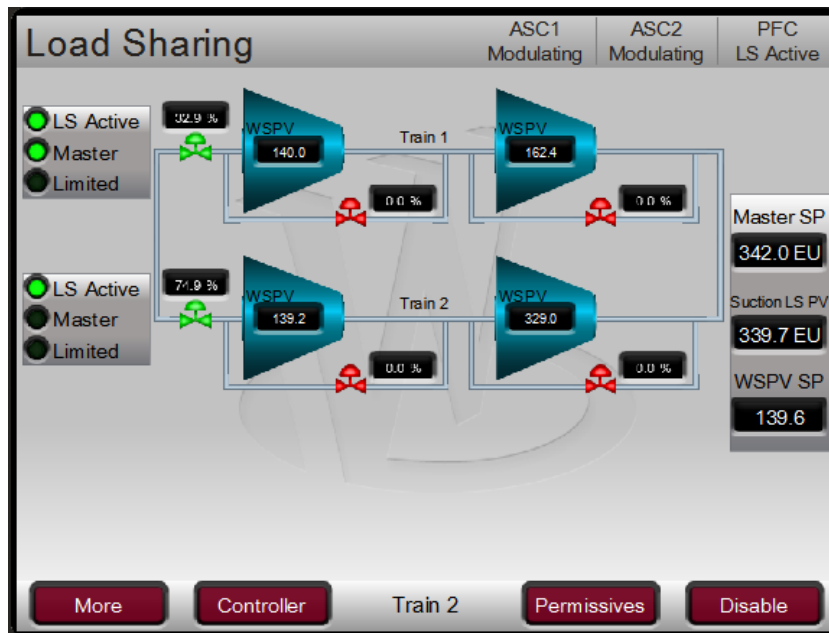


Figure 26-14. Train 2 Main Load Sharing Screen

Verify that both trains start sharing the load and their WSPV values.

Train 2 can also request to be master. To make Train 2 the master, press the function key underneath the “Controller” label.

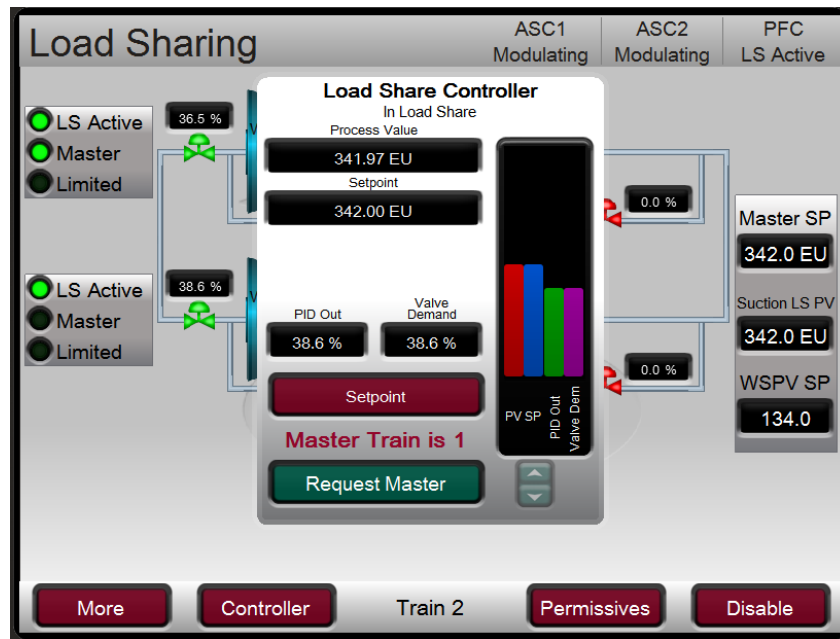


Figure 26-15. Main Menu Load Sharing Controller

Verify that the status of train 2 controller changes to “Master Train is 2”, and Master LED turns green. □

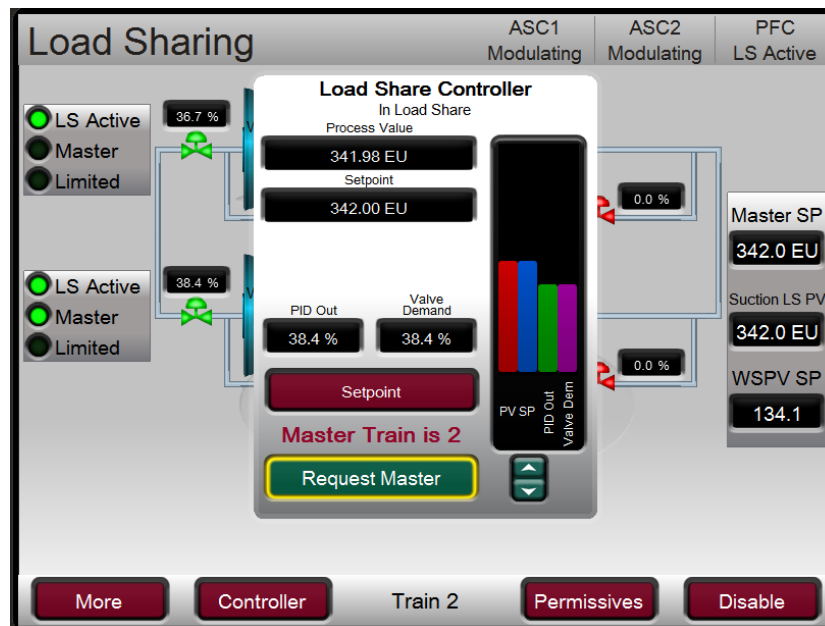


Figure 26-16. Main Menu Load Sharing Controller Master

At this stage, the load sharing controller should be tuned again by creating disturbances by changing master controller set point.

Load Sharing Troubleshooting

Trains Kicks Out from Load Sharing:

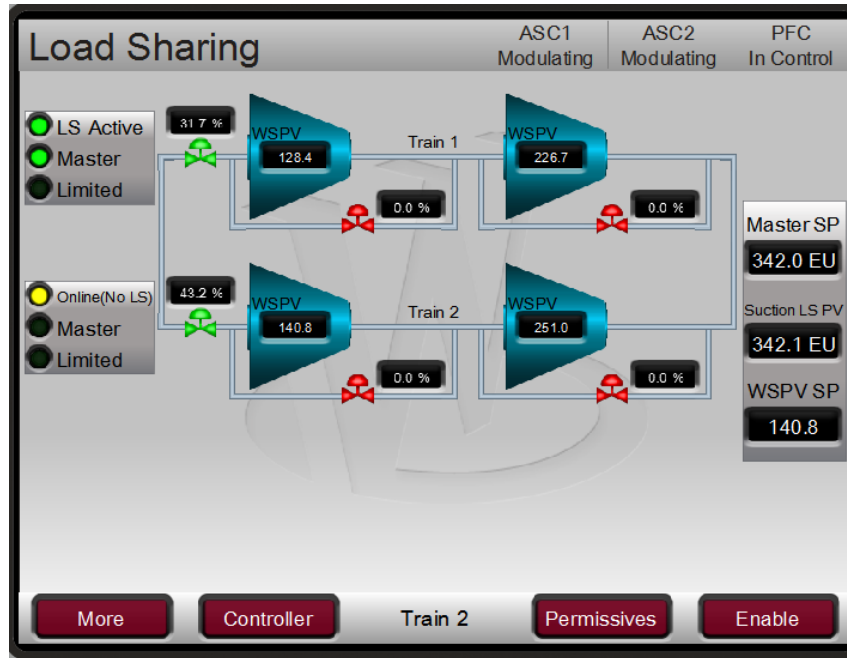


Figure 26-17. Train 2 Load Sharing Main Screen

When the train with master status kicks out from LS, the next train with the lowest Train ID is selected to be the new Master. (In the case of two trains, the next available train will be the next master).

Check on the same screen, press the function key underneath the “More” label, then press the function key to access the “kick-out” page.

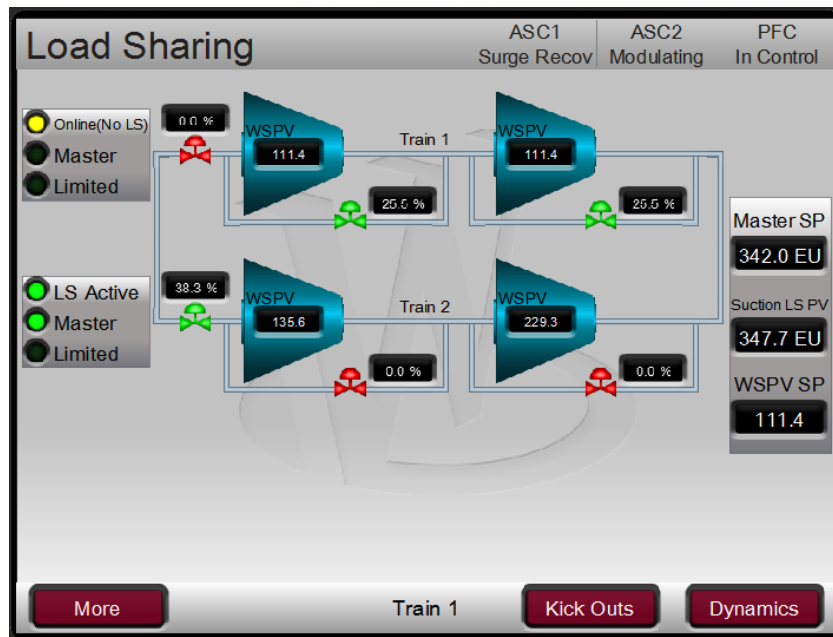


Figure 26-18. Train 1 Load Sharing Kickout

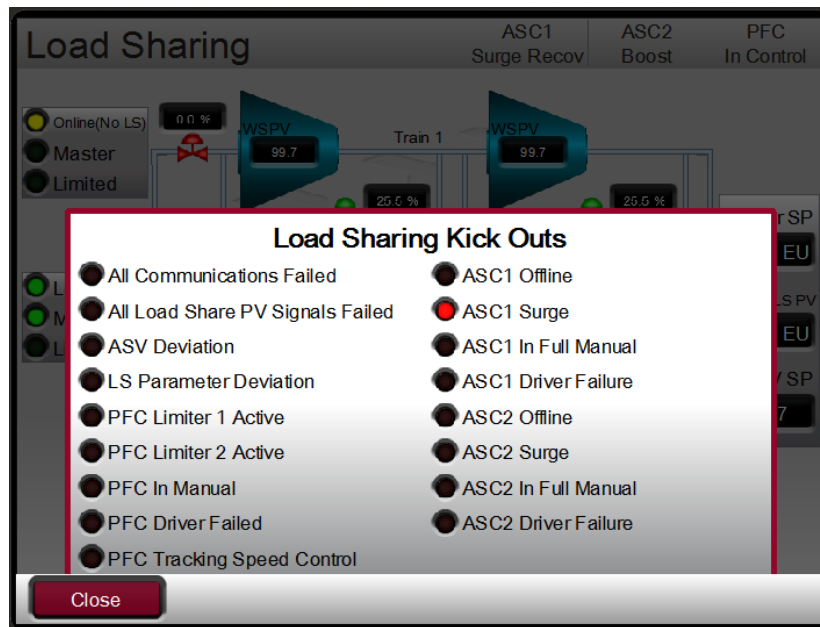


Figure 26-19. Train 1 Load Sharing Kick Outs

Look for the red LED indication parameter. In this example, ASC1 went into surge.

Now stabilize the process, and when LS is ready, enable it again.

If trains get kicked out due to LS parameters deviation, then increase the LS parameter range and delay timer using the Service menu, Load sharing screen.

The set point for the load sharing controller can only be manipulated through the train with Master status.

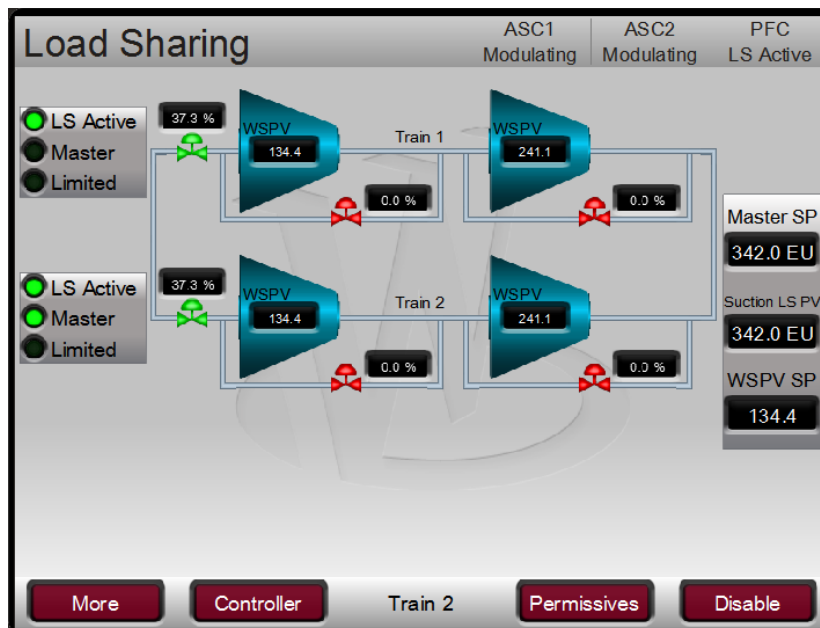


Figure 26-20. Load Sharing Final Screen

Chapter 27.

Post Commissioning Backup

At the end of commissioning, create back up files of:

- Configuration files
- Project files
- Communication architectures (including IP addresses)
- Surge Test Result Data with Trends

Ref 2: Thermodynamic Data Sheets

CENTRIFUGAL AND AXIAL COMPRESSOR DATA SHEET (API 617-7TH Chapter 2) SI UNITS		REVISION NO. _____	DATE _____
		PAGE <u>1</u> OF <u>7</u>	BY _____

1	APPLICABLE TO: <input type="radio"/> PROPOSAL <input checked="" type="radio"/> PURCHASE (A) <input type="radio"/> AS-BUILT						
2	FOR _____	UNIT _____					
3	SITE _____	SERIAL NO. _____					
4	SERVICE <u>FEED GAS COMPRESSOR</u>	NO. REQUIRED <u>ONE (1)</u>					
5	MANUFACTURER _____	DRIVER TYPE (1-3.1.1) <u>ELECTRIC MOTOR</u>					
6	MODEL _____	DRIVER ITEM NO. _____					
7							
8	INFORMATION TO BE COMPLETED: <input type="radio"/> BY PURCHASER <input type="checkbox"/> BY MANUFACTURER <input type="checkbox"/> MUTUAL AGREEMENT (PRIOR TO PURCHASE)						
9	OPERATING CONDITIONS						
10	(ALL DATA ON PER UNIT BASIS)						
11	NORMAL	RATED	60% TURNDOWN	LEAN GAS CASE	ALTERNATE	RICH GAS CASE	
12							
13	● GAS HANDLED (ALSO SEE PAGE ___)						
14	▲ GAS PROPERTIES (1-2.1.1.4)						
15	<input type="radio"/> Nm ³ /h(1.033kg/cm ² A & 0° C DRY)						
16	● WEIGHT FLOW (kg/h) (DRY)(WET)						
17	INLET CONDITIONS						
18	● PRESSURE (kg/cm ² A)						
19	● TEMPERATURE (° C)						
20	<input type="radio"/> RELATIVE HUMIDITY %						
21	● MOLECULAR WEIGHT						
22	■ Cp/Cv(K1)-OR-(KAVG)						
23	■ COMPRESSIBILITY(Z1)OR(ZAVG)						
24	■ INLET VOLUME (m ³ /h) (DRY)(WET)						
25	DISCHARGE CONDITIONS						
26	● PRESSURE (kg/cm ² A)						
27	■ TEMPERATURE (° C)						
28	■ Cp/Cv(K2) OR-(KAVG)						
29	■ COMPRESSIBILITY(Z2)OR(ZAVG)						
30	■ BHP REQUIRED (kW)						
31	■ TRAIN BHP REQUIRED (kW)						
32	■ BHP REQUIRED AT DRIVER INCL EXT. LOSSES (kW) (*)						
33	■ SPEED (RPM)						
34	■ TURNDOWN (%)						
35	■ POLYTROPIC HEAD (N-m/kg)						
36	■ POLYTROPIC EFFICIENCY (%)						
37	● CERTIFIED POINT						
38	<input type="checkbox"/> PERFORMANCE CURVE NUMBER						
39	PROCESS CONTROL (1-3.4.2.1)						
40	METHOD	<input type="radio"/> SUCTION THROTTLING	<input type="radio"/> VARIABLE INLET	<input checked="" type="radio"/> SPEED VARIATION	<input type="radio"/> DISCHARGE	<input type="radio"/> COOLED BYPASS	
41		FROM _____ (kg/cm ² G)	GUIDE VANES	FROM <u>70</u> %	BLOWOFF	FROM _____	
42		TO _____ (kg/cm ² G)	(2-3.4.2.2)	TO <u>105</u> %	TO _____	TO _____	

NATURAL GAS						
51340	53907	30804	49950	51520	50470	
41.00	41.00	41.00	41.00	45.00	41.00	
15.0	15.0	15.0	30.0	43.0	10.0	
17.82	17.82	17.82	16.46	16.26	19.71	
1.445	1.445	1.445	1.412	1.404	1.474	
0.906	0.906	0.906	0.935	0.943	0.867	
1555	1633	933	1778	1779	1299	
50.50	53.00	50.50	50.50	50.50	50.50	
32.4	36.6	33.8	48.5	53.8	26.4	
1.442	1.441	1.438	1.407	1.401	1.473	
0.908	0.909	0.910	0.938	0.945	0.867	
478	621	325	543	341	407	
478	621	325	543	341	407	
493	636	340	558	356	422	
11200	12246	10423	12321	10463	10091	(A)
47.1	42.8	12.0	49.5	62.4	42.1	(A)
26190	32510	26280	30800	17900	22210	
81.6	81.0	73.7	81.7	79.8	80.5	
Yes	Yes			Yes		
(Power)	(Head & Flow)			(Head & Flow)		(A)

Figure 28-2. Example Thermodynamic Data sheet-1

CENTRIFUGAL AND AXIAL COMPRESSOR DATA SHEET (API 617-7TH Chapter 2) METRIC UNITS (1-1.6.5)		JOB NO.	ITEM NO.
		REVISION NO. <u>0</u>	DATE
		PAGE <u>2</u> OF <u>8</u>	BY <u>A.O</u>
1 OPERATING CONDITIONS (Continued) (1-2.1.1.1) (1-3.1.2) (1-3.1.3)			
2 GAS ANALYSIS:		AS PER PAGE-1	
3 <input checked="" type="radio"/> MOL %	<input type="radio"/> VOL %	NORAML	RICH
4	MW	LEAN	ALTERNATE
5 AIR	28.966		
6 OXYGEN	32.000		
7 NITROGEN	28.016	0.14	0.0 0.04 0.175
8 WATER VAPOR	18.016		
9 CARBON MONOXIDE	28.010		
10 CARBON DIOXIDE	44.010	1.20	0.0 0.28 0.593
11 HYDROGEN SULFIDE	34.076	≤10	≤10 ≤10 ≤10 (1-2.2.1.6)
12 HYDROGEN	2.016		(1-2.2.1.9)
13 METHANE	16.042	92.16	83.25 98.17 98.994
14 ETHYLENE	28.052		
15 ETHANE	30.068	3.81	9.82 0.87 0.233
16 PROPYLENE	42.078		
17 PROPANE	44.094	1.72	4.43 0.38 0.005
18 i-BUTANE	58.120	0.47	2.5 0.26 0.0
19 n-BUTANE	58.120	0.5	0.0 0.00 0.0
20 i-PENTANE	72.146		
21 n-PENTANE	72.146		
22 HEXANE PLUS			
23 CORROSIVE AGENTS			(1-2.2.1.3)
24			
25 TOTAL		100	100.0 100 100
26 AVG. MOL. WT.		17.82	19.71 16.46 16.26
27 LOCATION: (1-2.1.8)		NOISE SPECIFICATIONS: (1-2.1.9)	
28 <input type="radio"/> INDOOR	<input checked="" type="radio"/> OUTDOOR	<input type="radio"/> GRADE	<input checked="" type="radio"/> APPLICABLE TO MACHINE:
29 <input type="radio"/> HEATED	<input checked="" type="radio"/> UNDER ROOF	<input checked="" type="radio"/> MEZZANINE (A)	SEE SPECIFICATION <u>85 dBA @ 1 m</u>
30 <input type="radio"/> UNHEATED	<input checked="" type="radio"/> PARTIAL SIDES	<input checked="" type="radio"/> Tropicalization	<input type="radio"/> APPLICABLE TO NEIGHBORHOOD:
31 <input checked="" type="radio"/> ELEC. AREA CLASSIFICATION (1-2.1.14) Zone <u>2</u>	GR <u>IIC</u> TEMP <u>T1</u>		SEE SPECIFICATION
32 SITE DATA (1-2.1.8)			ACOUSTIC HOUSING: <input checked="" type="radio"/> YES (A) <input type="radio"/> NO IF REQUIRED
33 <input checked="" type="radio"/> ELEVATION <u>18.5</u> m	BAROMETER <u>1012mBar G</u>		APPLICABLE SPECIFICATIONS:
34 <input checked="" type="radio"/> RANGE OF AMBIENT TEMPS:			API 617, 7TH CHAPTER 182
35	DRY BULB	WET BULB	<input checked="" type="radio"/> VENDOR HAVING UNIT RESPONSIBILITY (1-1.5.52) (1-1.8) (1-2.1.3)
36 NORMAL °C			COMPRESSOR MANUFACTURE
37 MAXIMUM °C	<u>38</u>	<u>28</u>	<input type="radio"/> GOVERNING SPECIFICATION (IF DIFFERENT)
38 MINIMUM °C	<u>14</u>		
39			
40 UNUSUAL CONDITIONS:	<input type="radio"/> DUST	<input type="radio"/> FUMES	PAINTING:
41			<input checked="" type="radio"/> MANUFACTURER'S STD.

Figure 28-3. Example Compressor Data Sheet-2

Ref 3: Compressor Performance Curves

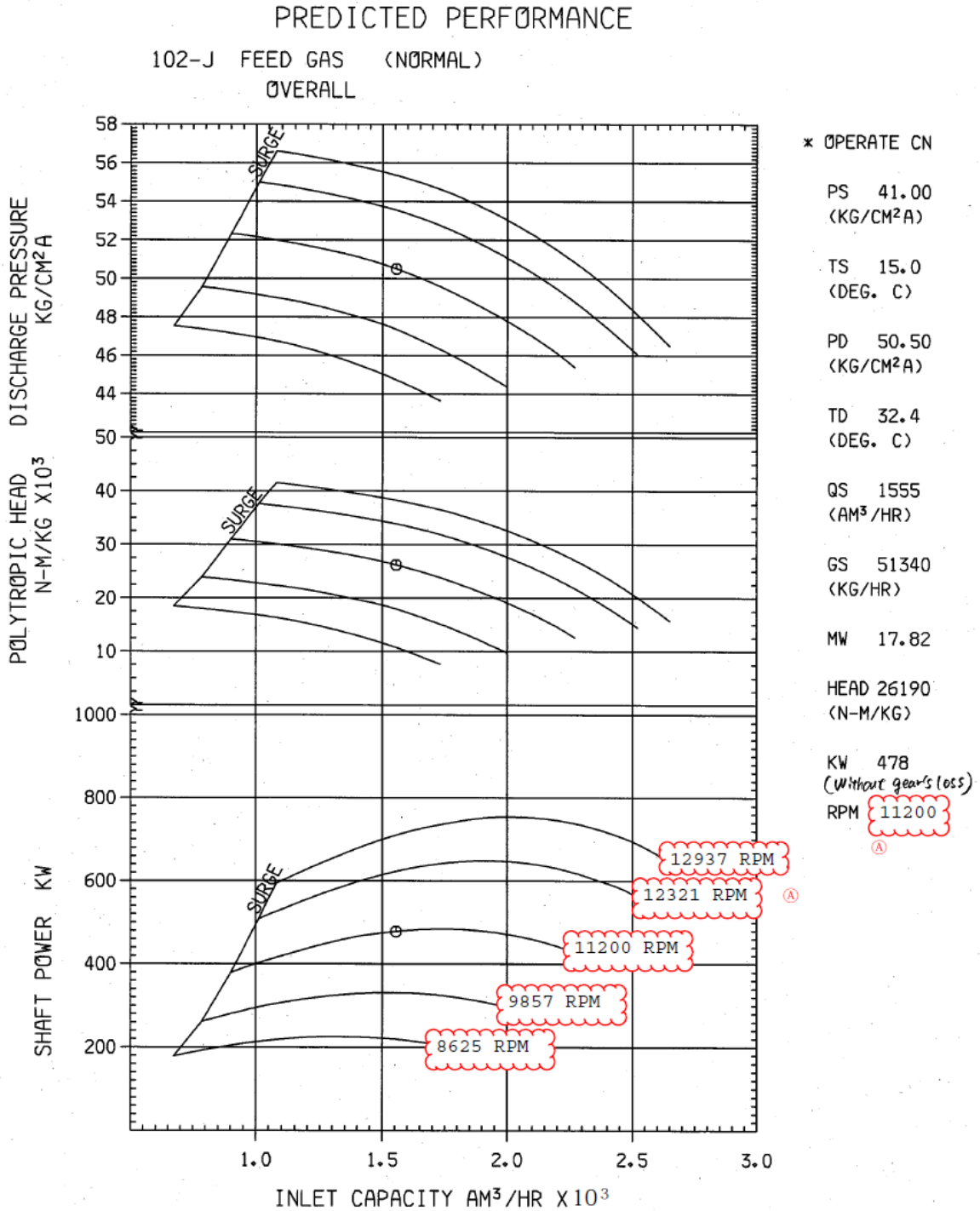


Figure 28-4. Predicted Performance Map-1

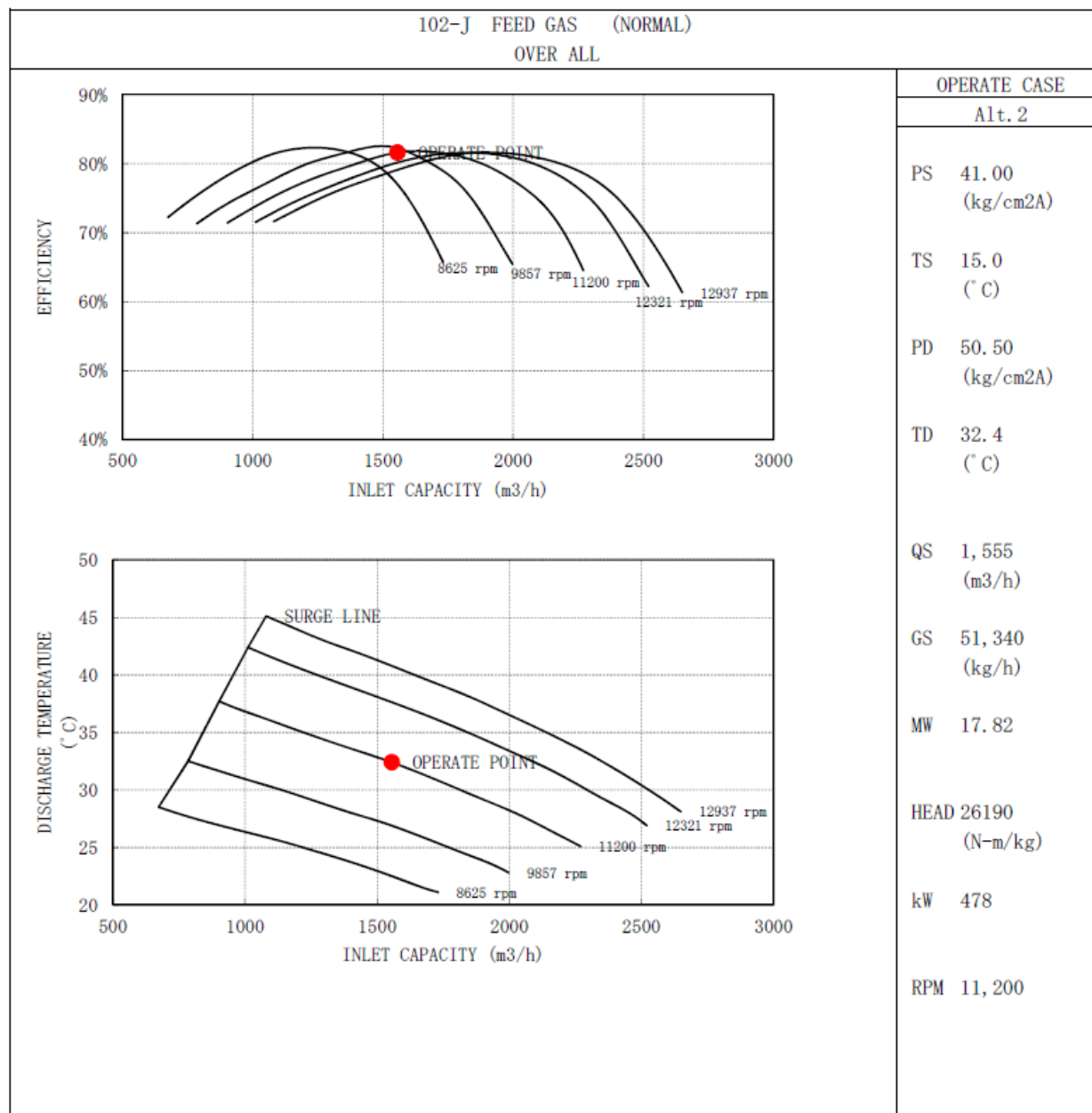


Figure 28-5. Predicted Map-2

Ref 4: FMD Data Sheet

Orifice Assembly						FORM: 101
PROJECT			TAG			
UNIT Ammonia			FE -1030			
P. O. DXKB111			SERVICE A-102-J DISCHARGE			
ITEM ORIFICE ASSEMBLY			PID NO. 1T4031PR/5D			
Work No. BA1063-00			LINE NO. 12NG 10301 D1A2 (S2)			
			DOC:0T2511-IN-DXKB111 PAGE 1			
SERVICE CONDITIONS	1	Process Fluid / State	NATURAL GAS / Gas/Vapor			
			Max.	Norm.	Min.	
	2	Flow Rate	67804	64575		
	3	Pressure		49.5		
	4	Temperature		32.4		
	5	Density		38.17		
	6	Specific Gravity				
	7	Specific Gravity at Base				
	8	Viscosity		0.01		
	9	Molecular Weight		17.82		
	10	Specific Heats CP/CV		1.45		
	11	Compressibility Factor Z		0.91		
	12	Quality % or Deg of Superheat				
	13	Velocity				
	14	Design Pressure	Max Min	58.3		
	15	Design Temperature	Max Min	100		
	16	Allowable Permanent Pressure Loss		0.1	kgf/cm ²	
	17	Vapor Pressure	Critical Pressure		kgf/cm ² -a	
18	Base Pressure	Base Temperature	1.033	kgf/cm ² -a		
19	Class		D1A2			
LINE	20	Size / Schedule / Line ID	12	in / 80	11.374	
BASIS	21	Type / Pressure Taps	Concentric Square Edge / Flange Tapping			
	22	Flow Range	0	to 100000	m ³ /h @ normal	
	23					
ORIFICE PLATE	25	Size and Flange Rating	12	in / ANSI 600#		
	26	Bore Diameter (d)	203.856	mm		
	27	Diameter Ratio (beta = d/D)	0.706			
	28	Material	A240 Tp.316/316L			
	29	Thickness	6 mm			
	30	Ring Material and Type	- / -			
	31	Drain or Vent Hole	Drain			
32	Diff. Pressure at Full Scale	1250 mmH2O				
33	Permanent Pressure Loss @ Max		0.0292	kgf/cm ²		
ORIFICE FLANGES	34	Type	Flange Tapping			
	35	Size, Rating and Facing	12	in / ANSI 600#	WN-RF	
	36	Flange Face Finish	125 - 250 micro inch			
	37	Flange Material	A105			
	38	Bolts and Nuts Material	A193GR.B7 / A194 Cl.2H			
	39	Gasket Material	SS 316 Spiral Wound + Graphite,IR- SS316, OR- LCS			
	40	Jack Screw Material	A193GR.B7			
	41	Nipple Type and Material for Press. Tap	1/2" NPT (M) x PE	/ A105 / SCH 80		
42	Pressure Taps Size and Orientation	1/2" NPT (2 sets)	/ 45 deg. up			
METER RUN	44	Upstream Length / Downstream Length	- / -			
	45	Material / End Connection	- / -			
	46					
PURCHASE	47	Manufacturer	EUROMISURE			
	48	Model				
Notes: 1) Vendor to provide 100 mm - 1 no. & 180 mm - 1 no. type A nipple						
Remarks:						
		2	SAG	5/13/2014	AAB SDN	Revised as per 3D Model

Figure 28-6. Example FMD Data Sheet

Ref 5: Anti-surge Valve Test Desired Response

Table 28-1. ASV Test Parameters

Serial No	Functions	Desired Response
1	Valve step open stroke time from 0%-100%	~ 2 seconds
2	Valve step closing stroke time from 100%-0%	< 4 seconds
3	Maximum Overshoots	< 1 %
4	Undershoots	None
5	Min. current to start opening valve from 0%	> 19.7 mA
6	Max. current to start closing valve from 100%	< 4.8 mA
7	Hysteresis	< 0.5%
8	Current fail	Immediate open
9	Instrument Air Fail	Immediate open

Chapter 29.

Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact the manufacturer or packager of your system.
- Contact the Woodward Full Service Distributor serving your area.
- Contact Woodward technical assistance (see “How to Contact Woodward” later in this chapter) and discuss your problem. In many cases, your problem can be resolved over the phone. If not, you can select which course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.

A current list of Woodward Business Partners is available at:

<https://www.woodward.com/en/support/industrial/service-and-spare-parts/find-a-local-partner>

Product Service Options

The following factory options for servicing Woodward products are available through your local Full-Service Distributor or the OEM or Packager of the equipment system, based on the standard Woodward Product and Service Warranty (Woodward North American Terms and Conditions of Sale 5-09-0690) that is in effect at the time the product is originally shipped from Woodward or a service is performed:

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is a flat-rate program and includes the full standard Woodward product warranty (Woodward North American Terms and Conditions of Sale 5-09-0690).

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned within 60 days, a credit for the core charge will be issued.

Flat Rate Repair: Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty (Woodward North American Terms and Conditions of Sale 5-09-0690) on replaced parts and labor.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in "like-new" condition and carry with it the full standard Woodward product warranty (Woodward North American Terms and Conditions of Sale 5-09-0690). This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:

- Return authorization number
- Name and location where the control is installed
- Name and phone number of contact person
- Complete Woodward part number(s) and serial number(s)
- Description of the problem
- Instructions describing the desired type of repair

Packing a Control

Use the following materials when returning a complete control:

- Protective caps on any connectors
- Antistatic protective bags on all electronic modules
- Packing materials that will not damage the surface of the unit
- At least 100 mm (4 inches) of tightly packed, industry-approved packing material
- A packing carton with double walls
- A strong tape around the outside of the carton for increased strength

NOTICE

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Replacement Parts

When ordering replacement parts for controls, include the following information:

- The part number(s) (XXXX-XXXX) that is on the enclosure nameplate
- The unit serial number, which is also on the nameplate

Engineering Services

Woodward offers various Engineering Services for our products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact. Emergency assistance is also available during non-business hours by phoning Woodward and stating the urgency of your problem.

Product Training is available as standard classes at many of our worldwide locations. We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from many of our worldwide locations or from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact one of the Full-Service Distributors listed at:

<https://www.woodward.com/en/support/industrial/service-and-spare-parts/find-a-local-partner>

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory at <https://www.woodward.com/support>, which also contains the most current product support and contact information.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can receive information and service.

Products Used in Electrical Power Systems	
Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 8818 5515
Germany	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 (12) 295 13 00
United States	+1 (970) 482-5811

Products Used in Engine Systems	
Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 8818 5515
Germany	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
United States	+1 (970) 482-5811

Products Used in Industrial Turbomachinery Systems	
Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 8818 5515
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+ 82 (51) 636-7080
Poland	+48 (12) 295 13 00
United States	+1 (970) 482-5811

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number _____

Prime Mover Information

Manufacturer _____

Turbine Model Number _____

Type of Fuel (gas, steam, etc.) _____

Power Output Rating _____

Application (power generation, marine,
etc.) _____

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Control/Governor #2

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Control/Governor #3

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Symptoms

Description _____

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Revision History

Revision A—

- Re-numbered all figures
- Replaced Figures 20-13, 20-14, 20-18, 20-27, 20-28, 20-44, 20-45, 20-46, 20-47, 20-49, 20-58, 20-59, and 20-64
- Revised Train Configuration and Train Parameters content
- Revised ASC1 Sequencing Online Detection content
- Revised Surge Test content

Revision-

- New manual
Author: Vinai Misra
Date: April 2018

We appreciate your comments about the content of our publications.

Send comments to: industrial.support@woodward.com

Please reference publication **35072V3**.



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Complete address / phone / fax / email information for all locations is available on our website.