

C-PAC Control Philosophy Overview

1. Overview

The C-PAC system consists of a control panel rated for Class 1 Zone II installations including the controller, color touch screen HMI and associated Allen Bradley Compactlogix based controller and I/O modules. This document describes the control philosophy for the C-PAC where the driven equipment is a reciprocating compressor.

The C-PAC is a complete shutdown and control system capable of monitoring a wide range of end devices on the engine / compressor unit and controls the lube oil system, engine crank, ignition, fuel valve, engine speed, suction valve, recycle valve and blowdown valve. Standard C-PAC logic includes the following:

- Start Sequencing
- Shutdown Sequencing
- Load / Unload Sequencing
- Alarm and Shutdown generation and logging

The standard PID control loops provided are to control Inlet suction pressure, Engine speed, Minimum suction (recycle) and Maximum discharge (recycle). Optional PID control loops are available for Manifold pressure override, Engine jacket water temperature override, Engine oil temperature override, compressor oil temperature override and cooler louver controls.

The C-PAC touch screen HMI provided manual control for maintenance purposes. These include manual engine crank and manual lube pump controls.

2. Start Sequence

The C-PAC system provides start sequencing to bring the engine and compressor to a “Ready to Load” state. This start sequence can only be engaged when all shutdowns are cleared and the unit is in a “Ready to Start” state. Each step of the start sequence is monitored and there is indication if the sequence step has failed to complete. The sequence is described as follows:

- 1) **COMPRESSOR DEPRESSURIZE:** the blowdown valve is opened until the suction pressure is lowered to a predetermined and adjustable set point.
- 2) **PRE-LUBE:** the engine and compressor pre-lube pump is run until the adjustable lube oil pressure permissives are achieved and the minimum pre-lube timer has expired.
- 3) **ENGINE CRANK:** the starter crank solenoid is operated and continues to operate until the crank termination speed permissive has been reached. There is a built in engine purge crank duration timer to ensure the engine cylinders are depleted of any unspent fuel.
- 4) **IGNITION / FUEL:** once the engine purge timer has completed in the crank sequence, the ignition module is energized. Two seconds after the ignition is energized, the fuel valve solenoid is energized.
- 5) **WARM-UP:** the engine speed is ramped to the predetermined and adjustable idle speed and is held at this speed until pre-configured warm-up temperatures are achieved. These temperatures can be either or all of the following, Engine jacket water temp, engine oil temp, compressor oil temp. There is also an adjustable minimum warm-up timer that needs to complete to advance to the ready to load state.
- 6) **READY TO LOAD:** the C-PAC will by default automatically start the load sequence once the warm-up sequence is complete. This automatic feature can be disabled via the HMI in which case the engine will remain at idle speed until the load sequence is manually engaged via an HMI pushbutton.

3. LOAD / UNLOAD SEQUENCE

Once the C-PAC system is in the “Ready to Load” sequence, the load command is either automatically or manually engaged depending on the Autoload mode selector. The load sequence is described as follows:

- 1) **ACCEL TO MINIMUM LOAD SPEED:** the engine speed control PID loop set point is ramped to the predetermined and adjustable minimum load speed.
- 2) **INITIATE LOADING:** the minimum suction and maximum discharge PID loops are placed in auto and the engine speed and recycle valves signals are operated based on the low selected output of these two loops.
 - a) the low select output of these loops are split ranged to the speed and recycle signals in one of two fashions. The engine speed is ramped to maximum load speed first then the recycle valve is closed or the recycle valve can operate first then the engine speed. This is determined via the split range limits which are adjustable via the HMI.
- 3) **ONLINE:** the engine / compressor unit is considered to be online once the minimum load speed has been achieved and the minimum suction and maximum discharge PID loops have been activated. The C-PAC will automatically operate the engine speed and recycle valve based on desired process conditions and an alarm can be activated if the unit has been running and on recycle for a predetermined amount of time.
- 4) **UNLOAD:** the engine / compressor will automatically unload as part of a normal shutdown sequence or when an unload command is issued via the HMI. The recycle valve will open and the engine speed will be decreased to the minimum load speed set point, again this can be reversed based on the split range selections.
- 5) **COOLDOWN:** as part of a normal shutdown, the engine / compressor is unloaded then the engine is set to idle speed for a predetermined amount of time adjustable via the HMI. Once this time has expired, the ignition and fuel valve will be de-energized to bring the unit to a stop.

4. SHUTDOWN SEQUENCING

The C-PAC system monitors a wide range of end devices on the engine / compressor unit. Based on data and signals from these devices, the C-PAC will automatically generate alarms or shutdowns in certain states from discrete devices and set points from analog devices.

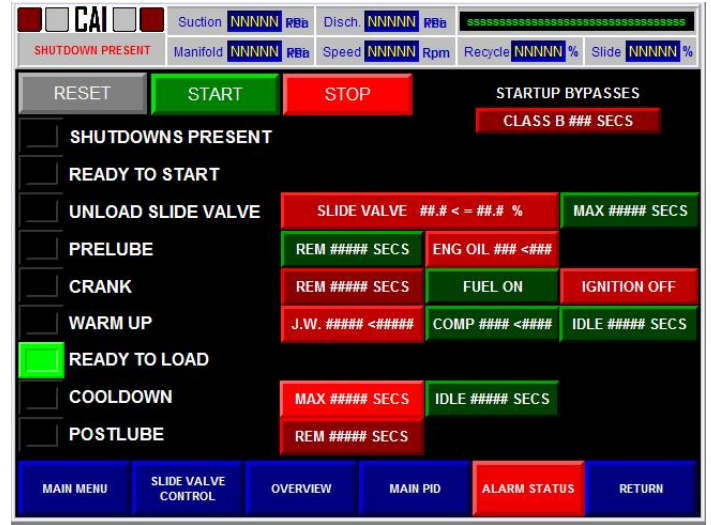
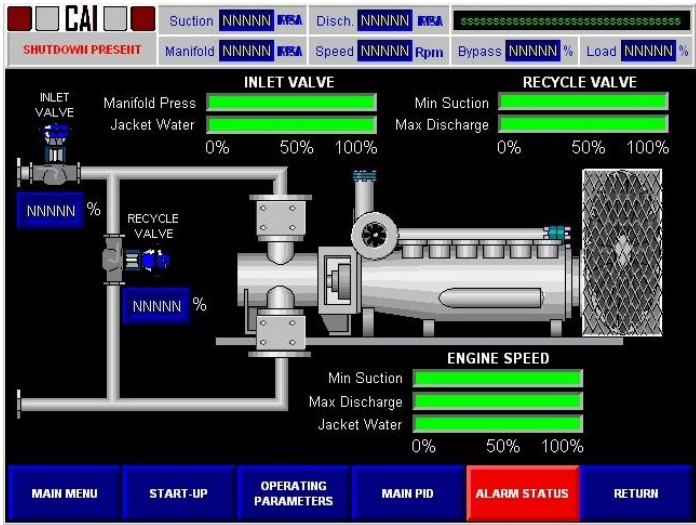
Alarms are provided to indicate problems that should be addressed when process variables have reached predetermined set points but will not cause the engine / compressor unit to be shutdown. Shutdowns are provided to protect the engine / compressor unit from damage or unsafe conditions based on data from the end devices.

Shutdowns can also be initiated manually from the HMI, ESD pushbutton on the panel, or customer ESD / USD contacts from the facility control system.

Alarms and Shutdowns are armed depending on their class. The following classes are supported and described as follows:

- Class A: Always armed
- Class B: Armed after the unit is running and the Class B timer has expired. The Class B timer is adjustable.
- Class b: Armed after the unit is running and the Class b timer has expired. The Call b timer is adjustable and is typically shorter in duration than the Class B timer.
- Class C: Armed after the unit is running and the low alarm set point has been satisfied or cleared.

C-PAC Reciprocating engine and compressor control screens



Reciprocating/Screw Compressor control

Compactlogix L-32E

- 750 KB of Memory
- 1 RS-232 and 1 Ethernet Communication Ports
- On-Line Programming Capabilities
- Expansion of up to 12 I/O cards (192 points)
- Variety of I/O cards (DI, DO, thermocouples, RTD, 1-5VDC or 4-20mA Analog)
- Input/Output and Gas Flow Measurement
- Class 1 DivII
- Control capabilities for Engine RPM, Recycle Valve, Engine Jacket Water,
- Discharge Gas Temperature
- One touch start-up procedure
- Remote starting
- Communication to existing plant PLC's and HMI's
- Web Access capabilities (view and/or control)



AB Panel view Plus 1000

- 10" Colour and Touch screen
- Alarm Banner
- Historical Alarm Screen
- Animation
- Historical trending capabilities
- Data Logging
- RS-232 Communication to Compactlogix
- Class 1 DivII
- Complete Set of Panel drawings and Shutdown Key



Refrigeration Control Panel

Compactlogix L-31

- 512 KB of Memory
- 2 RS-232 Communication Ports
- On-Line Programming Capabilities
- Class 1 DivII
- Expansion of up to 4 cards (80 points)



AB Panelview Plus 600

- 6" Colour and Touch screen
- Alarm Banner
- Historical Alarm Screen
- Animation
- Historical trending capabilities
- Data Logging
- RS-232 Communication to Compactlogix
- Class 1 DivII
- Complete Set of Panel drawings and Shutdown Key



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