



OPERATION MANUAL

Priority / Sequential Slow Fill

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PRIORITY PANEL: SEQUENCE OF OPERATION

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- ❖ Default user name: TGT
- ❖ Default password/PIN: 4809

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TYPE OF SYSTEM

The PLC is an IDEC FC6A-C24P1CE system monitoring output line pressures, ambient temperatures, and valve control based on user defined settings. Information is displayed to local 4.3" IDEC HG1G Series HMI touch displays. All user configurable variables can be entered into the PLC via the local HMI touch display. The panel is powered by a customer supplied 120vac. Throughout this sequence the controller is referred to as PLC.

SPECIAL PROVISIONS

The PLC outputs can be forced via the **HMI: Unit Config -> Maintenance** screen.

Password protection exists on all set points

The power for all relays is tied into the site ESD loop.

UNIT OPERATIONS

PRIORITY - The unit is started manually via the local start pushbutton or the HMI start pushbutton while the panel selection switch is in the "RUN" position.

SLOW FILL - The unit is started automatically via a call to start from the storage bank while the panel selection switch is in the "RUN" position.

SEQUENTIAL SLOW FILL (Optional add-on)

PLC I/O FORCING (MAINTENANCE MODE)

Once the **MAINTENANCE MODE SCREEN** is selected all running processes will be stopped. Leaving the **MAINTENANCE MODE SCREEN** will automatically disable all forces and return the unit to a normal functioning state. While the unit is in a non-ESD shutdown state and the **MAINTENANCE MODE SCREEN** is active the operator has the ability to manually force on/off all relevant digital outputs via the HMI.

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POWER UP AND READY TO START

When the Power to the panel is on the PLC will power up. Once booted the PLC will scan all inputs and the local HMI will display any alarms or shut downs that may exist. After the operator has corrected all shutdown conditions the PLC will initiate the currently selected fill mode

The startup states are as follows:

- ESD Remote loop = Energized (De-energized on ESD activation)
- Unit Fault Indicator = De-Energized (Energized when in fault condition)
- Unit/Station Healthy Status Indicator = Energized (De-energized when not healthy)
- ESD / Flow valve = Energized (Opened, Closed on fault))
- High Bank Priority solenoid valve = De-Energized (Closed)
- Mid Bank Priority solenoid valve = De-Energized (Closed)
- Low Bank Priority solenoid valve = De-Energized (Closed)
- Slow-Fill solenoid valve (Low) = De-Energized (Closed)
- Slow-Fill solenoid valve (Mid) = De-Energized (Closed)
- Slow-Fill solenoid valve (High) = De-Energized (Closed)

STORAGE FILLING SEQUENCE

The controller will maintain minimum pressures in each bank. Set points are provided for fill start and full stop for each of storage bank. Slow-fill is handled in the same way, except its starts are locked out until the user defined time windows is active. The slow-fill start will be allowed until the time window is no longer active.

During the user defined permitted time windows slow-fill will have the highest priority.

Once the PLC has energized the RUN SIGNAL relay (dry contact) , the PLC will energize the corresponding solenoid valve to the bank whose pressure is below its start pressure to begin filling the bank.

The demand offset set points for high, mid, and low banks should be of value ranging from smallest offset to largest because storage filling should be high bank first, then the mid bank, and lastly the low bank. slow fill, when enabled, can supersede high bank within the user defined time window otherwise it will fill after low bank.

Check valves should be installed downstream of the solenoid/actuator valves to prevent the banks from equalizing during the fill process. however, the storage banks will equalize pressures once the low bank is near the temperature compensated stopping pressure.

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STORAGE PRIORITY SETUP [UNIT CONFIG] [STORAGE *** BANK SETUP]

when any bank has a run status set to run on demand and its pressure is below demand pressure then a fill cycle begins. once a fill cycle has started the following behavior is in effect.

- ❖ **[TCR]: Temperature Compensation Reference** *Pressure:* Base temperature compensation pressure (Typical 3600psi). *Temperature:* Base temperature compensation temperature (Typical 70°F)
 - ❖ **[TEC]: Thermal Expansion Compensation %** This setting is the allowable over-fill percentage to compensate for the reduced volume from gas cooling
 - ❖ **[MCP/MTP]: Maximum Compensated Pressure/Maximum Target Pressure** This controls the absolute maximum temperature compensated pressure allowed regardless of all other factors. In essence clipping the algorithms maximum value.
 - ❖ **[DTD]: Demand Target Dead Band** This setting defines the offset from target pressure that establishes the demand pressure. (-100 to -2500; Typical -500)
 - ❖ **[PD]: Prioritizing Dead band** This establishes when the bank is re-prioritized after reaching target pressure. (-10 to -500; Typical -100)
 - ❖ **[MP]: Max Pressure** A defined pressure that will cause a system fault and shutdown if exceeded.
 - ❖ **[BANK STATUS] Disabled / Enabled** Enables or disables the fill bank function and removes it from priority.
 - ❖ **[RUN STATUS] Never Run/Run on Demand** The setting to allow a start command to be issued when demand is called (There must be at least one defined to start the bank filling process).
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- **SLOW FILL:** When slow fill is enabled and within the user define permitted time window it has priority above storage. If a hose in use signal is active then its priority is temporarily suspended in favor of storage. outside of the define time window slow fill has the lowest priority.
 - **HIGH BANK:** If high-bank pressure is below target pressure then the high bank valve (solenoid/actuator) will be energized (opened).
if slow fill is within the user define permitted time window, high bank is being filled, and the slow fill pressure drops below its final target pressure plus its prioritizing dead-band setting, then all bank valves (solenoids/actuators) will be de-energized (closed) to allow the compressor to fill the slow fill line.
 - **MID BANK:** If high-bank pressure is greater than its target pressure and mid-bank pressure is below its target pressure then the mid-bank valve (solenoid/actuator) will be

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energized (opened). If mid-bank is being filled and high-bank pressure drops below its target pressure plus its prioritizing dead-band setting, then the mid-bank valve (solenoid/actuator) will be de-energized (closed) to prioritize the filling of higher priority storage.

- **LOW BANK:** If high-bank and mid-bank pressures are greater than their target pressures and low-bank pressure is below its target pressure then the low-bank valve (solenoid/actuator) will be energized (opened). If low-bank is being filled and high-bank or mid-bank pressure drops below their target pressure plus its prioritizing dead-band setting, then the low bank valve (solenoid/actuator) will be de-energized (closed) to prioritize the filling of higher priority storage.

SLOW FILL MODES AND CONFIGURATIONS [UNIT CONFIG] [SLOW FILL LINE SETUP]

- ❖ **[TCR]: Temperature Compensation Reference** *Pressure:* Base temperature compensation pressure (Typical 3600psi). *Temperature:* Base temperature compensation temperature (Typical 70°F)
- ❖ **[TEC]: Thermal Expansion Compensation %** This setting is the allowable over-fill percentage to compensate for the reduced volume from gas cooling
- ❖ **[MCP/MTP]: Maximum Compensated Pressure/Maximum Target Pressure** This controls the absolute maximum temperature compensated pressure allowed regardless of all other factors. In essence clipping the algorithms maximum value.
- ❖ **[DTD]: Demand Target Dead Band** This setting defines the offset from target pressure that establishes the demand pressure. (-100 to -2500)
- ❖ **[MP]: Max Pressure** A defined pressure that will cause a system fault and shutdown if exceeded.
- ❖ **[VPT/PT]: Valve Permitted Time/Permitted Time** User settable start and stop times that define a start window when there is a demand call.
- ❖ **[SF STATUS] Disabled / Enabled** Enables or disables the slow-fill function.
- ❖ **[RUN STATUS] Never Run/Run on Demand** The setting to allow a start command to be issued when demand is called (There must be at least one defined to start the bank filling process).

There are 2 modes of slow-fill available, **Direct + Low** and **Sequential Fill**. set points are provided for fill start and full stop. Slow-fill starts are locked out until the user defined time windows is in effect. The slow-fill start and stop will be allowed until the time window has expired.

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DIRECT + LOW [DASHBOARD] [UNIT CONFIG] [SLOW FILL LINE SETUP] [SEQUENCING]

In this mode when there is a demand call on the slow-fill line the low bank/slow-fill valve energized.

SEQUENTIAL FILL [DASHBOARD] [UNIT CONFIG] [SLOW FILL LINE SETUP] [SEQUENCING]

This mode is based on TCR (Temperature Compensation Reference) pressure. There are 2 modes of slow-fill available

- **SLOW FILL LOW BANK** When demand is called on the slow-fill line the slow fill low-bank/delivery solenoid is energized, thus permitting gas to flow. The minimum **valve open duration** timer starts anew at the beginning of solenoid energizing. Once the minimum **valve open duration** timer expires if pressure is above temperature compensation adjusted **low-bank to mid-bank sequencing pressure** then the valve is closed to stabilize the pressure and re-evaluate the slow-fill lines pressure status.

If the pressure is found to be below 90% of the temperature compensation adjusted **low-bank to mid-bank sequencing pressure** the minimum valve open duration is incremented upwards by the minimum setting itself. If the pressure is equal to or greater than 90% of the temperature compensation adjusted **low-bank to mid-bank sequencing pressure** the minimum valve open duration equals its initial setting. The valve is then re-opened and the process and the timer begins again.

Once the temperature compensation adjusted **low-bank to mid-bank sequencing pressure** is reached during evaluation or the current bank is unable to deliver gas to the temperature compensation adjusted **low-bank to mid-bank sequencing pressure** then the sequence moves to the next bank.

- **SLOW FILL MID BANK** This solenoid is energized when all low bank conditions have been satisfied and Final Target pressure has not been reached. The slow fill low-bank/delivery solenoid is energized, thus permitting gas to flow. The minimum **valve open duration** timer starts anew at the beginning of every solenoid energizing. Once the minimum **valve open duration** timer expires if pressure is above temperature compensation adjusted **mid-bank to high-bank sequencing pressure** then the valve is closed to stabilize the pressure and re-evaluate the slow-fill line pressure status.

If the pressure is found to be below 90% of the temperature compensation adjusted **mid-bank to high-bank sequencing pressure** the minimum valve open duration is incremented upwards by the minimum setting itself. If the pressure is equal to or greater than 90% of the temperature compensation adjusted **mid-bank to high-bank sequencing pressure** the minimum valve open duration equals its initial setting. The

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valve is then re-opened and the process and the timer begins again.

Once the temperature compensation adjusted **mid-bank to high-bank sequencing pressure** is reached during evaluation or the current bank is unable to deliver gas to the temperature compensation adjusted **mid-bank to high-bank sequencing pressure** then the sequence moves to the next bank.

- **SLOW FILL HIGH BANK** This solenoid is energized when all low bank and mid bank conditions have been satisfied and Final Target pressure has not been reached. The slow fill low-bank/delivery solenoid is energized, thus permitting gas to flow. The minimum **valve open duration** timer starts anew at the beginning of every solenoid energizing. Once the minimum **valve open duration** timer expires if pressure is above **TEC% adjusted target pressure** then the valve is closed to stabilize the pressure and re-evaluate the slow-fill line pressure status.

If the pressure is found to be below 90% of the **TEC% adjusted target pressure** the minimum valve open duration is incremented upwards by the minimum setting itself. If the pressure is equal to or greater than 90% of the **TEC% adjusted target pressure** the minimum valve open duration equals its initial setting. The valve is then re-opened and the process and the timer begins again.

Once the **TEC% adjusted target pressure** is reached during evaluation or the current bank is unable to deliver gas to the **TEC% adjusted target pressure** then the sequence is ended

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FAULT HANDLING AND SHUTDOWNS

Priority System

Exceeded Max Pressure: Any bank pressure reached higher than the user defined maximum for that bank.

Transmitter out of range: Any banks transmitters value is less than 3.84mA or greater than 20.4mA.

If a shutdown condition occurs, the following conditions will be provided:

- ESD Remote loop = Energized (De-energized on ESD activation)
- Unit Fault Indicator = Energized (Energized when in fault condition)
- High Bank solenoid valve = De-Energized (Closed)
- Mid Bank solenoid valve = De-Energized (Closed)
- Low Bank solenoid valve = De-Energized (Closed)

Slow Fill System

Exceeded Max Pressure: Any bank pressure reached higher than the user defined maximum for that bank.

Transmitter out of range: Any banks transmitters value is less than 3.84mA or greater than 20.4mA.

If a shutdown condition occurs, the following conditions will be provided:

- ESD Remote loop = Energized (De-energized on ESD activation)
- Unit Fault Indicator = Energized (Energized when in fault condition)
- High Bank Slow-fill solenoid valve = De-Energized (Closed)
- Mid Bank Slow-fill solenoid valve = De-Energized (Closed)
- Low Bank Slow-fill solenoid valve = De-Energized (Closed)

Control System

- Unit/Station Healthy Status = De-Energized when both priority system and slow fill systems have active faults
- ESD / Flow valve = De-Energized on ESD activations or over-pressure condition.

Ambient Temperature Thermocouple failure will default the system to 0

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The HMI will indicate the shutdown condition on the dashboard page.

Once the fault shutdown condition has been corrected and the operator has pressed the **RESET** HMI pushbutton, the PLC will advance to a **STATUS OK** state and will wait for a demand call.

TEMPERATURE COMPENSATION

The below Formula used to derive the temperature compensated **FINAL TARGET** pressures for and **SLOW-FILL**.

$$P_T = (((T - 70) * 16.6) + P_S)$$

$$P_O = P_T * (1 + (F / 100))$$

$$\text{If } (P_O > P_m) \text{ then } \{ P_{\text{Final}} = P_m \} \text{ else } \{ P_{\text{Final}} = P_O \}$$

- P_t = **TARGET** pressure
- P_r = **Temperature Compensation Reference** pressure
- P_O = Target with **Thermal Expansion Compensation percentage** applied
- P_{Final} = **FINAL TARGET** pressure with **Maximum Target Pressure** applied
- T = Ambient Temperature in degrees Fahrenheit
- F = Thermal Expansion Compensation percentage
- P_m = Maximum Target Pressure

If $P_{\text{Final}} > P_m$ then $P_{\text{Final}} = P_m$.

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IO PLC Reference

OUTPUT IO List

PLC OUTPUT CHANNELS	DESCRIPTION
Q00	High Bank Priority solenoid
Q01	Mid Bank Priority solenoid
Q02	Low Bank Priority solenoid
Q03	ESD Output
Q04	Sequential Slow-fill Low Bank solenoid /Single Slow-Fill solenoid
Q05	Sequential Slow-fill Mid Bank solenoid
Q06	Sequential Slow-fill High Bank solenoid
Q07	Compressor Run Signal (Dry contact)
Q10	Fault LED (Red)
Q11	Unit Status LED (Green)
PLC INPUT CHANNELS	DESCRIPTION
I00	Local ESD
I01	Remote ESD
I02	unused
I03	Dispenser in use
I04	unused
I05	unused
I06	unused
I07	unused
I10	unused
I11	unused
ANALOG MODULE	DESCRIPTION
A00	TRANSDUCER – High Bank (4-20ma,0-10kpsi)
A01	TRANSDUCER – Mid Bank (4-20ma,0-10kpsi)
A02	TRANSDUCER – Low Bank (4-20ma,0-10kpsi)
A03	TRANSDUCER – Slow fill (4-20ma,0-10kpsi)
A04	TRANSDUCER – COMPRESSOR 1: DISCHARGE PRESSURE
A05	TRANSDUCER – COMPRESSOR 2: DISCHARGE PRESSURE
A06	Unused
A07	GLOBAL: AMBIENT TEMPERATURE PROBE
THEROCOUPLE ANALOG	DESCRIPTION
TC00	THERMOCOUPLE – Ambient Temperature (type K)
TC01	Unused

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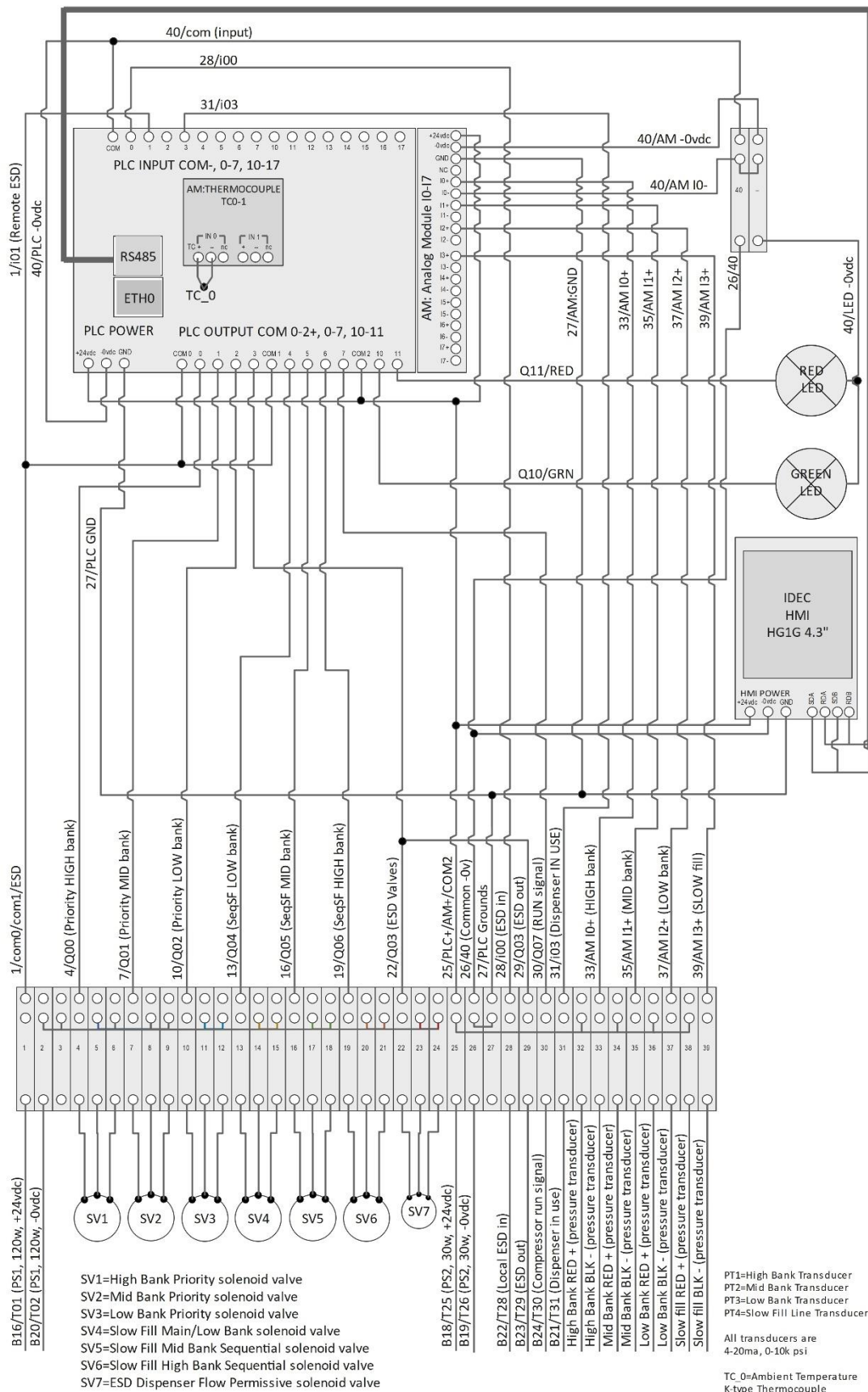
TECHNICIANS NOTES:

#	HIGH BANK SETTINGS	FACTORY	SETPOINT
01	TRC: Temperature compensation reference [Pressure]	3600	
02	TRC: Temperature compensation reference [Temperature]	70	
03	TEC%: Thermal Expansion Compensation Percentage	5.0	
04	MCP: Maximum Target Pressure	4320	
05	DTD: Demand Target Dead band	-500	
06	PD: Prioritizing Dead band	-100	
07	MP: Max Pressure	4450	
08	Bank Status	ENABLED	
09	Run Status	DEMAND	
#	MID BANK SETTINGS	FACTORY	SETPOINT
10	TRC: Temperature compensation reference [Pressure]	3600	
11	TRC: Temperature compensation reference [Temperature]	70	
12	TEC%: Thermal Expansion Compensation Percentage	5.0	
13	MCP: Maximum Target Pressure	4320	
14	DTD: Demand Target Dead band	-500	
15	PD: Prioritizing Dead band	-100	
16	MP: Max Pressure	4450	
17	Bank Status	ENABLED	
18	Run Status	NEVER	
#	LOW BANK SETTINGS	FACTORY	SETPOINT
19	TRC: Temperature compensation reference [Pressure]	3600	
20	TRC: Temperature compensation reference [Temperature]	70	
21	TEC%: Thermal Expansion Compensation Percentage	5.0	
22	MCP: Maximum Target Pressure	4320	
23	DTD: Demand Target Dead band	-500	
24	PD: Prioritizing Dead band	-100	
25	MP: Max Pressure	4450	
26	Bank Status	ENABLED	
27	Run Status	NEVER	
#	SLOW FILL SETTINGS	FACTORY	SETPOINT
28	TRC: Temperature compensation reference [Pressure]	3600	
29	TRC: Temperature compensation reference [Temperature]	70	
30	TEC%: Thermal Expansion Compensation Percentage	5.0	
31	MCP: Maximum Target Pressure	4320	
32	DTD: Demand Target Dead band	-500	
33	PD: Prioritizing Dead band	-100	
34	MP: Max Pressure	4450	
35	VPT: Permitted Time (Start Hour)	1	
36	VPT: Permitted Time (Stop Hour)	1	
37	Bank Status	ENABLED	

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38	Runs Status	DEMAND	
#	SEQUENTIAL SLOW FILL SETTINGS	FACTORY	SETPOINT
39	MID BANK to HIGH BANK Sequencing pressure	3240	
40	LOW BANK to MID BANK Sequencing pressure	2520	
41	VOD: Valve Open Duration (Minimum)	30	
42	VOD: Valve Open Duration (Maximum)	120	
43	OP MODE	SEQUENCE	

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