EPCIC

TOPSIDE INTERFACE STRUCTURE

CONDENSATE METERING PACKAGE - FUNCTIONAL DESIGN SEPCIFICATION - TT2220JM001

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HOLD RECORD

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1 INTRODUCTION

1.1 Overview

This document describes the electronics scope of supply i.e. computer, software, panel hardware and network for the condensate metering system.

The condensate metering system comprises of four 33% Coriolis metering streams, a Coriolis master meter and a dual can sampling system. The system shall provide uni-directional batch metering of the condensate liquid.

Each of the four metering streams is equipped with a liquid Coriolis meter, a flow control valve, dual temperature transmitters and dual pressure transmitters. Each stream has a motor operated inlet, outlet and prover valve. The outlet and prover valves are fitted with automatic leak detection. Each of the four streams can be aligned and proved against the Coriolis master meter.

Each of the four condensate metering streams is equipped with a dedicated FloBoss S600+ flow computer configured with a single stream liquid Coriolis application.

Description	Flow Computer Tag Number
Condensate Metering Stream 01	TT2220FQI3511
Condensate Metering Stream 02	TT2220FQI3521
Condensate Metering Stream 03	TT2220FQI3531
Condensate Metering Stream 04	TT2220FQI3541

The master meter stream is equipped with a liquid Coriolis meter, a flow control valve, dual temperature transmitters, dual pressure transmitters and a motor operated outlet valve with automatic leak detection.

The sampling and analysis system consists of dual densitometers, dual watercut meters, dual temperature transmitters, a RVP analyser, a TVP analyser, dual pressure transmitters, dual cell samplers and dual sample receivers with level transmitters. Dual sampler pumps, dual inlet filter differential pressure transmitters and a single VA meter are provided. A manual sampling system will be provided.

A single Floboss S600+ flow computer provides the master meter and sampling capabilities.

Description	Flow Computer Tag Number
Master Meter Stream and Sampler	TT2220FQI3551

The S600+ flow computers are complemented with an Emerson Metering Suite supervisory system which shall offer the following system functionality:

- Two engineering workstations operating redundantly.
- Flow Computer Communication via Primary and Secondary Networks.
- Monitoring of Process Variables
- Graphical Mimics for Streams, Batching, Master Meter and Sampler System
- Current, Hourly, Daily, Provisional Batch, Final Batch and Proof Reports
- Local Historical Storage
- Historical Trending
- Batch Control
- User interface to allow modification of S600+ Flow Computer Process Parameters
- Redundant Modbus TCP links to the ICSS
- Full Alarm Annunciation, including Alarm Diagnostics, Suppression and Delay Capabilities
- Full Audit Trail for Alarms and Events
- Full Security System
- Flow Computer Time Synchronisation

The flow computer is the fiscal point of measurement in the event of a dispute.

1.2 Referenced Documents

The table below lists the documents and drawings referenced in the development of this document:

Document No.	Rev.	Document Title
4404GGBISF0010T	EX-DE_02	Supply Specification for Metering Systems
4404GGBISG0007T	EX-DE_02	General Specification for Instrumentation for Packaged Systems
4404GGBIGA0013T	EX-DE_02	Technical Data Sheets for Metering Systems
4404GGBISF0044T	EX-DE_01	Metering Philosophy
4424TTDIFC001DE	EX-DE_02	Control and Logic Diagrams
4424TTDITB002DE	EX-DE_01	System Cards I/O Assignment
4424TTDIFB001DE	EX-DE_02	System Architecture Diagram
4424TTDIDP001DE	EX-DE_03	Piping and Instrument Diagram
4424TTDIDA003DE	EX-DE_03	Arrangement Drawings for Panels
4424TTDIFL001DE	EX-DE_03	Junction Boxes, Panels and Loop Wiring Diagram

Table - Referenced Documents

1.3 Definitions

Throughout this document, the words ‘should’, ‘may’, ‘shall’ and ‘must’ when used in the context of action by the system user have specific meanings as follows:

shall/must	-	indicates a mandatory operation
may	-	indicates a possible course of action
should	-	indicates a preferred course of action

The following list of abbreviations are used through the document:

Abbreviation	Description
AC	Alternating Current
ADC	Analogue to Digital Convertor
AO	Analogue Output
API	American Petroleum Institute
BSW	Base Sediment and Water
CB	Circuit Breaker
CCF	Combined Correction Factor
CCR	Central Control Room
CFMS	Condensate Flow Metering System
CPU	Central Processing Unit
CVOL	Corrected Volume
DAC	Digital to Analogue Convertor
DC	Direct Current
DCS	Distributed Control System
DI	Digital Input
DO	Digital Output
DP	Differential Pressure
DPIT	Differential Pressure Indicating Transmitter
DPT	Differential Pressure Transmitter
DT	Densitometer
ESD	Emergency Shutdown
ESW	Ethernet Switch
EWS	Engineering Workstation
FAT	Factory Acceptance Test
FC	Flow Computer
FCV	Flow Control Valve
FDS	Functional Design Specification
FLNG	Floating Liquefied Natural Gas
FR	Flow Rate
FT	Flow Transmitter
FWA	Flow Weighted Average
HART	Highway Addressable Remote Transducer

Abbreviation	Description
HMI	Human Machine Interface
ICSS	Integrated Control and Safety System
IFAT	Integrated Factory Acceptance Test
I/O	Input / Output
IP	Institute of Petroleum
IS	Intrinsically Safe
ISO	International Standards Association
ITR	Instrument Technical Room
KF	K-Factor
KP	Keypad
LAN	Local Area Network
LQ	Living Quarters
MA	Milliamp
MF	Meter Factor
MID	Measuring Instrument Directive
MM	Master Meter
MOV	Motor Operated Valve
MSC	Metering Supervisory Computer
NTP	Network time Protocol
OLE	Object Link Embedding
OPC	Object Link Embedding for Process Control
PID	Proportional, Integral, Derivative
PIR	Portside Instrumentation Room
PIT	Pressure Indicating Transmitter
PT	Pressure Transmitter
PSU	Power Supply Unit
PV	Process Variable
PV	Primary Variable (HART)
QCR	Living Quarters Computer Room
RAM	Random Access Memory
RO	Read Only
ROM	Read Only Memory
RVP	Reid Vapour Pressure
RW	Read Write
S600+	Emerson S600+ Flow Computer
SAT	Site Acceptance Test
SP	Setpoint
TBA	To be Advised
TBC	To be Confirmed
TCP	Transmission Control Protocol
TIT	Temperature Indicating Transmitter
TPS	Time Period Signal

Abbreviation	Description
TT	Temperature Transmitter
TVP	True Vapour Pressure
TWA	Time Weighted Average
VA	Variable Area
VCF	Volume Correction Factor

Table - List of Definitions/Abbreviations

1.4 Standards

The following standards are applicable to the Development FLNG condensate metering system:

Standard	Description
API	American Petroleum Institute
MPMS Chapter 4	Proving Systems
MPMS Chapter 5.6	Measurement of Liquid Hydrocarbons by Coriolis Meters
MPMS Chapter 6	Metering Assemblies
MPMS Chapter 8	Sampling
MPMS Chapter 11.1	Temperature and Pressure Volume Correction Factors for Generalised Crude Oils, Refined Products and Lubricating Oils (2004), Including Addendum 1 (2007)
ISO	International Standards Organisation
ISO 6551	Petroleum Liquids and Gases – Fidelity and Security of Dynamic Measurement – cabled transmission of electric and/or electronic pulsed data (1982)
ISO 80000-1	Quantities and Units Part 1: General (2009)
ISO 3171	Petroleum Liquids – Automatic Pipeline Sampling (1988)
ISO 6551	Petroleum Liquids and Gases – Fidelity and Security of Dynamic Measurement – Cabled Transmission of electric and/or Electronic Pulsed Data (1982)
ISO 9001	Quality Systems – Model for Quality Assurance in Design/Development, Production, Installation and Servicing (2008)
ISO 90003	Guidelines for the Application of ISO 9001:2008 to Computer Software (2014)
OIML	Organisation Internationale de Metrologie Legale
OIML R 117-1	Dynamic Measuring Systems for Liquids other than Water (2007)

Table - List of Standards

1.5 Reference Conditions

The following reference conditions apply to all flow calculations:

Temperature 15°C
Pressure 1.01325 bara

1.6 Units of Measurement

Units of measurement for metering calculations will be as follows:

Description	Units	Display Resolution	Range per Stream
Gross Mass Total	t	2 decimal places	0 to 999999999 t
Gross Observed Volume Total	m^3	2 decimal places	0 to 999999999 m^3
Gross Observed Volume Total	bbl	2 decimal places	0 to 999999999 bbl
Gross Standard Volume Total	Sm^3	2 decimal places	0 to 999999999 Sm^3
Gross Standard Volume Total	Sbbl	2 decimal places	0 to 999999999 Sbbl
Net Standard Volume Total	Sm^3	2 decimal places	0 to 999999999 Sm^3
Gross Mass Flowrate	t/hr	2 decimal places	0 to 1000 t/hr
Gross Observed Volume Flowrate	m^3/hr	2 decimal places	0 to 1350 m^3/hr
Gross Observed Volume Flowrate	bbl/hr	2 decimal places	0 to 8400 bbl/hr
Gross Standard Volume Flowrate	Sm3/hr	2 decimal places	0 to 1350 Sm^3/hr
Gross Standard Volume Flowrate	Sbbl/hr	2 decimal places	0 to 8350 bbl/hr
Net Standard Volume Flowrate	Sm3/hr	2 decimal places	0 to 1350 Sm^3/hr
Temperature*	°C	2 decimal places	-10 to 100 °C
Pressure	barg	3 decimal places	0 to 50 barg
Differential Pressure	bar	3 decimal places	0 to 0.5 bar
Density	kg/m^3	3 decimal places	700 to 800 kg/m^3
Standard Density*	kg/Sm^3	3 decimal places	700 to 800 kg/m^3
K-Factor	pls/t	4 decimal places	TBA
Meter Factor	-	5 decimal places	0.9 to 1.1
CTLm	-	5 decimal places	0.9 to 1.1
CPLm	-	5 decimal places	0.9 to 1.1
CCFm	-	5 decimal places	0.9 to 1.1
CTLd	-	5 decimal places	0.9 to 1.1
CPLd	-	5 decimal places	0.9 to 1.1
Watercut	%	3 decimal places	0 to 1 %

Table - Units of Measurement

The following notes apply to values displayed at the S600+ flow computer; the S600+ has a limited set of descriptive unit types for parameters so the following will be used:

* - flow computer will display temperature in units of Deg.C and standard density in units of kg/m3.

1.7 TCP IP Addresses

The following TCP/IP addresses are used on the Development FLNG condensate metering system.

1.7.1 Metering LAN

Description	Primary		Secondary	
	IP	Subnet	IP	Subnet
Coriolis Stream 1 Flow Computer	192.168.132.1	255.255.255.0	192.168.133.1	255.255.255.0
Coriolis Stream 2 Flow Computer	192.168.132.2	255.255.255.0	192.168.133.2	255.255.255.0
Coriolis Stream 3 Flow Computer	192.168.132.3	255.255.255.0	192.168.133.3	255.255.255.0
Coriolis Stream 4 Flow Computer	192.168.132.4	255.255.255.0	192.168.133.4	255.255.255.0
Master Meter Flow Computer	192.168.132.5	255.255.255.0	192.168.133.5	255.255.255.0
Emerson Metering Suite EWS Primary	192.168.132.16	255.255.255.0	192.168.133.9	255.255.255.0
Emerson Metering Suite EWS Secondary	192.168.132.9	255.255.255.0	192.168.133.16	255.255.255.0
Emerson Metering Suite Workstation accesed from CCR	192.168.132.15	255.255.255.0	192.168.133.15	255.255.255.0
Laser Jet Printer	192.168.132.12	255.255.255.0	--	--
ADAM 6017 (CONV-101)	192.168.132.7	255.255.255.0	--	--
ADAM 6017 (CONV-102)	--	--	192.168.133.7	255.255.255.0

Table - Metering LAN IP Addresses

1.8 Serial Configuration

The following serial link setup is used on the Development FLNG condensate metering system.

1.8.1 Master Meter Flow Computer to Stream Flow Computer Communications

A Modbus serial link exists between the master meter flow computer and stream flow computers for passing data associated with master metering proving. The master meter flow computer shall act as the master on the link with the stream flow computers configured as multi-dropped slave devices. The link configuration parameters are as follows:

Description	Parameter
Protocol	Modbus RTU
Baud Rate	19200
Data Bits	8
Stop Bits	1
Parity	None
Signal Type	RS422

Table - Master Meter Flow Computer to Stream Flow Computer Serial Communications Setup

The following slave ID's are configured in the flow computers.

Description	Modbus Slave ID
Stream 1	1
Stream 2	2
Stream 3	3
Stream 4	4

Table - Flow Computer Slave ID

1.8.2 Master Meter Flow Computer to Watercut Meter Communications

A Modbus serial link exists between the master meter flow computer and each of the two watercut meters. The flow computer shall act as the master on each link with the watercut meters being the slave device. The “In Use” watercut process variable will be downloaded to the stream flow computers via the Master Meter to Stream Flow computer multidropped serial link. The link configuration parameters are as follows:

Description	Parameter
Protocol	Modbus RTU
Baud Rate	9600
Data Bits	8
Stop Bits	2
Parity	None
Signal Type	RS485

Table - Master Meter Flow Computer to Watercut Meter Serial Communications Setup

1.8.3 Master Meter Flow Computer to RVP Communications

A Modbus serial link exists between the master meter flow computer and the RVP analyser. The flow computer shall act as the master with the RVP analyser being the slave device. The link configuration parameters are as follows:

Description	Parameter
Protocol	Modbus RTU
Baud Rate	9600
Data Bits	8
Stop Bits	1
Parity	None
Signal Type	RS485
Slave Address	1

Table - Master Meter Flow Computer to RVP Analyser Serial Communications Setup

1.8.4 Master Meter Flow Computer to TVP Communications

A Modbus serial link exists between the master meter flow computer and the TVP analyser. The flow computer shall act as the master with the TVP analyser being the slave device. The link configuration parameters are as follows:

Description	Parameter
Protocol	Modbus RTU
Baud Rate	9600
Data Bits	8
Stop Bits	1
Parity	None
Signal Type	RS485
Slave Address	1

Table - Master Meter Flow Computer to TVP Analyser Serial Communications Setup

2 SYSTEM OVERVIEW

2.1 General Overview

The Metering Control System comprises of two main levels of hardware, the Emerson S600+ flow computers and the redundant Emerson Metering Suite engineering / operator workstations.

The Emerson S600+ flow computers interface directly with the field mounted transmitters and use traditional I/O to calculate flow rates and totals. The S600+ flow computers are the fiscal / custody transfer measurement point. All fiscal calculations are performed locally at the flow computer in accordance with the relevant standards and equations detailed in this document. In the event of a measurement dispute the totals at the flow computer shall be taken as the fiscally accurate values.

The Emerson Metering Suite engineering / operator workstations will host the Emerson Metering Suite servers that communicate with the Emerson S600+ flow computers, display and allow control of the metering system, generate and store metering reports and provide Modbus communications to the client ICSS.

2.2 Metering Overview

The front-end metering is performed by Emerson S600+ flow computers. The Emerson S600+ microprocessor based instrument is used to provide flow measurement and monitoring functions such as totalisation, alarm monitoring, valve monitoring and control. Field devices are monitored by the flow computers using interfaces, such as HART, digital I/O, analogue inputs, analogue outputs and Modbus serial connections. Specific details on the parameters that are monitored and the methods used can be found in the flow computers section of this document (Section-3).

The system is configured with five S600+ flow computers. Each of the four Coriolis metering streams has a dedicated S600+ flow computer. The fifth S600+ flow computer shall interface with the Coriolis master meter and fast loop sampling system to provide master meter proving, sampling and condensate analysis functionality.

Each of the four Coriolis metering streams is equipped with dual HART temperature indicating transmitters, dual HART pressure indicating transmitters and a Coriolis meter with dual pulse outputs and a HART output. Each stream has a motor operated inlet, outlet and prover valve with status and control signals. The outlet valve and prover valve have automatic leak detection with a drain solenoid and HART cavity pressure transmitter. Each stream is equipped with a FCV with analogue position and 4-20mA feedback signals.

The Coriolis master meter stream is equipped with dual HART temperature indicating transmitters, dual HART pressure indicating transmitters and a Coriolis meter with dual pulse outputs and a HART output. The master meter stream has an outlet valve with status, control and automatic leak detection with a drain solenoid and a HART cavity pressure transmitter. The master meter stream is equipped with a FCV with analogue position and 4-20mA feedback signals.

The flow computer will read the primary HART variable and the second status byte from each of the HART transmitters. This shall provide the process variable and the health status for

each HART transmitter. Further details can be found in the flow computers section of this document (Section 3).

The fast loop sampling system is equipped with dual cell samplers, dual sampler receivers each with analogue level indicators. A variable area flow meter is provided. The analysers on the fast loop consist of dual TPS densitometer meters with dual HART temperature indicating transmitters and dual HART pressure indicating transmitters. Dual watercut analysers a RVP analyser and a TVP analyser, each with separate Modbus serial connections are provided.

The Emerson S600+ is designed to provide standalone flow metering. The redundant Emerson Metering Suite engineering / operator workstations provide centralised control and monitoring and is the primary method for interaction and control. In the event of supervisory failure, the S600+ flow computers can be monitored and controlled from the flow computer front of panel display, with the flow computers providing a local reporting facility; via a web interface for stream totals and flow rates.

Each of the five S600+ flow computers transfer data via dual Modbus TCP links to the Emerson Metering Suite supervisory computers. The metering supervisory computer collates the information from the flow computers to display the data and generate reports, alarms and events based on data obtained from the field.

2.3 Emerson Metering Suite Supervisory Control System

The Emerson Metering Suite metering supervisory computer (MSC) is used to provide high level controls and functions for the condensate metering system. The MSC consists of two redundant rack mount engineering / operator workstation computers which shall be located within the metering control panel.

The MSC provides the following functions:

- Operator interface for control and monitoring functions.
- Period totalisation on a station basis.
- Automatic and on demand report generation.
- Long term storage of metering report data.
- Data entry and downloading to the flow computers.
- Full alarm annunciation, including alarm diagnostics, suppression and delay capabilities.
- User management and security
- Trending
- Line control
- Batch Control
- Master Meter Proof Control
- Automatic or Manual Meter Factor Acceptance
- Time synchronisation of S600+ Flow Computers via NTP
- Redundant Modbus TCP interface to ICSS.
- Communication Status and Server Redundancy Status.

2.4 Hardware Overview

The Coral North Development FLNG condensate metering system comprises of the following main items of supply:

Metering Control Panel

Two Rittal metering control panels shall be supplied in a two-bay configuration. Each panel measures 800mm wide x 800mm deep x 2000mm high with a 100mm plinth.

Bay 1 (flow computer panel) shall contain the five S600+ flow computers and all field signal terminations and ADAM I/O modules required for the metering system. It shall have a swing frame front door with an external vented and glazed door. Both doors shall be equipped with locks.

Bay 2 (logic control panel) shall contain the rackmount Emerson Metering Suite Engineering Workstations, a 19" panel mounted monitor, keyboard drawer, pull-out monitor and keyboard with touchpad, two 16 port Ethernet switches and a laser jet printer. It shall have a hinged front door with built in vent and lock.

The metering control panels shall have bottom plates for field cable entry. Each panel will be front access only. The panels shall have top mounted cooling fans which shall continuously operate.

The panel input power shall be 230VAC supplied by dual UPS (provided by others). Dual DC power supplies in Bay 2 shall supply the 24VDC instrumentation, such as the flow computers.

Hardwired digital signals to the Master Meter flow computer shall provide the following panel failure alarms:

- 24VDC PSU A Failure
- 24VDC PSU B Failure
- Panel A Temperature High
- Panel B Temperature High
- Ethernet Switch A Fail
- Ethernet Switch B Fail

Flow Computers

Five Emerson S600+ flow computers shall be supplied:

Four Coriolis stream flow computers will be supplied with the following hardware:

x1 P152 CPU Card
x1 P144 I/O Card
x1 P188 HART Card

The Coriolis master meter and sampling flow computer will be supplied with the following hardware:

x1 P152 CPU Card
x1 P144 I/O Card
x1 P188 HART Card
x1 P154 Prover Card

The functionality of the flow computer applications is detailed in section 3 of this document.

2.5 Software Licenses

License Code	Description	Assigned to	Functionality
TBA	Windows Server 2022	Emerson metering Suite Primary Engineering Workstation	Operating System
TBA	Windows Server 2022	Emerson metering Suite Secondary Engineering Workstation	Operating System
TBA	Emerson metering Suite SCADA License	Emerson metering Suite Primary & Secondary Workstations	Metering Supervisory System Software
TBA	Emerson metering Suite Editor	Emerson metering Suite Primary Workstations	Metering Supervisory System Engineering WS Operation.
TBA	Emerson metering Suite Redundancy Pack	Emerson metering Suite Primary & Secondary Workstations	Metering Supervisory System Engineering WS Redundant Operation.
TBA	Emerson metering Suite Client Runtime Operator Workstation	Emerson metering Suite Operator Workstation (Installed on Virtualised ICSS OWS)	Metering Supervisory System Software
TBA	Config 600 Lite	Emerson metering Suite Primary Workstation	Program to download flow computer applications to S600+
TBA	McAfee Endpoint Security Anti-Virus Software	Emerson metering Suite Primary & Secondary Workstations	Anti-Virus Software

Table - System Software Licenses

3 FLOW COMPUTERS

Two flow computer applications will be developed for the Coral North Development FLNG condensate metering system, a single stream liquid Coriolis application and a liquid Coriolis master meter/sampler application.

The single stream liquid Coriolis application will be installed on the dedicated flow computers for the four metering streams.

The liquid Coriolis master meter / sampler application will be installed on the master meter flow computer.

The following sections detail the operation and configuration of these two applications.

3.1 Liquid Coriolis Flow Computer Application

3.1.1 Introduction

This section details the functionality of the FloBoss S600+ Flow Computer fitted with the Coral North Development FLNG condensate metering liquid Coriolis application software. This application software is developed specifically to meet the requirements of the Coral metering streams. This application will be installed in each of the four metering stream flow computers (*TT2220*FQI3511, *TT2220*FQI3521, *TT2220*FQI3531, *TT2220*FQI3541).

The flow computer can operate as a stand-alone flow computer, or form an integral part of a metering system.

The flow computer application is for a single stream.

3.1.2 Summary of Functions

A summary of the functions provided by this flow computer application are detailed below:

1. Measure the frequency and quantity of pulses from the stream Coriolis meter, to ISO6551 level A.

2. Measure the pressure of the liquid in the metering line using dual pressure transducers fitted in the metering line (HART).

3. Measure the temperature of the liquid in the metering line using dual temperature elements fitted in the metering line (HART).

4. Calculate the mass flowrate for the metered stream from the frequency of pulses received from the Coriolis meter and the meter k-factor.

5. Accept a base (standard) density value from the master meter flow computer via a Modbus data link.

6. Calculate correction factors for the effects of temperature and pressure on the liquid at the stream meter.

7. Calculate a meter density from base (standard) density.

8. Accept a % volume base sediment water value from the master meter flow computer via a Modbus data link.

9. Accept a Reid vapour pressure from the master meter flow computer via a Modbus data link.

10. Accept a True vapour pressure from the master meter flow computer via a Modbus data link.

11. Calculate the gross uncorrected volume, gross standard volume and net standard volume flow rates.

12. Calculate cumulative, batch/previous batch, current/previous totals for the following periods; minute, hourly and daily for gross uncorrected volume, gross standard volume, mass and net standard volume. The end of day hour will be 06:00.

13. Control and monitor the stream inlet motor operated valve.

14. Control and monitor the stream outlet motor operated valve, including cavity pressure (HART) for leak detection purposes.

15. Control and monitor the prover (off take) motor operated valve, including cavity pressure (HART) for leak detection purposes.

16. Control (4-20mA) and monitor (4-20mA) the stream flow control valve.

17. Provide an operator interface through which relevant data may be viewed and/or modified.

18. Operate a comprehensive alarm system.

19. Provide a maintenance mode facility.

20. Provide dual Ethernet links to transfer data to, and receive commands from the Emerson Metering Suite system using Modbus TCP/IP.

21. Operate a flow computer watchdog alarm output to provide an indication of a critical failure at the flow computer (power fail or active group 1 alarm).

3.1.3 Field Inputs/Outputs

The input/output requirements of the flow computer application are such that the following hardware is required:

1 off P152 (CPU Board)
1 off P144 (I/O Board)
1 off P188 (HART Board)

The flow computer has the following I/O signals:

Inputs

Description	Type
Stream Coriolis	Dual Pulse
Stream Pressure (TX-A)	HART
Stream Pressure (TX-B)	HART
Stream Temperature (TX-A)	HART
Stream Temperature (TX-B)	HART
Outlet Valve Cavity Pressure	HART
Prover Valve Cavity Pressure	HART
Flow Control Valve Position	4-20mA
Inlet Valve Open Status	Digital
Inlet Valve Close Status	Digital
Inlet Valve Local / Remote Status	Digital
Inlet Valve Fault Status	Digital
Outlet Valve Open Status	Digital
Outlet Valve Close Status	Digital
Outlet Valve Local / Remote Status	Digital
Outlet Valve Fault Status	Digital
Prover Valve Open Status	Digital
Prover Valve Close Status	Digital
Prover Valve Local / Remote Status	Digital
Prover Valve Fault Status	Digital

Table – Liquid Coriolis Flow Computer Application Inputs

Outputs

Description	Type
Flow Control Valve	4-20mA
Inlet Valve Open Control	Digital
Inlet Valve Close Control	Digital
Outlet Valve Open Control	Digital
Outlet Valve Close Control	Digital
Outlet Valve Drain Control	Digital
Prover Valve Open Control	Digital
Prover Valve Close Control	Digital
Prover Valve Drain Control	Digital

Table – Liquid Coriolis Flow Computer Application Outputs

Communications

Description	Protocol / Com Port	Additional Information
HMI Link 1 (Primary MSC)	Ethernet Modbus TCP/IP	TCP Port 501
HMI Link 1 (Secondary MSC)	Ethernet Modbus TCP/IP	TCP Port 501
Emerson metering Suite Link 2 (Primary MSC)	Ethernet Modbus TCP/IP	TCP Port 502
Emerson metering Suite Link 2 (Secondary MSC)	Ethernet Modbus TCP/IP	TCP Port 502
Prover Modbus Slave Link (link to prover flow computer)	Modbus RTU -Serial RS422 – Com 5	19200 baud, 8 data bits, 1 stop bit, no parity

Table – Liquid Coriolis Flow Computer Application Communications

3.1.4 Coriolis Meter

The flow computer monitors a dual pulse train from the Coriolis meter to ISO6551 Level A. The pulse trains are known as A and B and are out of phase with each other. The pulses should arrive at the flow computer correctly sequenced i.e. ABABABA, and any pulse that does not form part of a good sequence e.g. ABAABA is classed as a bad pulse. The pulse train is reconstituted within the flow computer to form a good pulse count. Bad pulses are separately counted to form a bad pulse count.

Each pulse represents a mass increment; the number of pulses per unit mass is the K-factor (pls/t).

When calculating the relevant mass increment correction for bad pulses is performed.

The frequency of the pulse train is used to calculate a mass flow rate.

For this application a single Meter K-Factor is used at all times (as opposed to a Meter K-Factor linearisation curve). This Meter K-Factor is keypad entered. The ability to enter/download the flow rate, temperature, pressure applicable at the time of deriving the Meter Factor (i.e. prove conditions) is provided and a Prove Required alarm can be raised if the current conditions deviate from the prove conditions.

3.1.4.1 Bad Pulses

A bad pulse counter is used to indicate the number of bad pulses received.

A delta bad pulse counter is incremented at the same rate as the bad pulse counter when the pulse frequency is greater than the keypad entered error check frequency.

An alarm is raised when the delta bad pulse count exceeds the keypad entered bad pulse threshold.

The delta bad pulse count will automatically reset whenever:

1. The pulse frequency equals or falls below the error check frequency.
2. The number of continuous good pulses exceeds the keypad enterable reset threshold.

3.1.4.2 Definitions

Pulse Input Count:
This is the number of pulses that have occurred.

Pulse Frequency:
This is the input frequency in Hz.

Low Frequency Cut Off:
Pulse frequencies below this value (Hz) will cause the flow rate and input frequency to be set to zero.

Note: there is a separate low flow cut-off for alarm suppression and maintenance mode interlocks.

Live/Check Keypad Frequency:
When the FloBoss S600+ is in Maintenance mode, a check frequency can be selected and a keypad frequency entered.

3.1.4.3 K-Factor

For this application, a single K-Factor (pls/t) is used at all times.

The following alarms and events are raised on the parameter:

Alarms	Value High
	Value Low

3.1.4.4 Meter Factor

There are two modes available for the 'In Use' Meter Factor:

Mode	Description
CALCULATED	This uses the meter factor calculated from the 10-point linearisation curve
KEYPAD	This uses the keypad value, selectable from the front panel

Table – Liquid Coriolis Flow Computer Application Meter Factor Modes

The mode will not change until another mode is manually selected.

The 10-point linearisation curve of raw mass flow rate against Meter Factor will be initially populated during commissioning with the results of the calibration laboratory test for the Coriolis meter specific to the stream. During batch operations the stream should be master meter proved at least once at the nominal loading rate. Following a successful proof, the operator can choose to accept the new meter factor. This meter factor will be for a specific mass flowrate (the average mass flowrate of the master meter proof). Upon accepting the meter factor the curve is updated with the new meter factor and associated mass flow rate. The new values will overwrite the closest existing curve values. The Emerson Metering Suite supervisory shall maintain a history of the last 30 proved meter factor results. Accepting meter factors based on the results of a master meter proof will adjust the totals calculated by the stream Coriolis meter away from the flow laboratory calibration and towards the master meter Coriolis meter.

If the calculated mode was selected when a new meter factor downloaded following a successful proof is accepted, the new meter factor will be inserted into the linearisation curve.

If the keypad mode was selected when a new meter factor downloaded following a successful prove is accepted, the new meter factor will replace the keypad value and will be inserted into the linearisation curve.

The following alarms and events are raised on the parameter:

Alarms	Value High Value Low
Events	Each Mode change (i.e. Calculated to Keypad) etc.

3.1.4.5 Prover Pulse Bus

The flow computer has a raw pulse output which when enabled outputs the pulse train from the Coriolis meter. The pulse output can be enabled from either the front panel keypad or via a downloaded command from a prover flow computer or supervisory computer.

The raw pulse output is connected to a prover flow computer pulse bus input. This allows the prover flow computer to count pulses from the Coriolis meter for the purpose of deriving a new Meter Factor. It is essential that only one stream should have its raw pulse output enabled when proving is in progress.

3.1.5 HART Interface

The P188 (HART board) uses bell 202 modem circuits to communicate to the transmitter loops. The HART Interface consists of twelve independent Hart loop scanners, which can scan up to fifty sensors.

When the FloBoss S600+ is powered up, certain data, such as range, is read and stored in the on-board database. The module then continues to read the process variable and status from each sensor in turn on the loop at a rate of about 0.5 seconds per sensor.

If a sensor with address zero is connected to the loop, this sensor only will be scanned on that loop.

If a sensor configured in the 4-20mA mode (address 0) is connected to the loop the process variables will be scanned approximately every 0.5 seconds. All other sensors on the loop will be ignored. The data will be available at the first sensor address on the loop.

If the sensors on the loop have an address other than 0 then the loop scan time will be 0.5 seconds times the number of sensors plus 0.5 seconds.

When a sensor is disconnected or faulty the most significant bit in the reply second status byte will be set high. The bits in this status code are defined as follows:

Bit 0 – Primary variable out of limits
Bit 1 – Variable (not primary) out of limits
Bit 2 – Analogue output saturated
Bit 3 – Output current fixed
Bit 4 – Reserved
Bit 5 – Cold start
Bit 6 – Configuration changed
Bit 7 – Device malfunction

A device error is associated with any of the following alarms:

1. A communications failure
2. Primary variable out of limits
3. Analog output saturated
4. Device malfunction

Note: In this configuration, the transmitters are point to point, therefore all transmitter addresses should be configured with address 0.

3.1.6 Transmitter Modes

3.1.6.1 Dual Hart Transmitter

Dual transmitter handling is provided for the following:

Meter Pressure/Meter Temperature

The operating mode for each transmitter pair can be selected from one of the following:

Mode	Description
KEYPAD	When Keypad is selected the Dual TX keypad value will be used in the metering calculations.
TX-A	When TXA is selected the TXA value will be used in the metering calculations provided that the TXA operating mode is measured. If the TXA operating mode is not measured then the TXB value will be selected provided that the TXB operating mode is measured. If the TXB operating mode is not measured the Dual TX operating mode will default to the Dual TX keypad value. The mode will automatically switch back to TXA or TXB when the TXA or TXB operating mode returns to measured depending which becomes available first, however, the TXA value will be used as soon as the TXA operating mode returns to measured.
TX-B	When TXB is selected the TXB value will be used in the metering calculations provided that the TXB operating mode is measured. If the TXB operating mode is not measured then the TXA value will be selected provided that the TXA operating mode is measured. If the TXA operating mode is not measured the Dual TX operating mode will default to the Dual TX keypad value. The mode will automatically switch back to TXB or TXA when the TXB or TXA operating mode returns to measured depending which becomes available first, however, the TXB value will be used as soon as the TXB operating mode returns to measured.

Table – Liquid Coriolis Flow Computer Application Dual TX Modes

Discrepancy checking is performed between the TXA and TXB values, with an alarm being raised if the transmitter values differ by more than the keypad limit for more than a configurable amount of time.

Alarms	Value High Value Low Value Discrepancy
Events	Each Mode change (TXA to TXB) etc.

3.1.6.2 Meter Pressure/Temperature and Outlet/Prover Cavity Pressure

The flow computer receives six HART signals which are converted to:

Meter Pressure TXA in barg
Meter Pressure TXB in barg
Meter Temperature TXA in Deg C
Meter Temperature TXB in Deg C
Prover (Off take) Valve Cavity Pressure in barg
Outlet Valve Cavity Pressure in barg

The operating mode for the transmitters can be selected from one of the following:

Mode	Description
MEASURED	This uses the process variable read from the HART transmitter, selectable from the front panel
KEYPAD	*This uses the keypad value, selectable from the front panel*
LASTGOOD-F	When the HART input signal has failed (Device Error), the last good value is used. This can only be selected by the FloBoss S600+, while in MEASURED mode. If the input signal returns to a non-failed state, the measured value is used and the relevant mode shows MEASURED.

Table – Liquid Coriolis Flow Computer Application HART Modes

A transducer fail (device error) is associated with any of the following alarms:

1. A communications failure
2. Primary variable out of limits
3. Analog output saturated
4. Device malfunction

The following alarms and events are raised on this input.

Alarms	Value High Value Low Transmitter Device Error
Events	Each Mode change (measured to keypad) etc.

3.1.6.3 FCV Feedback Position

The FloBoss S600+ Flow Computer receives a 4-20mA signal, which is converted to FCV Feedback Position in %

The transducer signal is deemed to have failed if the internally calculated current is greater than 20.5mA or less than 3.5mA.

There are three modes available for the FCV Feedback Position:

Mode	Description
MEASURED	*This uses t*he derived calculated value from the incoming analogue signal, selectable from the front
KEYPAD	*This uses the keypad value, selectable from the front panel*
LASTGOOD-F	When the transducer input signal has failed (Device Error), the last good value is used. This can only be selected by the FloBoss S600+, while in MEASURED mode. If the input signal returns to a non-failed state, the measured value is used and the relevant mode shows MEASURED.

Table – Liquid Coriolis Flow Computer Application 4-20mA Modes

The following alarms and events are raised on the parameter:

Alarms	Value High Value Low Device Error
Events	Each Mode change (i.e. Measured to Keypad) etc.

3.1.7 Process Variable Modes

3.1.7.1 Base (Standard) Density / Base Sediment Water / RVP / TVP

The Base Density in kg/m3, Base Sediment Water (BSW) in % (volume), Reid Vapour Pressure (RVP) in barg and True Vapour Pressure (TVP) in barg are received via telemetry from the master meter computer.

There are two modes available for these parameters:

Mode	Description
DOWNLOAD	*This uses the* downloaded value, selectable from the front panel.
KEYPAD	*This uses the keypad value, selectable from the front panel*

Table – Liquid Coriolis Flow Computer Application Download Modes

The following alarms and events are raised on each parameter:

Alarms	Value High Value Low
Events	Each Mode change (i.e. Calculated to Keypad) etc.

3.1.7.2 Combined Correction Factor (CCF)

The Combined Correction Factor is calculated from the meter density using the meter pressure and meter temperature.

There are two modes available for the ‘In Use’ CCF:

Mode	Description
CALCULATED	*This uses* the calculated combined correction factor (meter to base volume correction)
KEYPAD	*This uses the keypad value, selectable from the front panel*

Table – Liquid Coriolis Flow Computer Application CCF Modes

The following alarms and events are raised on the parameter:

Alarms	Value High Value Low
Events	Each Mode change (i.e. Calculated to Keypad) etc.

3.1.7.3 Meter Density

The Meter Density in kg/m3 is calculated from the base density using the combined correction factor.

There are two modes available for the 'In Use' Meter Density:

Mode	Description
CALCULATED	*This uses* the calculated meter density
KEYPAD	*This uses the keypad value, selectable from the front panel*

Table – Liquid Coriolis Flow Computer Application Meter Density Modes

The following alarms and events are raised on the parameter:

Alarms Value High
Value Low

Events Each Mode change (i.e. Calculated to Keypad) etc.

3.1.8 Block Valves

Motor operated stream inlet, outlet and prover (off take) valves are monitored and controlled. The flow computer will action valve movement commands either entered locally or downloaded over telemetry.

3.1.8.1 Valve Position Inputs

The flow computer monitors two digital input signals (per valve) to determine the valve position.

The interpretation of the two inputs is shown below. A '1' indicating a contact closure/active signal and a '0' indicating an open contact/inactive signal.

CAS2 is the valve 'Closed' limit switch and OAS2 is the valve 'Open' limit switch.

For correct operation the Valve Closed limit switch remains closed until the closed stop is reached, and the Open limit switch remains closed until the Open stop is reached, this means that both inputs are active when the valve is moving and ensures that a valve illegal alarm is raised due to a wiring fault.

Actual Valve Position	Limit Switch OAS2	Limit Switch CAS2	Flow Computer Open Input	Flow Computer Closed Input
OPEN	0	1	1	0
MOVING	1	1	1	1

Actual Valve Position	Limit Switch OAS2	Limit Switch CAS2	Flow Computer Open Input	Flow Computer Closed Input
CLOSED	1	0	0	1
FAULT	0	0	0	0

Table – Liquid Coriolis Flow Computer Application Valve Inputs

To achieve this operation, it is necessary for the Closed Limit Switch CAS2 to be wired to the flow computer valve open input, and the Open Limit Switch OAS2 to be wired to the flow computer valve closed input.

3.1.8.2 Valve Position Outputs

Two digital outputs are used to command the valve to move. Following a request to command the valve to open the 'valve open' digital output is activated for 2 seconds. Following a request to command the valve to close, the 'valve close' digital output is activated for 2 seconds. The digital outputs are not activated if the valve local/remote status input is not set.

A valve timeout alarm is raised if the valve position inputs do not reflect the required position within a configurable timeout period. The timer is activated when the flow computer actions the command.

3.1.8.3 Integrity Checking

The outlet and prover (off take) valves are equipped with a drain solenoid to drain the valve cavity, and a pressure transmitter to subsequently monitor the valve cavity for leaks.

When a controlled valve reaches the closed position, a digital output will be set for a configurable drain time (default 10s) to activate the drain solenoid and reduce the valve cavity pressure. Once the cavity has been drained and sealed, a snapshot will be taken of the valve cavity pressure. The valve pressure transmitter shall then monitor the pressure within the cavity for a configurable test time (default 300s). If the monitored valve cavity pressure increases beyond the snapshot pressure plus an operator entered allowable limit, an MOV leak fail alarm will be raised. The test time is configurable. Once the test time has expired the flow computer will no longer monitor the valve for leaks.

3.1.9 Flow Control Valve

A 4-20mA output is provided to drive a flow control valve (FCV).

The 3-term proportional, integral and derivative (PID) controller has the following control settings, which are under operator control.

Auto/Man Mode	**Manual** The output is set to the manual position value. **Auto** The controller output is adjusted in order that the measured process variable, mass flow rate, maintains the required set point value.
Control Action	**Forward** The output is increased if the measured process variable is below the set point value. **Reverse** The output is decreased if the measured process variable is above the set point value.
Set Point Tracking	**On** When the controller is in auto mode the manual position will be set equal to the current output value. When the controller is in manual mode the set point will be set equal to the process variable. **Off** When the controller is in auto mode the manual position will remain unchanged. When the controller is in manual mode the set point will remain unchanged and the integral action value is set to the value required in order to maintain the current position.
Clamp High	**%** This value limits the output’s maximum value i.e. 100%.
Clamp Low	**%** This value limits the output’s minimum value i.e. 0%.
Slew Limit	**%/s** This value limits the maximum rate of change of the output signal. If the value = 0 it is not used, i.e. the control output is passed straight through to the DAC output.
Ramp Rate	**m3/h/s** This value limits the maximum rate at which the set point used in the PID algorithm tracks the required set point. If the value = 0 it is not used, i.e. the required set point is used directly by the PID algorithm.
Manual Position	**%** When the controller mode is 'manual' the controller output is set to this value.

Set Point **m3/h**
This represents the desired process condition and when the controller mode is auto the controller output is modified in order that the measured process variable equals this value.

PV Range **m3/h**
This is the range of the process variable measuring instrument.

Proportional Band **%**
This is the amount that the process variable must change as a percentage of the process variable range that will cause the controller to cover its full range.

Integral Time **s**
This is the time taken for integral action to reproduce the same change in the controller output as that caused by the proportional action for a given sustained step discrepancy i.e. the controller output is proportional to the amount of time the error is present. If the integral action time is zero, the integral action is set to zero.

Derivative Time **s**
This is the time taken for derivative action to reproduce the same change in the controller output as that caused by the proportional action when the discrepancy is changing at a constant rate i.e. the controller output is proportional to the rate of change of the error. If the derivative action time is zero, the derivative action is set to zero.

Output Position **%**
This represents the controller output signal, which drives the analogue output device.

PID algorithm

The PID controller output signal is calculated from the sum of the proportional, integral and derivative actions:

Output = P + I + D

Each term depends on Error and Gain:

If the control action is Forward:

Error = Process Variable – Set Point

If the control action is Reverse:

Error = Set Point – Process Variable

If the proportional gain is applied to all terms:

Gain = 1 / PV Range * 100 / Proportional Band * 100

If the algorithm is processed at regular intervals:

Delta Time = Current Time – Previous Time

Proportional Action (P)

The degree of proportional action (P) is directly proportional to the error and is calculated from the formula:

P = Error * Gain

A high proportional action produces a large change in the output for a given change in the error, a low proportional action produces a small change in the output, that is the action is less sensitive. If the proportional gain is too high the system becomes unstable.

A suitable initial value for flow control is 200 %.

Integral Action (P)

The degree of integral action (I) is calculated from the formula:

I (new) = I (previous) + (Error * Gain * Delta time) / (Integral Action Time)

Integral action provides a cumulative offset that eliminates residual error.

A suitable initial value for flow control is 3 seconds.

Derivative Action (D)

The degree of derivative action (D) is calculated from the formula:

D = (Error – (2 * Old Error) + Very Old Error) * Gain * Derivative Action Time / Delta Time

Derivative action responds to rate of change in successive errors. The action is sensitive and anything greater than a small value of the derivative action time can make the system unstable.

A suitable initial value for flow control is 0.01 seconds.

3.1.10 Operational Settings

3.1.10.1 Modes of Operation

During normal operation the flow computer is automatically set to one of the following modes:

Status	Description
UNDEFINED	The status task is not running correctly.
MAINT	The flow computer has been placed into Maintenance mode.
VLV-ILLEGAL	One of the monitored valves is indicating an unknown/illegal position.
UNHEALTHY	There is not a flow path through the meter run AND the measured mass flow rate is above the low flow cut-off limit.
ONLINE	There is a flow path through the meter AND the measured mass flow rate is above the low flow cut-off limit.
OFFLINE	The measured mass flow rate is below the low flow cut-off limit.

Table – Liquid Coriolis Flow Computer Application Stream Status

3.1.10.2 Maintenance Mode

The flow computer should be put into Maintenance Mode when calculation or calibration tests are to be carried out on the computer.

The following selection is available Set / Clear.

Entry of Maintenance Mode is only possible if the stream status is Off-Line, and the outlet and prover off take valves are in the closed position.

To Exit Maintenance Mode the Off-Line interlock checks must be satisfied.

Whist in Maintenance Mode the following occurs:

1. Alarm digital outputs (except Watchdog) are forced to the no alarm position.
2. Totalisation pulse outputs are inhibited. (Not used in this configuration)
3. Any flow registered is totalised into separate maintenance totalisers.

A maintenance report is generated automatically at change of maintenance mode status.

3.1.10.3 Security

Each object at the flow computer is allocated an associated security level between 0 and 9. The user cannot modify data assigned level 0.

Access to security level 1 requires the security bit link to be fitted on the P152 CPU board. Any user can change data assigned Level 9.

In order to change data when utilising the front panel display the user must enter a password of the required security level or higher.

The following passwords are the startup defaults:

Security Level	Password
0	N/A
1	1111*
2	2222
3	3333
4	4444
5	5555
6	6666
7	7777
8	8888
9	9999

* requires that security bit link fitted (P3) on P152 CPU board.

Table – Liquid Coriolis Flow Computer Application Security

3.1.11 Totalisation

The primary flow measurement is mass total, which is derived from the Coriolis meter pulse count. The mass increment is used to form gross uncorrected volume, gross standard volume and net standard volume increments. These increments are likewise added to the relevant totals.

3.1.11.1 Totalisation Registers

Each total is held as two discrete values, a displayed total and a remainder. Increments are added into the remainder and are only added into the displayed total when the remainder overflows.

The displayed total is truncated, i.e. not rounded up.

e.g.	Actual Total	=	10.57382
	Displayed Total	=	10.5
	Remainder	=	0.07382

The value of each total is held in triple registers for increased security.

The displayed total and the remainder are held in discrete registers. A total of six registers are used in order to hold the value of each total.

A partial total fail alarm is raised if the value held in one register differs from the other two associated registers. A total fail alarm is raised if the value held in each of the three associated registers differ.

The cumulative total (i.e. non-resettable) represents the quantity of the relevant parameter that has been registered by the flow computer since its totals were last reset excluding any amount which has passed whilst the flow computer has been in maintenance mode.

The daily total represents the quantity of the relevant parameter that has been registered by the computer since the last day end occurred excluding any amount which has passed whilst the flow computer has been in maintenance mode.

The maintenance total represents the quantity of the relevant parameter that has been registered by the computer while it has been operating in maintenance mode.

Note: The maintenance totals are transferred to a previous maintenance mode total on exit of maintenance mode and the current maintenance mode total is reset to zero.

3.1.11.2 Base Time and Period Frequency

Base Time

The Base Time specifies the hour at which the 24 hr day ends. The value can be in the range 0-23 hrs. The Base Time for this application is set to 06:00 hrs.

At day end the current daily displayed total is copied into the previous day displayed total and the current daily displayed total is set to zero. It should be noted that the associated current daily remainder (which is not displayed) would remain unchanged.

The following example shows the transfer of totals over a five-day period, the values shown are those recorded just after the relevant base times.

Day	Sum of Daily Increments	Cumulative Total Displayed	Remainder	Daily Total	Previous Day Total
1	10.57382	10.5	0.07382	10.5	0.0
2	11.66431	22.2	0.03813	11.7	10.5
3	7.14692	29.3	0.08505	7.1	11.7
4	8.19030	37.5	0.07535	8.2	7.1
5	9.99999	47.5	0.07534	10.0	8.2

Multi-Minute Frequency

The flow computer maintains separate current and previous multi-minute totals. The value entered as the Period Frequency determines when Current Period totals are transferred to Previous Period totals registers.

The multi-minute interval is defaulted to 1 for the Coral project.

Period Frequency

The flow computer maintains separate current and previous period totals. The value entered as the Period Frequency determines when Current Period totals are transferred to Previous Period totals registers.

The Period Frequency is configured using the PC Setup program and for this system, two periods are configured:

Period 1	Hourly
Period 2	Daily

3.1.11.3 Displayed Total Resolution

The maximum number of characters available in order to display a total is 15, 14 if a decimal point is utilised.

This application has all cumulative totals format of 9 before, 2 after.

The resolution selected for each cumulative total should be such that the time interface between rollover of each total, when operating at maximum flow rate (i.e. relevant flow rate Hi Limit) is greater than three calendar months.

The cumulative total continues to increase until an additional increment produces a total, which cannot be displayed within the relevant totals resolution. At this time a total ‘ROLLOVER’ will occur, an example of which is given below.

Example of a total with a resolution of seven digits before the decimal point and one digit after the decimal point.

Current Total (Pre-Rollover)	9999998.6
Increment	3.2
Actual Total (if no Roll-Over)	100000001.8
Displayed Total (with Roll-Over)	1.8

A common rollover alarm is raised each time a total rolls over to zero.

3.1.11.4 Totals Reset

A ‘total reset’ will reset all totals and therefore this function should be treated with extreme caution.

The totals may be reset by selecting ‘cold start’ from the System Run Mode display. This enters the “Cold Start” menu, which is separate from the standard metering displays. A high-level security code must be entered to access the “Cold Start” menu from the System Run Mode display and also to execute the “Reset Totals” command.

3.1.11.5 Batch Totalisation

The batch total represents the quantity of the relevant parameter that has been registered between Define and Terminate Batch commands.

At “Batch Define” the current batch total is set to zero. It should be noted that the associated current batch remainder (which is not displayed) will also be reset to zero.

At “Batch Terminate” the current batch totals stop incrementing and the current batch totals are copied into the previous batch totals.

3.1.11.6 Finalised Batch Total

If a retrospective application of a new Standard Density and Water Cut is required, the new values may be entered during the “Wait Recalc” batch stage.

When this method is used the Standard Density and Water Cut are adjusted after the provisional end of the batch. Once these values are confirmed, new standard and net batch totals are calculated. The cumulative totals will not be adjusted. The final batch report will then be generated.

3.1.12 Batching

3.1.12.1 Introduction

Batching provides the control process for loading a defined quantity of product. The process is run as a sequence stepping through a series of stages.

The flow computer shall operate as a supervised stream batch. The Emerson Metering Suite supervisory shall issue the relevant commands to the flow computer's batch sequence. The batch quantity shall be measured in mass.

3.1.12.2 Batch Sequence and Control

The sequence will be supervised by the Emerson Metering Suite supervisory computer. The following batch commands will be available at the flow computer:

Value	Batch Command	Description
1	Define	Accept the load parameters and reset batch totals.
2	Start	Advances the batch stage to monitor from the idle or hold stage.
5	Hold	Pauses a batch that is in the monitor stage.
6	Terminate	Ends the batch from the monitor stage or hold stage.

Table – Batch Commands and Descriptions

3.1.12.3 Batch Stages

The batch stages are summarised in the following table:

Value	Batch Stage	Description
0	Idle	Idle, await Define Command Once “Define” issued: 1. Zero the batch totals 2. Increment the batch number 3. Proceed to Wait Sampler
1	Wait Sampler	Wait for the Sampler to Reset Once sampler is reset: Proceed to Batch Defined
2	Batch Defined	Await Start Command If “Start” command issued 1. Snapshot the cumulative totals 2. Proceed to Batch Monitor Stage If “Terminate” issued: 1. Proceed to Terminating
15	Batch Complete	1. Snapshot the final totals 2. Generate the Batch report 3. Proceed to Wait Recalc Command
16	Batch Monitor	Batch Control from Supervisory
17	Wait Recalc Command	Await Recalc or Terminate Command If “Terminate” issued: 1. Proceed to Terminating If “Re-Calc” is issued: 1. Proceed to Recalculating Go to the Re-Calculating stage
18	Recalculating	Recalculating the batch totals based on lab entered Standard Density and Watercut. Wait for the streams to indicate they have completed their re-calcs: 1. Proceed to the Recalc Complete stage. If “Terminate” issued: 1. Command the streams to Terminate 2. Proceed to Terminating

Value	Batch Stage	Description
19	Terminating	Wait for streams to go to Idle: 1. Proceed to Idle 2. Generate Final Batch Report
20	Recalc Complete	Halted: Await Terminate Command If “Terminate” issued: 1. Command the streams to Terminate 2. Proceed to Idle 3. Generate the Final Batch Report

Table – Batch Stages and Descriptions

3.1.13 Calculations

3.1.13.1 Standard References

Name	Standard Reference
Flow Rate	General Mathematical Principles
Totalisation	General Mathematical Principles
Liquid Volume Correction	API CH11.1 – 2004 / ASTM D1250-04 / IP 200/04 and Addendum 1 2007

Table – Liquid Coriolis Flow Computer Application Standard Reference

3.1.13.2 Mass Flow Rate (t/h)

$$qm = \frac{f}{KF} \times MF \times 3600 \times TPF$$

$$TPF = 1 + Ktpfl(P - Ptcal)$$

Where:

f	=	Coriolis meter frequency (Hz)
KF	=	K-Factor (pls/tonne)
MF	=	Meter Factor
TPF	=	Totals pressure correction factor
Ktpfl	=	Totals pressure correction factor constant
P	=	Meter pressure (barg)
Ptcal	=	Totals calibration pressure (barg)

3.1.13.3 Gross Uncorrected Volume Flow Rate (m^3/h)

$$qv = \frac{qm}{\rho_m} \times 1000$$

Where:

qm	=	Mass flow rate (t/h)
ρ_m	=	Meter density (kg/m^3)

3.1.13.4 Gross Uncorrected Volume Flow Rate (bbl/h)

$$qv_{bbl} = qv \times 6.28981057$$

Where:

qv	=	Gross uncorrected volume flow rate (m^3/h)

3.1.13.5 Gross Standard Volume Flow Rate (Sm^3/h)

$$qv_{std} = qv \times CCF_m$$

Where:

qv = Gross uncorrected volume flow rate (m^3/h)

CCF_m = Combined correction factor

3.1.13.6 Gross Standard Volume Flow Rate (Sbbl/h)

$$qv_{stdbbl} = qv_{std} \times 6.28981057$$

Where:

qv_{std} = Gross standard volume flow rate (m^3/h)

3.1.13.7 Net Standard Volume Flow Rate (Sm^3/h)

$$qv_{nett} = qv_{std} \times \left(1 - \frac{BSW}{100}\right)$$

Where:

Qv_{std} = Gross standard volume flow rate (Sm^3/h)

BSW = Base sediment water volume (%)

3.1.13.8 Mass Increment (tonnes)

$$\Delta Qm = \frac{\Delta pls}{KF} \times MF \times TPF$$

$$TPF = 1 + Ktpfl(P - Ptcal)$$

Where:

Δpls = Number of pulses from the Coriolis meter in the sample period

KF = K-Factor (pls/tonne)

MF = Meter Factor

TPF = Totals pressure correction factor

$Ktpfl$ = Totals pressure correction factor constant

P = Meter pressure (barg)

$Ptcal$ = Totals calibration pressure (barg)

3.1.13.9 Gross Uncorrected Volume Increment (m^3)

$$\Delta Qv = \frac{\Delta Qm}{\rho_{\mathrm{m}}} \times 1000$$

Where:
ΔQm = Mass increment (tonnes)
ρ_m = Meter density (kg/m^3)

3.1.13.10 Gross Uncorrected Volume Increment (bbl)

$$\Delta Qv_{bbl} = \Delta Qv \times 6.28981057$$

Where:
ΔQv = Gross uncorrected volume increment (m^3)

3.1.13.11 Gross Standard Volume Increment (Sm^3)

$$\Delta Qv_{std} = \Delta Qv \times CCF_m$$

Where:
ΔQv = Gross volume increment (m^3)
CCF_m = Combined correction factor

3.1.13.12 Gross Standard Volume Increment (bbl)

$$\Delta Qv_{stdbbl} = \Delta Qv_{std} \times 6.28981057$$

Where:
ΔQv_{std} = Gross standard volume increment (m^3)

3.1.13.13 Net Standard Volume Increment (Sm^3)

$$\Delta Qv_{nett} = \Delta Qv_{std} \times \left(1 - \frac{BSW}{100}\right)$$

Where:
ΔQv_{std} = Gross volume increment (m^3)
BSW = Base sediment water volume (%)

3.1.13.14 Correction Factor for the Effect of Temperature and Pressure on the Liquid (Base to Meter)

Method to correct a density from metric base conditions to alternate conditions reference API section 11.1.7.1

For CCFm, CTLm and CPLm the alternate temperature and pressure are at the meter.

Step 1 – Convert the metric base temperature (deg C to deg F), alternate temperature (deg C to deg F) and alternate pressure (barg to psig) reference API section 11.1.5.1

$$t^*_{std} = 1.8 \times T_{std} + 32$$

Where:

t*std = Base temperature (deg F)

Tstd = Base temperature (deg C)

$$t^* = 1.8 \times T + 32$$

Where:

t* = Alternate temperature (deg F)

T = Alternate temperature (deg C)

The input temperatures must be altered to comply with the IPTS-68 temperature scale (reference API section 11.1.3.11), which was superseded by the ITS-90 temperature scale and generally results in the temperature shifting slightly. The shift in temperature is defined as:

$$\Delta_t = t_{c90} - t_{c68} \equiv \sum_{i=1}^{8} a_i \left(\frac{t_{c90}}{630} \right)^i$$

Where:

Δt = Difference between equivalent temperatures (deg C)

tc90 = Temperature in the ITS-90 temperature scale (deg C)

tc68 = Temperature in the IPTS-68 temperature scale (deg C)

a i = Constant coefficients given in the a i constants table

Firstly, calculate the scaled temperature for both the base and alternate temperatures using the following:

$$\tau = \frac{t_{c90}}{630}$$

Where:

τ = Scaled temperature value

tc90 = Temperature, ITS-90 scale (deg C)

$$\Delta_t = (a_1 + (a_2 + (a_3 + (a_4 + (a_5 + (a_6 + (a_7 + a_8\tau)\tau)\tau)\tau)\tau)\tau)\tau)\tau$$

Where:

i	a_i
1	-0.148759
2	-0.267408
3	1.080760
4	1.269056
5	-4.089591
6	-1.871251
7	7.438081
8	-3.536296

Table – Liquid Coriolis Flow Computer Application a_i Constants

This can be used to calculate the IPTS-68 corrected temperature:

$$t_{c68} = t_{c90} - \Delta_t$$

Where:
t_{c68} = IPTS-68 corrected base temperature (deg C)
t_{c90} = Temperature, ITS-90 scale (deg C)
Δ_t = Shift in base temperature

$$t_{f68} = 1.8t_{c68} + 32$$

Where:
t_{f68} = IPTS-68 corrected base temperature (deg F)
t_{c68} = IPTS-68 corrected base temperature (deg C)

Apply this to the given base and alternate temperatures to provide:

t^*_{std} = IPTS-68 corrected base temperature (deg F)
t^* = IPTS-68 corrected alternate temperature (deg F)

The alternate pressure can be converted to metric units:

$$P^* = \frac{P}{0.06894757}$$

Where:

P^* = Alternate pressure (psig)

P = Alternate pressure (barg)

Step 2 – Calculate the correction factors for the density at 60 deg F corresponding to the metric base density reference API section 11.1.6.2. The pressure correction need not be calculated since the metric base pressure barg is the same as the base pressure in psig.

$$\rho^* = \rho_{60}\left\{1 + \frac{EXP\left[A(1+0.8A)\right]-1}{1+A(1+1.6A)B}\right\}$$

Where:

$$A = \frac{\delta_{60}}{2}\left[\left(\frac{K_0}{\rho_{60}} + K_1\right)\frac{1}{\rho_{60}} + K_2\right]$$

$$B = \frac{2K_0 + K_1\rho_{60}}{K_0 + \left(K_1 + K_2\rho_{60}\right)\rho_{60}}$$

ρ^* = Base density shifted to IPTS-68 60 deg F basis (kg/m^3)

ρ_{60} = Base density at 60 deg F and 0 psig (kg/m^3)

δ_{60} = Temperature shift value (deg F) = 0.01374979457

K_0 = Liquid specific constants ((kg^2/m^6)/deg F)

K_1 = Liquid specific constants ((kg/m^3)/deg F)

K_2 = Liquid specific constants (/deg F)

$$\rho_{60} = \frac{\rho_{15}}{CCF_{60}}$$

ρ_{60} = Base density at 60 deg F and 0 psig (kg/m^3)

ρ_{15} = Base density at 15 deg C and 0 psig (kg/m^3)

CCF_{60} = Base density at 60 deg F and 0 psig (kg/m^3)

Note: The iterative section of the calculation is demonstrated here as ρ_{60} is calculated by correcting the base density at 60 deg F, 0 psig. The iterative method is according to API section 11.1.6.2A. This requires the calculation of CCF_{60}, shown below.

$$CCF_{60} = CTL_{60} \times CPL_{60}$$

While CPL_{60} is 1 since no correction is needed, CTL_{60} is worked out using parameters being calculated simultaneously.

Rounding set to OFF; in the flow computer application for the base to meter density calculation.

$$\alpha_{60} = \left(\frac{K_0}{\rho^*} + K_1 \right) \frac{1}{\rho^*} + K_2$$

Where:

α_{60}	=	Coefficient of thermal expansion of the liquid (/deg F)
K_0	=	Liquid specific constants ((kg^2/m^6)/deg F)
K_1	=	Liquid specific constants ((kg/m^3)/deg F)
K_2	=	Liquid specific constants (/deg F)
ρ^*	=	Metric base density corrected to 60 deg F (kg/m^3)

$$\Delta t_{std} = t^*_{std} - 60.0068749$$

Where:

Δt_{std}	=	Metric base temperature minus the base temperature
t^*_{std}	=	IPTS-68 corrected metric base temperature (deg F)

$$CTL_{60} = EXP\{-\alpha_{60}\Delta t_{std}[1 + 0.8\alpha_{60}(\Delta t_{std} + \delta_{60})]\}$$

Where:

CTL_{60}	=	Correction factor for the effect of temperature on the liquid
α_{60}	=	Coefficient of thermal expansion of the liquid (/deg F)
Δt_{std}	=	Alternate temperature (metric base) minus the base temperature
δ_{60}	=	Temperature shift value (deg F) = 0.01374979457

Step 3 – Calculate the density at alternate conditions reference API section 11.1.6.1

$$\rho^* = \rho_{60}\left\{1 + \frac{EXP[A(1+0.8A)] - 1}{1 + A(1+1.6A)B}\right\}$$

Where:

$$A = \frac{\delta_{60}}{2}\left[\left(\frac{K_0}{\rho_{60}} + K_1\right)\frac{1}{\rho_{60}} + K_2\right]$$

$$B = \frac{2K_0 + K_1\rho_{60}}{K_0 + (K_1 + K_2\rho_{60})\rho_{60}}$$

ρ^*	=	Base density shifted to IPTS-68 60 deg F basis (kg/m^3)
ρ_{60}	=	Base density at 60 deg F and 0 psig (kg/m^3)
δ_{60}	=	Temperature shift value (deg F) = 0.01374979457
K_0	=	Liquid specific constants ((kg^2/m^6)/deg F)
K_1	=	Liquid specific constants ((kg/m^3)/deg F)
K_2	=	Liquid specific constants (/deg F)

$$\rho_{60} = \frac{\rho_{15}}{CCF_{60}}$$

ρ_{60}	=	Base density at 60 deg F and 0 psig (kg/m^3)
ρ_{15}	=	Base density at 15 deg C and 0 psig (kg/m^3)
CCF_{60}	=	Combined correction factor at 60 deg F and 0 psig

$$\alpha_{60} = \left(\frac{K_0}{\rho^*} + K_1 \right) \frac{1}{\rho^*} + K_2$$

Where:

α_{60}	=	Coefficient of thermal expansion of the liquid (/deg F)
K_0	=	Liquid specific constants ((kg^2/m^6)/deg F)
K_1	=	Liquid specific constants ((kg/m^3)/deg F)
K_2	=	Liquid specific constants (/deg F)
ρ^*	=	Base density corrected to 60 deg F (kg/m^3)

$$\Delta t = t^* - 60.0068749$$

Where:

Δt	=	Alternate temperature minus the base temperature
t^*	=	Alternate temperature (deg F)

$$C^*_{TL} = EXP\{-\alpha_{60}\Delta t[1 + 0.8\alpha_{60}(\Delta t + \delta_{60})]\}$$

Where:

C^*_{TL}	=	CTL correcting base density at 60 deg F to observed conditions
α_{60}	=	Coefficient of thermal expansion of the liquid (/deg F)
Δt	=	Alternate temperature minus the base temperature
δ_{60}	=	Temperature shift value (deg F) = 0.01374979457

$$F^*_P = EXP\left(-1.9947 + 0.00013427 \times t^* + \frac{793920 + 2326.0 \times t^*}{\rho^{*2}} \right)$$

Where:

F^*_P	=	Compressibility factor (/psi)
t^*	=	Alternate temperature (deg F)
ρ^*	=	Base density corrected to 60 deg F (kg/m^3)

$$CPL = \frac{1}{1 - (10^{-5} F^*_P (P^* - P_e))}$$

Where:

CPL	=	Correction factor for the effect of pressure on the liquid
F^*_P	=	Compressibility factor (/psi)

P^* =	Alternate pressure (psig)
P_e =	Equilibrium vapour pressure (psig)

Step 4 – Calculate the correction factors for the metric base temperature

$$CTL = \frac{C^*_{TL}}{CTL_{60}}$$

Where:

CTL =	Correction factor for the effect of temperature on the liquid
C^*_{TL} =	CTL correcting base density at 60 deg F to alternate conditions
CTL_{60} =	CTL correcting base density at 60 deg F to 15 deg C

$$F_P = \frac{F^*_P}{0.06894757}$$

Where:

F_P =	Compressibility factor (/bar)
F^*_P =	Compressibility factor (/psi)

$$CCF = CPL \times CTL$$

Where:

CPL =	Correction factor for the effect of pressure on the liquid
CTL =	Correction factor for the effect of temperature on the liquid

Note: The Liquid specific constants used in the above equations depend upon the commodity group:

Product	**Density Range**	K_0	K_1	K_2
A CRUDE	610.6 <= ρ_{60} < 1163.5	341.0957	0.0	0.0
B REFINED	838.3127 <= ρ_{60} < 1163.5	103.8720	0.2701	0.0
B REFINED	787.5195 <= ρ_{60} < 838.3127	330.3010	0.0	0.0
B REFINED	770.3520 <= ρ_{60} < 787.5195	1489.0670	0.0	-0.0086840
B REFINED	610.6 <= ρ_{60} < 770.3520	192.4571	0.2438	0.0
D LUBE OILS	800.9 <= ρ_{60} < 1163.5	0.0	0.34878	0.0

Table – Liquid Coriolis Flow Computer Application Liquid Specific Constants

3.1.13.15 Meter Density (kg/m^3)

$$\rho_m = \rho_{std} \times CPL_m \times CTL_m$$

Where:

ρ_{std} =	Base (standard) density (kg/m^3)
CPL_m =	Correction factor for the effect of pressure on the liquid at the meter

CTL_m	=	Correction factor for the effect of temperature on the liquid at the meter

3.1.13.16 Linearisation

$$MF_{(calc)} = \left[\frac{(X - lowerX_p)(higherY_p - lowerY_p)}{(higherX_p - lowerX_p)} \right] + lowerY_p$$

Where:

$$X = \frac{f}{KF} \times 3600 \times TPF$$

Where:

f	=	Coriolis meter frequency (Hz)
KF	=	K-Factor (pls/t)
TPF	=	Totals pressure correction factor
X_p	=	Flow rate co-ordinates (t/h)
Y_p	=	Factor co-ordinates

3.1.13.17 Flow Weighted Averaging (FWA)

For each period type (i.e. hourly and daily) the task relies upon the elapsed primary total for the period, multiplied by the present FWA value to give the 'weight' for the average. The latest measure value (of the variable being averaged), multiplied by the elapsed total since the last FWA calculation was performed, gives the new 'weight' to be incorporated into the whole.

This is only calculated when the period total is greater than zero.

$$FWA_{Var(n)} = \frac{\left(P\_Total * \ FWA_{Var(p)}\right) + Var_{Meas} * Total_{Inc}}{P\_Total * Total_{Inc}}$$

Where:

$FWA_{Var(n)}$	New flow weighted average of variable (Var)
P_Total	Period total (t)
$FWA_{Var(p)}$	Previously calculated flow weighted average of the variable (Var)
Var_{Meas}	Current measured value of the variable (Var)
$Total_{Inc}$	Increase in period total since $FWA_{Var(p)}$ was calculated (t)

Note: The following variables are averaged in this configuration. An average is calculated for each period interval, e.g. minute, hourly and daily:

Meter Pressure (Barg)
Meter Temperature (DegC)
Meter Density (kg/m3)
Base Density (kg/m3)
K-Factor (pls/t)
Meter Factor
Base Sediment Water (%)

Reid Vapour Pressure (BarG)
True Vapour Pressure (BarG)

3.1.13.18 Time Weighted Averaging (TWA)

For each period type (i.e. hourly and daily) the task relies upon the elapsed time for the period, multiplied by the present TWA value to give the 'weight' for the average. The latest measured value (of the variable being averaged), multiplied by the elapsed time since the last TWA calculation was performed, gives the new 'weight' to be incorporated into the whole.

This is only calculated when the flow rate is greater than zero.

$$TWA_{Var(n)} = \frac{(P\_Elapsed * \ TWA_{Var(p)}) + Var_{Meas} * Time_{Inc}}{P\_Elapsed * Time_{Inc}}$$

Where:

$TWA_{Var(n)}$	New time weighted average of variable (Var)
P_Elapsed	Time since period began
$TWA_{Var(p)}$	Previously calculated flow weighted average of the variable (Var)
VAR_{Meas}	Current measured value of the variable (Var)
$Time_{Inc}$	Time elapsed since $TWA_{Var(p)}$ was calculated

Note: The following variables are averaged in this configuration. An average is calculated for each period interval, e.g. hourly and daily:

Gross Uncorrected Volume Flow Rate (m3/h)
Gross Uncorrected Volume Flow Rate (bbl/h)
Gross Standard Volume Flow Rate (Sm3/h)
Gross Standard Volume Flow Rate (Sbbl/h)
Mass Flow Rate (t/h)
Net Standard Volume Flow Rate (Sm3/h)

3.1.14 Reports

The following reports can be requested from the flow computer front panel or via the web browser interface.

3.1.14.1 Current Report

The following report can be requested at any time:

```
================================================================================
                     CURRENT REPORT                         XX/XX/XXXX XX:XX:XX
================================================================================
STREAM  1

             CUMULATIVE                FLOW RATE
GUVOL                X.XX      m3            X.XX   m3/h
GUVOL                X.XX      bbl           X.XX   bbl/h
GSVOL                X.XX      Sm3           X.XX   Sm3/h
GSVOL                X.XX      Sbbl          X.XX   Sbbl/h
MASS                 X.XX      t             X.XX   t/h
NSVOL                X.XX      Sm3           X.XX   Sm3/h

================================================================================
```

3.1.14.2 Maintenance Report

The following report is generated on entry to and exit from maintenance mode. The last 5 reports are historically stored.

```
================================================================================
                     MAINTENANCE REPORT                     XX/XX/XXXX XX:XX:XX
================================================================================
STREAM  1                              X

            CUMULATIVE        MAINTENANCE             FLOW RATE
GUVOL                X.XX              X.XX    m3             X.XX   m3/h
GUVOL                X.XX              X.XX    bbl            X.XX   bbl/h
GSVOL                X.XX              X.XX    Sm3            X.XX   Sm3/h
GSVOL                X.XX              X.XX    Sbbl           X.XX   Sbbl/h
MASS                 X.XX              X.XX    t              X.XX   t/h
NSVOL                X.XX              X.XX    Sm3            X.XX   Sm3/h

================================================================================
```


3.1.14.3 Multi-Minute Report

The following report is generated at multi-minute end. The last 60 reports are historically stored.

```
================================================================================
                     MULTI-MINUTE REPORT (BASETIME XX:XX)    XX/XX/XXXX XX:XX:XX
================================================================================
STREAM  1

            CUMULATIVE        PERIOD                    FLOW RATE
GUVOL                X.XX                X.XX    m3             X.XX   m3/h
GUVOL                X.XX                X.XX    bbl            X.XX   bbl/h
GSVOL                X.XX                X.XX    Sm3            X.XX   Sm3/h
GSVOL                X.XX                X.XX    Sbbl           X.XX   Sbbl/h
MASS                 X.XX                X.XX    t              X.XX   t/h
NSVOL                X.XX                X.XX    Sm3            X.XX   Sm3/h

MTR PRESS     :     X.XXX  barg
MTR TEMP      :      X.XX  Deg.C
MTR DENS      :     X.XXX  kg/m3
BASE DENS     :     X.XXX  kg/m3
K-FACTOR      :    X.XXXX  pls/t
MTR FACTOR    :   X.XXXXX
BSW           :     X.XXX  %
RVP           :     X.XXX  barg
TVP           :     X.XXX  barg

GUVOL FR      :      X.XX  m3/h
GUVOL FR      :      X.XX  bbl/h
GSVOL FR      :      X.XX  Sm3/h
GSVOL FR      :      X.XX  Sbbl/h
MASS FR       :      X.XX  t/h
NSVOL FR      :      X.XX  Sm3/h

================================================================================
```

3.1.14.4 Hourly Report

The following report is generated each hour. The last 24 reports are historically stored.

```
================================================================================
                     HOURLY REPORT (BASETIME XX:XX)          XX/XX/XXXX XX:XX:XX
================================================================================
STREAM  1

            CUMULATIVE        PERIOD                  FLOW RATE
GUVOL                 X.XX              X.XX    m3              X.XX   m3/h
GUVOL                 X.XX              X.XX    bbl             X.XX   bbl/h
GSVOL                 X.XX              X.XX    Sm3             X.XX   Sm3/h
GSVOL                 X.XX              X.XX    Sbbl            X.XX   Sbbl/h
MASS                  X.XX              X.XX    t               X.XX   t/h
NSVOL                 X.XX              X.XX    Sm3             X.XX   Sm3/h

MTR PRESS     :      X.XXX  barg
MTR TEMP      :       X.XX  Deg.C
MTR DENS      :      X.XXX  kg/m3
BASE DENS     :      X.XXX  kg/m3
K-FACTOR      :     X.XXXX  pls/t
MTR FACTOR    :    X.XXXXX
BSW           :      X.XXX  %
RVP           :      X.XXX  barg
TVP           :      X.XXX  barg

GUVOL FR      :       X.XX  m3/h
GUVOL FR      :       X.XX  bbl/h
GSVOL FR      :       X.XX  Sm3/h
GSVOL FR      :       X.XX  Sbbl/h
MASS FR       :       X.XX  t/h
NSVOL FR      :       X.XX  Sm3/h

================================================================================
```

3.1.14.5 Daily Report

The following report is generated each day at 06:00. The last 35 daily reports are historically stored.

The daily report has the same layout as the hourly report, however, it contains daily figures.

3.1.14.6 Provisional Batch Report

The provisional batch report is generated automatically at batch end (following the batch stop command). The last 5 batch reports are stored.

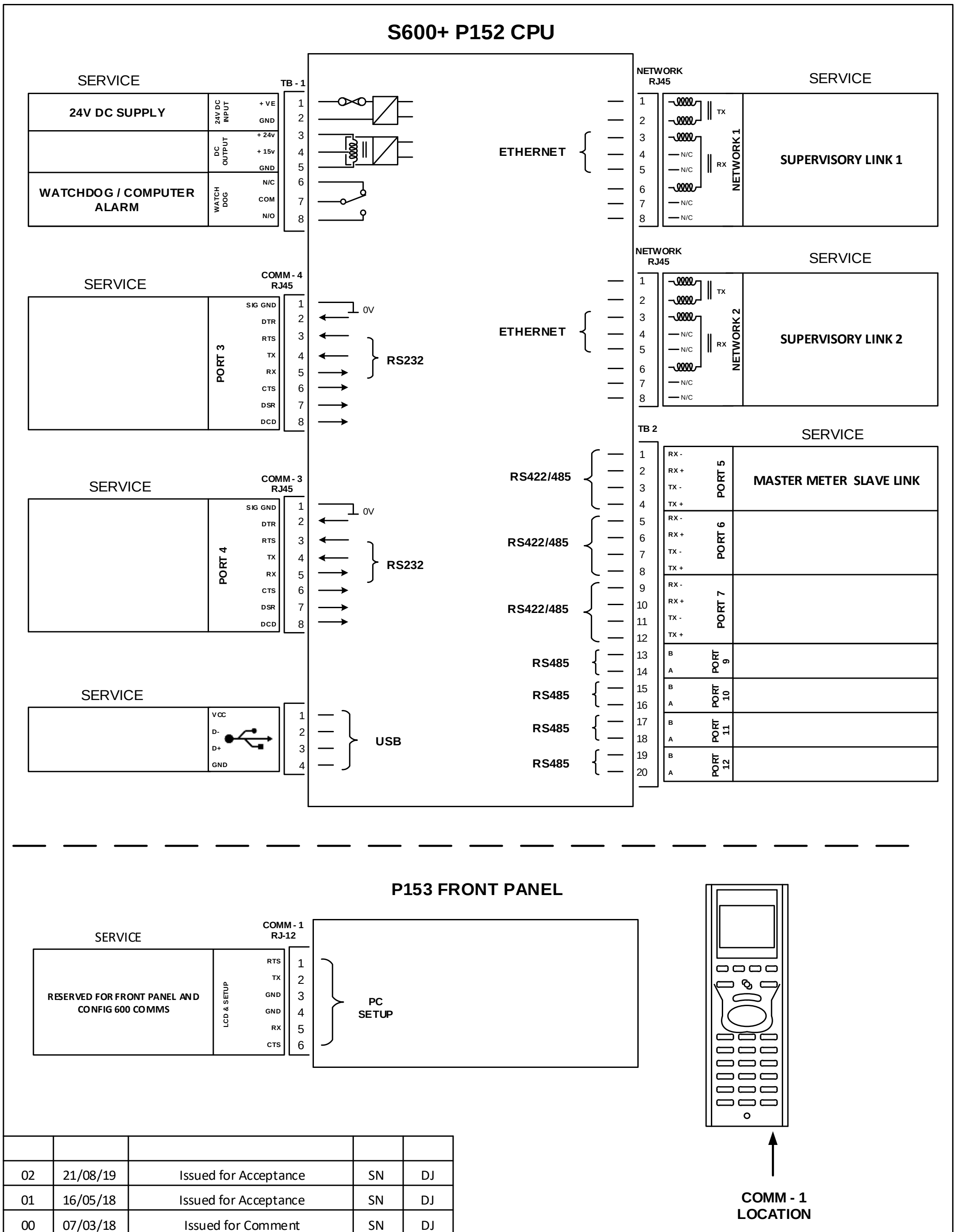
```
================================================================================
                              PROVISIONAL TICKET         XX/XX/XXXX XX:XX:XX
================================================================================
STREAM  1

            CUMULATIVE        PERIOD                  FLOW RATE
GUVOL                X.XX               X.XX    m3              X.XX   m3/h
GUVOL                X.XX               X.XX    bbl             X.XX   bbl/h
GSVOL                X.XX               X.XX    Sm3             X.XX   Sm3/h
GSVOL                X.XX               X.XX    Sbbl            X.XX   Sbbl/h
MASS                 X.XX               X.XX    t               X.XX   t/h
NSVOL                X.XX               X.XX    Sm3             X.XX   Sm3/h

MTR PRESS     :     X.XXX  barg
MTR TEMP      :      X.XX  Deg.C
MTR DENS      :     X.XXX  kg/m3
BASE DENS     :     X.XXX  kg/m3
K-FACTOR      :    X.XXXX  pls/t
MTR FACTOR    :   X.XXXXX
BSW           :     X.XXX  %
RVP           :     X.XXX  barg
TVP           :     X.XXX  barg

GUVOL FR      :      X.XX  m3/h
GUVOL FR      :      X.XX  bbl/h
GSVOL FR      :      X.XX  Sm3/h
GSVOL FR      :      X.XX  Sbbl/h
MASS FR       :      X.XX  t/h
NSVOL FR      :      X.XX  Sm3/h

BSW           :     X.XXX  %
BASE DENS     :     X.XXX  kg/m3

================================================================================
```

3.1.14.7 Final Batch Report

The final batch report is generated automatically at batch end (following the batch terminate command). The last 5 batch reports are stored.

```
================================================================================
                              FINAL TICKET                 XX/XX/XXXX XX:XX:XX
================================================================================
STREAM  1

            CUMULATIVE        PERIOD                  FLOW RATE
GUVOL                X.XX                X.XX    m3              X.XX   m3/h
GUVOL                X.XX                X.XX    bbl             X.XX   bbl/h
GSVOL                X.XX                X.XX    Sm3             X.XX   Sm3/h
GSVOL                X.XX                X.XX    Sbbl            X.XX   Sbbl/h
MASS                 X.XX                X.XX    t               X.XX   t/h
NSVOL                X.XX                X.XX    Sm3             X.XX   Sm3/h

MTR PRESS     :     X.XXX  barg
MTR TEMP      :      X.XX  Deg.C
MTR DENS      :     X.XXX  kg/m3
BASE DENS     :     X.XXX  kg/m3
K-FACTOR      :    X.XXXX  pls/t
MTR FACTOR    :   X.XXXXX
BSW           :     X.XXX  %
RVP           :     X.XXX  barg
TVP           :     X.XXX  barg

GUVOL FR      :      X.XX  m3/h
GUVOL FR      :      X.XX  bbl/h
GSVOL FR      :      X.XX  Sm3/h
GSVOL FR      :      X.XX  Sbbl/h
MASS FR       :      X.XX  t/h
NSVOL FR      :      X.XX  Sm3/h

BSW           :     X.XXX  %
BASE DENS     :     X.XXX  kg/m3

RECALC    (R)

================================================================================
```

3.1.15 I/O Schedule



02	21/08/19	Issued for Acceptance	SN	DJ
01	16/05/18	Issued for Acceptance	SN	DJ
00	07/03/18	Issued for Comment	SN	DJ
ISS	DATE	CHANGE	CHKD	APPD

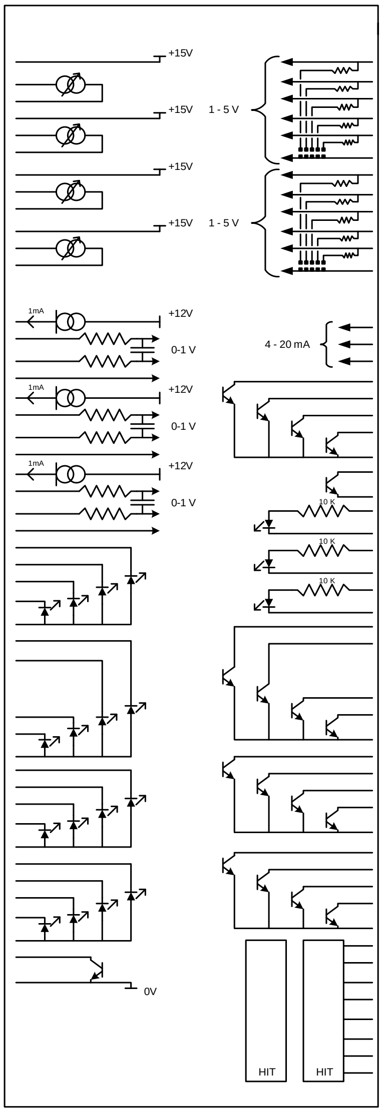
REF No.	ORIG SCALE	NTS	A4
	DIMENSIONS IN		N/A

TITLE	FLOBOSS S600+ I/O CONNECTION SCHEDULES	DRAWING NUMBER CORAL STREAM SH 1 OF 3	ISSUE 02

P144 IIO 1

SKT A

SERVICE		SKT A
FCV OUTPUT	SUPPLY	1
	DAC 1 OUTPUT	14
	GROUND	2
	SUPPLY	15
	DAC 2 OUTPUT	3
	GROUND	16
	SUPPLY	4
	DAC 3 OUTPUT	17
	GROUND	5
	SUPPLY	18
	DAC 4 OUTPUT	6
	GROUND	19



SKT A		SERVICE
8	ADC 1+	FCV FEEDBACK POSITION
21	ADC 2+	
9	ADC 3+	
22	ADC 4+	
10	ADC 5+	
20	GND	
11	ADC 6+	
24	ADC 7+	
12	ADC 8+	
25	ADC 9+	
13	ADC 10+	
23	GND	

SKT B

SERVICE		SKT B
	I+	4
	PRT 1 V+	1
	INPUT V-	21
	I-	24
	I+	5
	PRT 2 V+	2
	INPUT V-	22
	I-	25
	I+	6
	PRT 3 V+	3
	INPUT V-	23
	I-	26
INLET MOV OPEN STATUS	DIG IN 1-	13
INLET MOV CLOSED STATUS	DIG IN 2-	14
INLET MOV L/R STATUS	DIG IN 3-	15
INLET MOV FAULT STATUS	DIG IN 4-	16
+24v	COMMON + VE	17
PROVER MOV OPEN STATUS	DIG IN 5-	18
PROVER MOV CLOSED STATUS	DIG IN 6-	19

SKT B		SERVICE
8	ADC 11+	
7	ADC 12+	
20	GND	
30	PULSE OUT 1+	
31	PULSE OUT 2+	
32	PULSE OUT 3+	
33	PULSE OUT 4+	
35	PULSE 1-4 COM	
34 12	+ PULSE - OUTPUT 5	
9 27	+ DENSITY - INPUT 1	
10 28	+ DENSITY - INPUT 2	
11 29	+ DENSITY - INPUT 3	
36	DIG OUT 1+	INLET MOV OPEN COMMAND
37	DIG OUT 2+	INLET MOV CLOSE COMMAND

SKT C

SERVICE		SKT C
PROVER MOV L/R STATUS	DIG IN 7-	19
PROVER MOV FAULT STATUS	DIG IN 8-	18
+24v	COMMON + VE	17
OUTLET MOV OPEN STATUS	DIG IN 9-	16
OUTLET MOV CLOSED STATUS	DIG IN 10-	15
OUTLET MOV L/R STATUS	DIG IN 11-	14
OUTLET MOV FAULT STATUS	DIG IN 12-	13
+24v	COMMON + VE	12
	DIG IN 13-	11
	DIG IN 14-	10
	DIG IN 15-	9
	DIG IN 16-	8
+24v	COMMON + VE	7
RAW PULSE BUS	RAW PULSE + OUTPUT -	24 5

SKT C		SERVICE
37	DIG OUT 3+	PROVER MOV OPEN COMMAND
36	DIG OUT 4+	PROVER MOV CLOSE COMMAND
35	COMMON GND	0v
34	DIG OUT 5+	PROVER MOV DRAIN SOLENOID
33	DIG OUT 6+	OUTLET MOV OPEN COMMAND
32	DIG OUT 7+	OUTLET MOV CLOSE COMMAND
31	DIG OUT 8+	OUTLET MOV DRAIN SOLENOID
30	COMMON GND	0v
29	DIG OUT 9+	
28	DIG OUT 10+	
27	DIG OUT 11+	
26	DIG OUT 12+	
25	COMMON GND	0v
4 23	+ DUAL PULSE - CHANNEL 1	CORIOLIS PULSES A
3 22	+ DUAL PULSE - CHANNEL 2	CORIOLIS PULSES B
2 21	+ DUAL PULSE - CHANNEL 3	
1 20	+ DUAL PULSE - CHANNEL 4	

ISS	DATE	CHANGE	CHKD	APPD
02	21/08/19	Issued for Acceptance	SN	DJ
01	16/05/18	Issued for Acceptance	SN	DJ
00	07/03/18	Issued for Comment	SN	DJ

REF No.	ORIG SCALE	NTS	A4
	DIMENSIONS IN		N/A

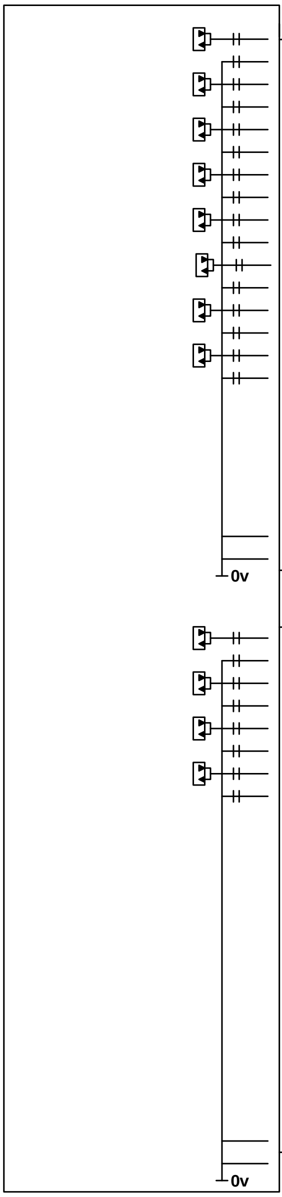
TITLE: **FLOBOSS S600+ I/O CONNECTION SCHEDULES**

DRAWING NUMBER: **CORAL STREAM**

SH 2 OF 3

ISSUE: 02

P188 IIO 2 - HART



SKT A - J5 25 'D' Male

Pin	Signal	SERVICE SENSOR 1	SENSOR 2
1	CHANNEL 1 +	STREAM PRESSURE TX-A	
14	CHANNEL 1 -		
2	CHANNEL 2 +	STREAM PRESSURE TX-B	
15	CHANNEL 2 -		
3	CHANNEL 3 +	STREAM TEMPERATURE TX-A	
16	CHANNEL 3 -		
4	CHANNEL 4 +	STREAM TEMPERATURE TX-B	
17	CHANNEL 4 -		
5	CHANNEL 5 +		
18	CHANNEL 5 -		
6	CHANNEL 6 +	PROVER MOV CAVITY PRESSURE (LEAK)	
19	CHANNEL 6 -		
7	CHANNEL 7 +	OUTLET MOV CAVITY PRESSURE (LEAK)	
20	CHANNEL 7 -		
8	CHANNEL 8 +		
21	CHANNEL 8 -		
10	COM2 TXD	NOT IN USE	
11	COM2 RXD		
23	COM2 RTS		
24	COM2 CTS		
12	NC		
13	NC		
25	NC		
9	GND		
22	GND		

SKT B - J6 25 'D' Female

Pin	Signal	SERVICE SENSOR 1	SENSOR 2
13	CHANNEL 9 +		
25	CHANNEL 9 -		
12	CHANNEL 10 +		
24	CHANNEL 10 -		
11	CHANNEL 11 +		
23	CHANNEL 11 -		
10	CHANNEL 12 +		
22	CHANNEL 12 -		
9	NC		
21	NC		
8	NC		
20	NC		
7	NC		
19	NC		
6	NC		
18	NC		
4	COM3 TXD	NOT IN USE	
3	COM3 RXD		
1	NC		
2	NC		
14	NC		
15	NC		
16	NC		
5	GND		
17	GND		

ISS	DATE	CHANGE	CHKD	APPD
02	21/08/19	Issued for Acceptance	SN	DJ
01	16/05/18	Issued for Acceptance	SN	DJ
00	07/03/18	Issued for Comment	SN	DJ

REF No.	ORIG SCALE	NTS	A4
	DIMENSIONS IN		N/A

TITLE **FLOBOSS S600+ I/O CONNECTION SCHEDULES**

DRAWING NUMBER **CORAL STREAM**

ISSUE 02

3.1.16 Alarm System

3.1.16.1 Introduction

The FloBoss S600+ flow computer operates a comprehensive alarm system, a summary of which is detailed below:

3.1.16.2 Visual Indication

Front Panel Display

An alarm indicator LED on the front panel is used to indicate status, as detailed below:

Flashing red	unaccepted alarm is present
Constant red	alarm condition is present; however, this has been accepted
Constant green	no alarms present

3.1.16.3 Potential Alarms

The alarms raised by the FloBoss S600+ flow computer are split into four alarm groups as detailed below:

1. Computer Alarm Group
   A fault has occurred which may affect the integrity of the flow computer, e.g. RAM FAIL

2. System Alarm Group
   A fault has occurred which affect the integrity of the system, e.g. ADC DEVICE ERROR

3. Process Alarm Group
   A process variable is outside its defined limits.

4. Telemetry Alarm Group
   Those individual alarms that are transferred to the Emerson Metering Suite via telemetry.

Note: An alarm can only be assigned to one group.

3.1.16.4 Alarm Outputs

Each alarm group has an alarm output. The alarm output indicates that one or more alarms within that group are in alarm state. The computer, system and process alarm outputs are transferred to the Emerson Metering Suite MSC via telemetry.

3.1.16.5 Alarms Transferred to the MSC

The following alarms will be transmitted to the MSC:

LF Low Flow
M Maintenance Mode

Item	Alarm	Description	Suppress	
			LF	M
SYS HOST	COLD ST	The S600+ has performed a cold start, all settings have been re-initialised.		
SYS HOST	WARM ST	The S600+ has performed a warm start, settings have been retained.		
SYS HOST	BATT FAIL	The battery voltage detected is below 2.8 volts and should be replaced as soon as possible.		
STR01 MTR PRESS TXA	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 MTR PRESS TXB	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 MTR TEMP TXA	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 MTR TEMP TXB	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device		Y

Item	Alarm	Description	Suppress	
			LF	M
		2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		
STR01 O-VLV CAVITY PRESS	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 P-VLV CAVITY PRESS	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 FCV POS	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. Device Open (flow computer HW failure) 2. Under-Range (input signal <3.5mA) 3. Over-Range (input signal >20.5mA) 4. Scaling (Transducer engineering scale invalid)		Y
STR01 CORIOLIS	BAD PULSE	The number of bad pulses exceeds the alarm threshold	Y	Y
STR01 MASS FR	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STR01 BASE DENS	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STR01 CCF	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STR01 K-FACTOR	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STR01 MTR FACTOR	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y

Item	Alarm	Description	Suppress	
			LF	M
STR01	PROVE REQUIRED	The current conditions require a master meter proof to be performed	Y	Y
STR01 BSW	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STR01 RVP	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STR01 TVP	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STR01 MTR PRESS	DISCRP	TXA value and TXB value differ by more than discrep limit	Y	Y
	L	Dual transmitter In-Use Value less than low limit	Y	Y
	H	Dual transmitter In-Use Value greater than high limit	Y	Y
STR01 MTR TEMP	DISCRP	TXA value and TXB value differ by more than discrep limit	Y	Y
	L	Dual transmitter In-Use Value less than low limit	Y	Y
	H	Dual transmitter In-Use Value greater than high limit	Y	Y
STR01 MTR DENS	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STR01 I-VLV	ILLEGAL	Valve status inputs indicate the is not in a valid position (i.e. Not open, closed or moving)		
	MOVE FAIL	Valve has not reached the required position within the allowable timeout period		
	FAULT	Valve fault input is set		
STR01 O-VLV	ILLEGAL	Valve status inputs indicate the is not in a valid position (i.e. Not open, closed or moving)		
	SEAL FAIL	Valve has not sealed during the test period		
	MOVE FAIL	Valve has not reached the required position within the allowable timeout period		
	FAULT	Valve fault input is set		
STR01 P-VLV	ILLEGAL	Valve status inputs indicate the is not in a valid position (i.e. Not open, closed or moving)		
	SEAL FAIL	Valve has not sealed during the test period		
	MOVE FAIL	Valve has not reached the required position within the allowable timeout period		
	FAULT	Valve fault input is set		

Additional alarms will exist at the FloBoss S600+ to diagnose faults. The following alarm outputs are transmitted to the MSC indicating that one or more alarms within a particular group are present.

Item	Alarm	Description	Suppress	
			LF	M
ALM GRP 1	COMP	One or more ‘computer group’ alarms are present.		
ALM GRP 2	PROC	One or more ‘process group’ alarms are present.		
ALM GRP 3	SYS	One or more ‘system group’ alarms are present.		

Table – Liquid Coriolis Flow Computer Application Alarms To MSC

3.2 Master Meter Flow Computer Application

3.2.1 Introduction

This section details the functionality of the FloBoss S600+ Flow Computer fitted with the Coral condensate master meter application software. This application software is developed specifically to meet the requirements of the Coral master meter and sampling system. This application will be installed in each of the master meter stream flow computer (*TT2220*FQI3551).

The flow computer can operate as a stand-alone flow computer, or form an integral part of a metering system.

The flow computer application is for a single stream.

3.2.2 Summary of Functions

A summary of the functions provided by this flow computer are detailed below:

1. Count the pulses received on the raw pulse bus, from the stream being proved.
2. Measure the frequency and quantity of pulses from the master Coriolis meter, to ISO6551 level A.
3. Measure the pressure of the liquid in the master meter line using dual transducers fitted in the master meter line (HART).
4. Measure the temperature of the liquid in the master meter line using dual temperature elements fitted in the master meter line (HART).
5. Calculate the mass flowrate for the master meter from the frequency of pulses received from the Coriolis meter and the meter k-factor.
6. Perform a maximum of 20 runs to produce a K-Factor from the required number of good runs (default 5) using statistical or traditional methods (operator selection).
7. Provide a tolerance for the repeatability between proof runs.
8. Measure the pressure of the liquid in the sampler fast loop using dual transducers fitted in the fast loop (HART).
9. Measure the temperature of the liquid in the sampler fast loop using dual temperature elements fitted in the fast loop (HART).
10. Measure the density of the liquid utilising two transducers fitted at the fast loop (frequency).
11. Calculate base density from the observed (measured) density.
12. Calculate correction factors for the effects of temperature and pressure on the liquid at the master meter.

13. Calculate a meter density from base density.
14. Calculate the gross uncorrected volume, gross standard volume and mass flow rates.
15. Calculate cumulative, current/previous totals for the following periods; hourly and daily for gross uncorrected volume, gross standard volume and mass. The end of day hour will be 06:00.
16. Control and monitor the master meter outlet motor operated valve, including cavity pressure (HART) for leak detection purposes.
17. Control (4-20mA) and monitor (4-20mA) the master meter flow control valve.
18. Control and monitor a sampler system comprising two samplers with common sample cans.
19. Measure the sample can 1 level utilising a transducer fitted at sample can 1 (4-20mA).
20. Measure the sample can 2 level utilising a transducer fitted at sampler can 2 (4-20mA).
21. Measure the sampler pump 1 casing temperature utilising a transducer fitted to the pump (4-20mA)
22. Measure the sampler pump 2 casing temperature utilising a transducer fitted to the pump (4-20mA)
23. Measure the sampler loop flowrate using a VA Meter fitted to the loop (4-20mA)
24. Measure the sampler pump 1 filter differential pressure utilising a transmitter fitted across the filter (4-20mA)
25. Measure the sampler pump 2 filter differential pressure utilising a transmitter fitted across the filter (4-20mA)
26. Provide serial data links (RS485) to two watercut meters to continually read the % water and download the density temperature and observed density for compensation purposes (AutoZero).
27. Measure the Reid Vapour Pressure (RVP) utilising an analyser fitted in the fast loop (RS485).
28. Measure the True Vapour pressure (TVP) utilising an analyser fitted in the fast loop (RS485).
29. Provide an RS422 communications link to the stream flow computers.
30. Provide an operator interface through which relevant data may be viewed and/or modified.
31. Operate a comprehensive alarm system.
32. Provide a maintenance mode facility.

33. Provide dual Ethernet links to transfer data to, and receive commands from the Emerson Metering Suite system using Modbus TCP/IP.

34. Operate a flow computer watchdog alarm output to provide an indication of a critical failure at the flow computer (power fail or active group 1 alarm).

3.2.3 Field Inputs/Outputs

The input/output requirements of the flow computer application are such that the following hardware is required:

1 off P152 (CPU Board)
1 off P144 (I/O Board)
1 off P188 (Hart Board)
1 off P154 (Prover Board)

The flow computer has the following I/O signals:

Inputs

Description	Type
Stream on Prove (Raw Pulse Bus)	Single Pulse
Master Meter Coriolis	Dual Pulse
Sampler Observed Density A	Frequency
Sampler Observed Density B	Frequency
Master Meter Pressure (TX-A)	HART
Master Meter Pressure (TX-B)	HART
Master Meter Temperature (TX-A)	HART
Master Meter Temperature (TX-B)	HART
Sampler Pressure (TX-A)	HART
Sampler Pressure (TX-B)	HART
Sampler Temperature (TX-A)	HART
Sampler Temperature (TX-B)	HART
Outlet Valve Cavity Pressure	HART
Inlet Header Pressure	HART
Inlet Header Temperature	HART
Sampler VA Flow Meter	4-20mA
Sample Can 1 Level	4-20mA
Sample Can 2 Level	4-20mA
Sampler Pump 1 Temperature	4-20mA
Sampler Pump 2 Temperature	4-20mA
Sampler Pump 1 Filter DP	4-20mA
Sampler Pump 2 Filter DP	4-20mA
Flow Control Valve Position	4-20mA
MM Outlet Valve Open Status	Digital
MM Outlet Valve Close Status	Digital
MM Outlet Valve Local / Remote Status	Digital
MM Outlet Valve Fault Status	Digital
Sampler Pump 1 Running Status	Digital
Sampler Pump 1 Available Status	Digital
Sampler Pump 1 Test Position	Digital

Description	Type
Sampler Pump 2 Running Status	Digital
Sampler Pump 2 Available Status	Digital
Sampler Pump 2 Test Position	Digital
Panel PSU_A Fail	Digital
Panel PSU_B Fail	Digital
Panel TSTAT_A High	Digital
Panel TSTAT_B High	Digital
Panel ESW_A Fail	Digital
Panel ESW_B Fail	Digital
RVP Enclosure Pressure Low	Digital
TVP Enclosure Pressure Low	Digital

Table – Master Meter Flow Computer Application Inputs

Outputs

Description	Type
Flow Control Valve	4-20mA
Outlet Valve Open Control	Digital
Outlet Valve Close Control	Digital
Outlet Valve Drain Control	Digital
Sample Grab Output	Digital
Cell Sampler Select	Digital
Sample Can Select	Digital
Sampler Pump 1 Start Command	Digital
Sampler Pump 1 Stop Command	Digital
Sampler Pump 1 Trip Command	Digital
Sampler Pump 2 Start Command	Digital
Sampler Pump 2 Stop Command	Digital
Sampler Pump 2 Trip Command	Digital

Table – Master Meter Flow Computer Application Outputs

Communications

Description	Protocol / Com Port	Additional Information
Emerson Metering Suite Link 1	Ethernet Modbus TCP/IP	
Emerson Metering Suite Link 2	Ethernet Modbus TCP/IP	
Prover Modbus Master Link (link to stream flow computers)	Modbus RTU -Serial RS422 – Com5	19200 baud, 8 data bits, 1 stop bit, no parity
Water Cut Meter A Modbus Master Link (link to water cut meter)	Modbus RTU -Serial RS485 – Com9	9600 baud, 8 data bits, 2 stop bit, no parity
Water Cut Meter B Modbus Master Link (link to water cut meter)	Modbus RTU -Serial RS485 – Com10	9600 baud, 8 data bits, 2 stop bit, no parity
RVP Analyser Master Link	Modbus RTU – Serial – RS485 – Com11	9600 baud, 8 data bits, 1 stop bit, no parity
TVP Analyser Master Link	Modbus RTU – Serial – RS485 – Com12	9600 baud, 8 data bits, 1 stop bit, no parity

Table – Master Meter Flow Computer Application Communications

3.2.4 Coriolis Meter

The flow computer monitors a dual pulse train from the Coriolis meter to ISO6551 Level A. The pulse trains are known as A and B and are out of phase with each other. The pulses should arrive at the flow computer correctly sequenced i.e. ABABABA, and any pulse that does not form part of a good sequence e.g. ABAABA is classed as a bad pulse. The pulse train is reconstituted within the flow computer to form a good pulse count. Bad pulses are separately counted to form a bad pulse count.

Each pulse represents a mass increment; the number of pulses per unit mass is the K-factor (pls/tonne).

When calculating the relevant mass increment correction for bad pulses is performed.

The frequency of the pulse train is used to calculate a mass flow rate.

3.2.4.1 Bad Pulses

A bad pulse counter is used to indicate the number of bad pulses received.

A delta bad pulse counter is incremented at the same rate as the bad pulse counter when the pulse frequency is greater than the keypad entered error check frequency.

An alarm is raised when the delta bad pulse count exceeds the keypad entered bad pulse threshold.

The delta bad pulse count will automatically reset whenever:

1. The pulse frequency equals or falls below the error check frequency.
2. The number of continuous good pulses exceeds the keypad enterable reset threshold.

3.2.4.2 Definitions

Pulse Input Count:
This is the number of pulses that have occurred.

Pulse Frequency:
This is the input frequency in Hz.

Low Frequency Cut Off:
Pulse frequencies below this value (Hz) will cause the flow rate and input frequency to be set to zero.

Note: there is a separate low flow cut-off for alarm suppression and maintenance mode interlocks.

Live/Check Keypad Frequency:
When the FloBoss S600+ is in Maintenance mode, a check frequency can be selected and a keypad frequency entered.

3.2.4.3 K-Factor

For this application, a single K-Factor (pls/tonne) is used at all times.
The following alarms and events are raised on the parameter:

Alarms	Value High Value Low

3.2.4.4 Meter Factor

There are two modes available for the 'In Use' Meter Factor:

Mode	Description
CALCULATED	This uses the meter factor calculated from the 10-point linearisation curve
KEYPAD	This uses the keypad value, selectable from the front panel

Table – Master Meter Flow Computer Application Meter Factor Modes

The mode will not change until another mode is manually selected.

The 10-point linearisation curve of raw mass flow rate against Meter Factor will be populated during commissioning with the results of the calibration laboratory test for the Coriolis meter specific to the stream. Subsequent laboratory calibrations shall result in the 10-point linearisation curve being updated.

The following alarms and events are raised on the parameter:

Alarms	Value High Value Low
Events	Each Mode change (i.e. Calculated to Keypad) etc.

3.2.5 Hart Interface

The P188 (HART board) uses bell 202 modem circuits to communicate to the transmitter loops. The HART Interface consists of twelve independent Hart loop scanners, which can scan up to fifty sensors.

When the FloBoss S600+ is powered up, certain data such as range is read and stored in the on-board database. The module then continues to read the process variable and status from each sensor in turn on the loop at a rate of about 0.5 seconds per sensor.

If a sensor with address zero is connected to the loop, this sensor only will be scanned on that loop.

If a sensor configured in the 4-20mA mode (address 0) is connected to the loop the process variables will be scanned approximately every 0.5 seconds. All other sensors on the loop will be ignored. The data will be available at the first sensor address on the loop.

If the sensors on the loop have an address other than 0 then the loop scan time will be 0.5 seconds times the number of sensors plus 0.5 seconds.

When a sensor is disconnected or faulty the most significant bit in the reply second status byte will be set high. The bits in this status code are defined as follows:

Bit 0 – Primary variable out of limits
Bit 1 – Variable (not primary) out of limits
Bit 2 – Analogue output saturated
Bit 3 – Output current fixed
Bit 4 – Reserved
Bit 5 – Cold start
Bit 6 – Configuration changed
Bit 7 – Device malfunction

A device error is associated with any of the following alarms:

1. A communications failure
2. Primary variable out of limits
3. Analog output saturated
4. Device malfunction

Note: In this configuration the transmitters are point to point, therefore all transmitter addresses should be configured with address 0.

3.2.6 Transmitter Modes

3.2.6.1 Dual Hart Transmitter

Dual transmitter handling is provided for the following:

Master Meter Pressure/Master Meter Temperature/Sampler Pressure/Sampler Temperature

The operating mode for each transmitter pair can be selected from one of the following:

Mode	Description
KEYPAD	When Keypad is selected the Dual TX keypad value will be used in the metering calculations.
TX-A	When TXA is selected the TXA value will be used in the metering calculations provided that the TXA operating mode is measured. If the TXA operating mode is not measured then the TXB value will be selected provided that the TXB operating mode is measured. If the TXB operating mode is not measured the Dual TX operating mode will default to the Dual TX keypad value. The mode will automatically switch back to TXA or TXB when the TXA or TXB operating mode returns to measured depending which becomes available first, however, the TXA value will be used as soon as the TXA operating mode returns to measured.
TX-B	When TXB is selected the TXB value will be used in the metering calculations provided that the TXB operating mode is measured. If the TXB operating mode is not measured then the TXA value will be selected provided that the TXA operating mode is measured. If the TXA operating mode is not measured the Dual TX operating mode will default to the Dual TX keypad value. The mode will automatically switch back to TXB or TXA when the TXB or TXA operating mode returns to measured depending which becomes available first, however, the TXB value will be used as soon as the TXB operating mode returns to measured.

Table – Master Meter Flow Computer Application Dual TX Modes

Discrepancy checking is performed between the TXA and TXB values, with an alarm being raised if the transmitter values differ by more than the keypad limit for more than a configurable amount of time.

Alarms	Value High
	Value Low
	Value Discrepancy
Events	Each Mode change (TXA to TXB) etc.

3.2.6.2 Master Meter Pressure/Temperature, Outlet Valve Cavity Pressure, Sampler Pressure/Temperature, Inlet Header Pressure/Temperature

The flow computer receives eleven HART signals which are converted to:

Master Meter Pressure TXA in barg
Master Meter Pressure TXB in barg
Master Meter Temperature TXA in Deg C
Master Meter Temperature TXB in Deg C
Outlet Valve Cavity Pressure in barg
Sampler Pressure TXA in barg
Sampler Pressure TXB in barg
Sampler Temperature TXA in Deg C
Sampler Temperature TXB in Deg C
Inlet Header Pressure in barg
Inlet Header Temperature in Deg C

The operating mode for the transmitters can be selected from one of the following:

Mode	Description
MEASURED	This uses the process variable read from the HART transmitter, selectable from the front panel
KEYPAD	*This uses the keypad value, selectable from the front panel*
LASTGOOD-F	When the HART input signal has failed (Device Error), the last good value is used. This can only be selected by the FloBoss S600+, while in MEASURED mode. If the input signal returns to a non-failed state, the measured value is used and the relevant mode shows MEASURED.

Table – Master Meter Flow Computer Application HART Modes

A transducer fail (device error) is associated with any of the following alarms:

1. A communications failure
2. Primary variable out of limits
3. Analog output saturated
4. Device malfunction

The following alarms and events are raised on each input.

Alarms	Value High Value Low Transmitter Device Error
Events	Each Mode change (measured to keypad) etc.

3.2.6.3 Sampler and FCV Analogue Inputs

The flow computer receives eight 4-20mA signals which are converted to:

Sampler Loop Flowrate in m3/h
Sampler Can 1 Level in Litres
Sampler Can 2 Level in Litres
Sampler Pump 1 Temperature in Deg C
Sampler Pump 2 Temperature in Deg C
Sampler Pump 1 Differential Pressure in mbar
Sampler Pump 2 Differential Pressure in mbar
FCV Feedback Position in %

The operating mode for the transmitters can be selected from one of the following:

Mode	Description
MEASURED	This uses the derived calculated value from the incoming analogue signal, selectable from the front panel
KEYPAD	*This uses the keypad value, selectable from the front panel*
LASTGOOD-F	When the transducer input signal has failed (Device Error), the last good value is used. This can only be selected by the FloBoss S600+, while in MEASURED mode. If the input signal returns to a non-failed state, the measured value is used and the relevant mode shows MEASURED.

Table – Master Meter Flow Computer Application 4-20mA Modes

A transducer fail (device error) is associated with any of the following alarms:

Alarm	Cause
Device Open	Flow computer hardware failure.
Under-Range	Input signal < 3.5mA
Over-Range	Input signal > 20.5mA
Scaling	Transducer engineering scale invalid.

Table – Master Meter Flow Computer Application 4-20mA Alarms

The following alarms and events are raised on each input.

Alarms	Value High
	Value Low
	Transmitter Device Error
Events	Each Mode change (measured to keypad) etc.

3.2.6.4 Observed (Measured) Density

The Observed Density in kg/m3 is calculated from the densitometer frequency using the densitometer calibration constants, temperature and pressure.

There are four modes available for the 'In Use' Observed Density:

Mode	Description
DENS-A	Uses the value obtained from Densitometer A. In the event of a transducer failure the value used will automatically default to the other transducer. In the event that both transducers fail then the mode will automatically default to the keypad value.
DENS-B	Uses the value obtained from Densitometer B. In the event of a transducer failure the value used will automatically default to the other transducer. In the event that both transducers fail then the mode will automatically default to the keypad value.
AVERAGE	Uses the value obtained from the average of Densitometer A and Densitometer B. In the event of a transducer failure the value used will automatically default to the other transducer. In the event that both transducers fail then the mode will automatically default to the keypad value.
KEYPAD	*This uses the keypad value, selectable from the front panel*
LASTGOOD-F	Both densitometer input signal failed (Device Error), the lastgood value is used. This can only be selected by the FloBoss S600+, while in DENS-A, DENS-B or AVERAGE mode. If an input signal returns the mode will automatically switch back to DENS-A or DENS-B depending upon which recovers first. The system will not automatically select the AVERAGE mode of operation.

Table – Master Meter Flow Computer Application Observed Density Modes

A discrepancy alarm is raised if the Dens-A value differs from the Dens-B value by more than the operator entered discrepancy limit (kg/m3) for more than the operator entered discrepancy time (seconds).

The following alarms and events are raised on the parameter:

Alarms	Value High Value Low Fail A Fail B
Events	Each Mode change (i.e. Dens-A to Keypad) etc.

3.2.7 Process Variable Modes

3.2.7.1 Base Density

The Base Density in kg/m3 is calculated from the observed density using the correction factors for the effect of temperature and pressure on the liquid at the densitometer.

There are two modes available for the ‘In Use’ Base Density:

Mode	Description
CALCULATED	This uses the calculated base density
KEYPAD	This uses the keypad value, selectable from the front panel

Table – Master Meter Flow Computer Application Base Density Modes

The following alarms and events are raised on the parameter:

Alarms	Value High Value Low
Events	Each Mode change (i.e. Calculated to Keypad) etc.

3.2.7.2 Combined Correction Factor (CCF)

The Combined Correction Factor is calculated from the base density using the meter pressure and meter temperature.

There are two modes available for the ‘In Use’ CCF:

Mode	Description
CALCULATED	This uses the calculated combined correction factor (meter to base volume correction)
KEYPAD	This uses the keypad value, selectable from the front panel

Table – Master Meter Flow Computer Application CCF Modes

The following alarms and events are raised on the parameter:

Alarms	Value High Value Low
Events	Each Mode change (i.e. Calculated to Keypad) etc.

3.2.7.3 Meter Density

The Meter Density in kg/m3 is calculated from the base density using the combined correction factor.

There are two modes available for the 'In Use' Meter Density:

Mode	Description
CALCULATED	This uses the calculated meter density
KEYPAD	This uses the keypad value, selectable from the front panel

Table – Master Meter Flow Computer Application Meter Density Modes

The following alarms and events are raised on the parameter:

Alarms	Value High Value Low
Events	Each Mode change (i.e. Calculated to Keypad) etc.

3.2.7.4 Base Sediment & Water (BSW)

The Base Sediment Water (BSW) in % is read from the watercut analysers via RS485 Modbus data links.

There are four modes available for the 'In Use' BSW:

Mode	Description
MEAS-A	This uses the process variable read from Watercut Meter A, selectable from the front panel.
MEAS-B	This uses the process variable read from Watercut Meter B, selectable from the front panel.
AVERAGE	This uses an average of the process variables read from Watercut Meter A and Watercut Meter B, selectable from the front panel
KEYPAD	This uses the keypad value, selectable from the front panel

Table – Master Meter Flow Computer Application BSW Modes

When any of the above modes are manually selected, the mode will not change until another mode is manually selected.

The following alarms and events are raised on the parameter:

Alarms Value High
Value Low

Events Each Mode change (i.e. Meas-A to Keypad) etc.

3.2.7.5 RVP Analyser

The Reid Vapour Pressure (RVP), in barg, is read from the RVP analyser via a RS485 Modbus data link.

There are two modes available for the 'In Use' RVP:

Mode	Description
MEASURED	This uses the process variable read from the RVP analyser, selectable from the front panel.
KEYPAD	This uses the keypad value, selectable from the front panel

Table – Master Meter Flow Computer Application RVP Modes

When any of the above modes are manually selected, the mode will not change until another mode is manually selected.

The following alarms and events are raised on the parameter:

Alarms Value High
Value Low

Events Each Mode change (i.e. Measured to Keypad) etc.

3.2.7.6 TVP Analyser

The True Vapour Pressure (TVP), in barg, is read from the TVP analyser via a RS485 Modbus data link.

There are two modes available for the 'In Use' TVP:

Mode	Description
MEASURED	This uses the process variable read from the TVP analyser, selectable from the front panel.
KEYPAD	This uses the keypad value, selectable from the front panel

Table – Master Meter Flow Computer Application TVP Modes

When any of the above modes are manually selected, the mode will not change until another mode is manually selected.

The following alarms and events are raised on the parameter:

Alarms	Value High Value Low
Events	Each Mode change (i.e. Measured to Keypad) etc.

3.2.8 Block Valves

A motor operated outlet valve is monitored and controlled. The flow computer will action valve movement commands either entered locally or downloaded over telemetry.

3.2.8.1 Valve Position Inputs

The flow computer monitors two digital input signals (per valve) in order to determine the valve position.

The interpretation of the two inputs is shown below. A ‘1’ indicating a contact closure/active signal and a ‘0’ indicating an open contact/inactive signal.

CAS2 is the valve ‘Closed’ limit switch and OAS2 is the valve ‘Open’ limit switch.

For correct operation the Valve Closed limit switch remains closed until the closed stop is reached, and the Open limit switch remains closed until the Open stop is reached, this means that both inputs are active when the valve is moving and ensures that a valve illegal alarm is raised due to a wiring fault.

Actual Valve Position	Limit Switch OAS2	Limit Switch CAS2	Flow Computer Open Input	Flow Computer Closed Input
OPEN	0	1	1	0
MOVING	1	1	1	1
CLOSED	1	0	0	1
FAULT	0	0	0	0

Table – Master Meter Flow Computer Application Valve Inputs

To achieve this operation, it is necessary for the Closed Limit Switch CAS2 to be wired to the flow computer valve open input, and the Open Limit Switch OAS2 to be wired to the flow computer valve closed input.

3.2.8.2 Valve Position Outputs

Two digital outputs are used to command the valve to move. Following a request to command the valve to open the ‘valve open’ digital output is activated for 2 seconds. Following a request to command the valve to close, the ‘valve close’ digital output is activated for 2 seconds. The digital outputs are not activated if the valve local/remote status input is not set.

A valve timeout alarm is raised if the valve position inputs do not reflect the required position within a configurable timeout period. The timer is activated when the flow computer actions the command.

3.2.8.3 Integrity Checking

The outlet valve is equipped with a drain solenoid to drain the valve cavity, and a pressure transmitter to subsequently monitor the valve cavity for leaks.

When the valve reaches the closed position, a digital output will be set for a configurable drain time (default 10s) to activate the drain solenoid and reduce the valve cavity pressure. Once the cavity has been drained and sealed, a snapshot will be taken of the valve cavity pressure. The valve pressure transmitter shall then monitor the pressure within the cavity for a configurable test time (default 300s). If the monitored valve cavity pressure increases beyond the snapshot pressure plus an operator entered allowable limit, an MOV leak fail alarm will be raised. The test time is configurable. Once the test time has expired the flow computer will no longer monitor the valve for leaks.

3.2.9 Flow Control Valve

A 4-20mA output is provided to drive a flow control valve (FCV).

The 3-term proportional, integral and derivative (PID) controller has the following control settings, which are under operator control.

Auto/Man Mode	**Manual** The output is set to the manual position value. **Auto** The controller output is adjusted in order that the measured process variable, mass flow rate, maintains the required set point value.
Control Action	**Forward** The output is increased if the measured process variable is below the set point value. **Reverse** The output is decreased if the measured process variable is above the set point value.
Set Point Tracking	**On** When the controller is in auto mode the manual position will be set equal to the current output value. When the controller is in manual mode the set point will be set equal to the process variable. **Off**

When the controller is in auto mode the manual position will remain unchanged.
When the controller is in manual mode the set point will remain unchanged and the integral action value is set to the value required in order to maintain the current position.

Clamp High **%**
This value limits the output's maximum value i.e. 100%.

Clamp Low **%**
This value limits the output's minimum value i.e. 0%.

Slew Limit **%/s**
This value limits the maximum rate of change of the output signal. If the value = 0 it is not used, i.e. the control output is passed straight through to the DAC output.

Ramp Rate **m3/h/s**
This value limits the maximum rate at which the set point used in the PID algorithm tracks the required set point. If the value = 0 it is not used, i.e. the required set point is used directly by the PID algorithm.

Manual Position **%**
When the controller mode is 'manual' the controller output is set to this value.

Set Point **m3/h**
This represents the desired process condition and when the controller mode is auto the controller output is modified in order that the measured process variable equals this value.

PV Range **m3/h**
This is the range of the process variable measuring instrument.

Proportional Band **%**
This is the amount that the process variable must change as a percentage of the process variable range that will cause the controller to cover its full range.

Integral Time **s**
This is the time taken for integral action to reproduce the same change in the controller output as that caused by the proportional action for a given sustained step discrepancy i.e. the controller output is proportional to the amount of time the error is present. If the integral action time is zero, the integral action is set to zero.

Derivative Time **s**
This is the time taken for derivative action to reproduce the same change in the controller output as that caused by the proportional action when the discrepancy is changing at a constant rate i.e. the

controller output is proportional to the rate of change of the error. If the derivative action time is zero, the derivative action is set to zero.

Output Position **%**
This represents the controller output signal, which drives the analogue output device.

PID algorithm

The PID controller output signal is calculated from the sum of the proportional, integral and derivative actions:

Output = P + I + D

Each term depends on Error and Gain:

If the control action is Forward:

Error = Process Variable – Set Point

If the control action is Reverse:

Error = Set Point – Process Variable

If the proportional gain is applied to all terms:

Gain = 1 / PV Range * 100 / Proportional Band * 100

If the algorithm is processed at regular intervals:

Delta Time = Current Time – Previous Time

Proportional Action (P)

The degree of proportional action (P) is directly proportional to the error and is calculated from the formula:

P = Error * Gain

A high proportional action produces a large change in the output for a given change in the error, a low proportional action produces a small change in the output, that is the action is less sensitive. If the proportional gain is too high the system becomes unstable.

A suitable initial value for flow control is 200 %.

Integral Action (P)

The degree of integral action (I) is calculated from the formula:

I (new) = I (previous) + (Error * Gain * Delta time) / (Integral Action Time)

Integral action provides a cumulative offset that eliminates residual error.

A suitable initial value for flow control is 3 seconds.

Derivative Action (D)

The degree of derivative action (D) is calculated from the formula:

D = (Error – (2 * Old Error) + Very Old Error) * Gain * Derivative Action Time / Delta Time

Derivative action responds to rate of change in successive errors. The action is sensitive and anything greater than a small value of the derivative action time can make the system unstable.

A suitable initial value for flow control is 0.01 seconds.

3.2.10 Operational Settings

3.2.10.1 Modes of Operation

During normal operation, the flow computer is automatically set to one of the following modes:

Status	Description
UNDEFINED	The status task is not running correctly.
MAINT	The flow computer has been placed into Maintenance mode.
VLV-ILLEGAL	One of the monitored valves is indicating an unknown/illegal position.
UNHEALTHY	There is not a flow path through the meter run AND the measured mass flow rate is above the low flow cut-off limit.
ONLINE	There is a flow path through the meter AND the measured mass flow rate is above the low flow cut-off limit.
OFFLINE	The measured mass flow rate is below the low flow cut-off limit.

Table – Master Meter Flow Computer Application Stream Status

3.2.10.2 Maintenance Mode

The flow computer should be put into Maintenance Mode when calculation or calibration tests are to be carried out on the computer.

The following selection is available Set / Clear.

Entry of Maintenance Mode is only possible if the stream status is Off-Line, and the outlet and prover off take valves are in the closed position.

To Exit Maintenance Mode the Off-Line interlock checks must be satisfied.

Whist in Maintenance Mode the following occurs:

1. Alarm digital outputs (except Watchdog) are forced to the no alarm position.
2. Totalisation pulse outputs are inhibited. (Not used in this configuration)
3. Any flow registered is totalized into separate maintenance totalisers.

A maintenance report is generated automatically at change of maintenance mode status.

3.2.10.3 Security

Each object at the flow computer is allocated an associated security level between 0 and 9. The user cannot modify data assigned level 0.

Access to security level 1 requires the security bit link to be fitted on the P152 CPU board. Any user can change data assigned Level 9.

In order to change data when utilising the front panel display the user must enter a password of the required security level or higher.

The following passwords are the startup defaults:

Security Level	Password
0	N/A
1	1111*
2	2222
3	3333
4	4444
5	5555
6	6666
7	7777
8	8888
9	9999

* requires that security bit link fitted (P3) on P152 CPU board.

Table – Master Meter Flow Computer Application Security

3.2.11 Totalisation

The primary flow measurement is mass total, which is derived from the Coriolis meter pulse count. The mass increment is used to form gross uncorrected volume and gross standard volume increments. These increments are likewise added to the relevant totals.

3.2.11.1 Totalisation Registers

Each total is held as two discrete values, a displayed total and a remainder. Increments are added into the remainder and are only added into the displayed total when the remainder overflows.

The displayed total is truncated, i.e. not rounded up.

e.g.	Actual Total	=	10.57382
	Displayed Total	=	10.5
	Remainder	=	0.07382

The value of each total is held in triple registers for increased security.

The displayed total and the remainder are held in discrete registers. A total of six registers are used in order to hold the value of each total.

A partial total fail alarm is raised if the value held in one register differs from the other two associated registers. A total fail alarm is raised if the value held in each of the three associated registers differ.

The cumulative total (i.e. non-resettable) represents the quantity of the relevant parameter that has been registered by the flow computer since its totals were last reset excluding any amount which has passed whilst the flow computer has been in maintenance mode.

The daily total represents the quantity of the relevant parameter that has been registered by the computer since the last day end occurred excluding any amount which has passed whilst the flow computer has been in maintenance mode.

The maintenance total represents the quantity of the relevant parameter that has been registered by the computer while it has been operating in maintenance mode.

Note: The maintenance totals are transferred to a previous maintenance mode total on exit of maintenance mode and the current maintenance mode total is reset to zero.

3.2.11.2 Base Time and Period Frequency

Base Time

The Base Time specifies the hour at which the 24 hr day ends. The value can be in the range 0-23 hrs. The Base Time for this application is set to 06:00 hrs.

At day end the current daily displayed total is copied into the previous day displayed total and the current daily displayed total is set to zero. It should be noted that the associated current daily remainder (which is not displayed) would remain unchanged.

The following example shows the transfer of totals over a five day period, the values shown are those recorded just after the relevant base times.

Day	Sum of Daily Increments	Cumulative Total Displayed	Remainder	Daily Total	Previous Day Total
1	10.57382	10.5	0.07382	10.5	0.0
2	11.66431	22.2	0.03813	11.7	10.5
3	7.14692	29.3	0.08505	7.1	11.7
4	8.19030	37.5	0.07535	8.2	7.1
5	9.99999	47.5	0.07534	10.0	8.2

Multi-Minute Frequency

The flow computer maintains separate current and previous multi-minute totals. The value entered as the Period Frequency determines when Current Period totals are transferred to Previous Period totals registers.

The multi-minute interval is defaulted to 1 for the Coral project.

Period Frequency

The flow computer also maintains separate current and previous period totals. The value entered as the Period Frequency determines when Current Period totals are transferred to Previous Period totals registers.

The Period Frequency is configured using the PC Setup program and for this system, four periods are configured:

Period 1	Hourly
Period 2	Daily

3.2.11.3 Displayed Total Resolution

The maximum number of characters available in order to display a total is 15, 14 if a decimal point is utilised.

This application has all cumulative totals format of 9 before, 2 after.

The resolution selected for each cumulative total should be such that the time interface between rollover of each total, when operating at maximum flow rate (i.e. relevant flow rate Hi Limit) is greater than three calendar months.

The cumulative total continues to increase until an additional increment produces a total, which cannot be displayed within the relevant totals resolution. At this time a total 'ROLLOVER' will occur, an example of which is given below.

Example of a total with a resolution of seven digits before the decimal point and one digit after the decimal point.

Current Total (Pre-Rollover)	9999998.6
Increment	3.2
Actual Total (if no Roll-Over)	100000001.8
Displayed Total (with Roll-Over)	1.8

A common rollover alarm is raised each time a total rolls over to zero.

3.2.11.4 Totals Reset

A 'total reset' will reset all totals and therefore this function should be treated with extreme caution.

The totals may be reset by selecting 'cold start' from the System Run Mode display. This enters the "Cold Start" menu, which is separate from the standard metering displays. A high-level security code must be entered to access the "Cold Start" menu from the System Run Mode display and also to execute the "Reset Totals" command.

3.2.12 Calculations

3.2.12.1 Standard References

Name	Standard Reference
Flow Rate	General Mathematical Principles
Totalisation	General Mathematical Principles
Liquid Volume Correction	API CH11.1 – 2004 / ASTM D1250-04 / IP 200/04 and Addendum 1 2007

Table – Master Meter Flow Computer Application Standard Reference

3.2.12.2 Mass Flow Rate (t/h)

$$qm = \frac{f}{KF} \times MF \times 3600 \times TPF$$

$$TPF = 1 + Ktpfl(P - Ptcal)$$

Where:

f = Coriolis meter frequency (Hz)
KF = K-Factor (pls/tonne)
MF = Meter Factor
TPF = Totals pressure correction factor
Ktpfl = Totals pressure correction factor constant
P = Meter pressure (barg)
Ptcal = Totals calibration pressure (barg)

3.2.12.3 Gross Uncorrected Volume Flow Rate (m^3/h)

$$qv = \frac{qm}{\rho_m} \times 1000$$

Where:

qm = Mass flow rate (t/h)
ρ_m = Meter density (kg/m^3)

3.2.12.4 Gross Uncorrected Volume Flow Rate (bbl/h)

$$qv_{bbl} = qv \times 6.28981057$$

Where:

qv = Gross uncorrected volume flow rate (m^3/h)

3.2.12.5 Gross Standard Volume Flow Rate (Sm^3/h)

$$qv_{std} = qv \times CCF_m$$

Where:
qv = Gross uncorrected volume flow rate (m^3/h)
CCF_m = Combined correction factor

3.2.12.6 Gross Standard Volume Flow Rate (Sbbl/h)

$$qv_{stdbbl} = qv_{std} \times 6.28981057$$

Where:
qv_{std} = Gross standard volume flow rate (m^3/h)

3.2.12.7 Mass Increment (tonnes)

$$\Delta Qm = \frac{\Delta pls}{KF} \times MF \times TPF$$

$$TPF = 1 + Ktpfl(P - Ptcal)$$

Where:
Δpls = Number of pulses from the Coriolis meter in the sample period
KF = K-Factor (pls/tonne)
MF = Meter Factor
TPF = Totals pressure correction factor
$Ktpfl$ = Totals pressure correction factor constant
P = Meter pressure (barg)
$Ptcal$ = Totals calibration pressure (barg)

3.2.12.8 Gross Uncorrected Volume Increment (m^3)

$$\Delta Qv = \frac{\Delta Qm}{\rho_m} \times 1000$$

Where:
ΔQm = Mass increment (tonnes)
ρ_m = Meter density (kg/m^3)

3.2.12.9 Gross Uncorrected Volume Increment (bbl)

$$\Delta Qv_{bbl} = \Delta Qv \times 6.28981057$$

Where:

ΔQv = Gross uncorrected volume increment (m^3)

3.2.12.10 Gross Standard Volume Increment (Sm^3)

$$\Delta Qv_{std} = \Delta Qv \times CCF_m$$

Where:
ΔQv = Gross volume increment (m^3)
CCF_m = Combined correction factor

3.2.12.11 Gross Standard Volume Increment (bbl)

$$\Delta Qv_{stdbbl} = \Delta Qv_{std} \times 6.28981057$$

Where:
ΔQv_{std} = Gross standard volume increment (m^3)

3.2.12.12 Observed (Measured) Density (kg/m^3)

Solartron Equation:

$$D_I = K_0 + K_1 T + K_2 T^2$$

$$D_T = D_I\left(1 + K_{18}\left(t_d - t_{cal}\right)\right) + K_{19}\left(t_d - t_{cal}\right)$$

$$K_{20} = K_{20A} + K_{20B}\left(p_d - p_{cal}\right) + K_{20C}\left(p_d - p_{cal}\right)^2$$

$$K_{21} = K_{21A} + K_{21B}\left(p_{dA} - p_{cal}\right) + K_{21C}\left(p_d - p_{cal}\right)^2$$

$$D_P = D_T\left(1 + K_{20}\left(p_d - p_{cal}\right)\right) + K_{21}\left(p_d - p_{cal}\right)$$

$$D_{PT} = D_P\left(1 + K_{22}\left(t_d - t_{cal}\right)\left(p_d - p_{cal}\right)\right) + K_{23}\left(t_d - t_{cal}\right)\left(p_d - p_{cal}\right)$$

Where:

D_I	=	Uncorrected measure density (kg/m^3)
T	=	Period of the signal from the densitometer (usecs)
D_T	=	Measured density corrected for temperature (kg/m^3)
t_d	=	Temperature of the liquid at the densitometer (deg C)
t_{cal}	=	Densitometer calibration temperature (deg C)
D_P	=	Temperature corrected density corrected for pressure (kg/m^3)
p_d	=	Pressure of the liquid at the densitometer (barg)
p_{cal}	=	Densitometer calibration pressure (barg)
D_{PT}	=	Temperature and pressure corrected density (kg/m^3)

K_0, K_1, K_2, K_{18}, K_{19}, K_{20A}, K_{20B}, K_{20C}, K_{21A}, K_{21B}, K_{21C}, K_{22} *and* K_{23} are densitometer calibration constants.

The densitometer calibration pressure should always be 1.0 bar i.e. Not operator enterable.

Note: The limits for the densitometer period must be accepted along with the densitometer constants after operator entry.

3.2.12.13 Correction Factor for the Effect of Temperature and Pressure on the Liquid (Observed to Base)

Method to correct a density from metric observed (densitometer) conditions to metric base reference API section 11.1.7.2

Step 1 – Convert the observed temperature (deg C to deg F), metric base temperature (deg C to deg F) and observed pressure (barg to psig) reference API section 11.1.5.1

$$t_d^* = 1.8 \times T_d + 32$$

Where:

t^*_d	=	Observed (densitometer) temperature (deg F)
T_d	=	Observed (densitometer) temperature (deg C)

$$t_{std}^* = 1.8 \times T_{std} + 32$$

Where:

t^*_{std}	=	Base temperature (deg F)
T_{std}	=	Base temperature (deg C)

The observed pressure can be converted to metric units:

$$P^* = \frac{P_d}{0.06894757}$$

Where:

P^*	=	Observed (densitometer) pressure (psig)
P_d	=	Observed (densitometer) pressure (barg)

Step 2 – Calculate the correction factors for the density at 60 deg F corresponding to the metric base density reference API section 11.1.6.2. The pressure correction need not be calculated since the metric base pressure barg is the same as the base pressure in psig.

$$\rho^* = \rho_{60} \left\{ 1 + \frac{EXP[A(1+0.8A)] - 1}{1 + A(1+1.6A)B} \right\}$$

Where:

$$A = \frac{\delta_{60}}{2} \left[\left(\frac{K_0}{\rho_{60}} + K_1 \right) \frac{1}{\rho_{60}} + K_2 \right]$$

$$B = \frac{2K_0 + K_1 \rho_{60}}{K_0 + (K_1 + K_2 \rho_{60}) \rho_{60}}$$

ρ^*	=	Base density shifted to IPTS-68 60 deg F basis (kg/m^3)

ρ_{60} = Base density at 60 deg F and 0 psig (kg/m^3)
δ_{60} = Temperature shift value (deg F) = 0.01374979457
K_0 = Liquid specific constants ((kg^2/m^6)/deg F)
K_1 = Liquid specific constants ((kg/m^3)/deg F)
K_2 = Liquid specific constants (/deg F)

$$\alpha_{60} = \left(\frac{K_0}{\rho^*} + K_1\right)\frac{1}{\rho^*} + K_2$$

Where:
α_{60} = Coefficient of thermal expansion of the liquid (/deg F)
K_0 = Liquid specific constants ((kg^2/m^6)/deg F)
K_1 = Liquid specific constants ((kg/m^3)/deg F)
K_2 = Liquid specific constants (/deg F)
ρ^* = Metric base density corrected to 60 deg F (kg/m^3)

$$\Delta t_{std} = t^*_{std} - 60.0068749$$

Where:
Δt_{std} = Metric base temperature minus the base temperature
t^*_{std} = IPTS-68 corrected metric base temperature (deg F)

$$CTL_{60} = EXP\left\{-\alpha_{60}\Delta t_{std}\left[1 + 0.8\alpha_{60}\left(\Delta t_{std} + \delta_{60}\right)\right]\right\}$$

Where:
CTL_{60} = Correction factor for the effect of temperature on the liquid
α_{60} = Coefficient of thermal expansion of the liquid (/deg F)
Δt_{std} = Alternate temperature (metric base) minus the base temperature
δ_{60} = Temperature shift value (deg F) = 0.01374979457

Step 3 – Calculate the density at alternate conditions reference API section 11.1.6.1

$$\rho^* = \rho_{60}\left\{1 + \frac{EXP\left[A(1 + 0.8A)\right] - 1}{1 + A(1 + 1.6A)B}\right\}$$

Where:

$$A = \frac{\delta_{60}}{2}\left[\left(\frac{K_0}{\rho_{60}} + K_1\right)\frac{1}{\rho_{60}} + K_2\right]$$

$$B = \frac{2K_0 + K_1\rho_{60}}{K_0 + \left(K_1 + K_2\rho_{60}\right)\rho_{60}}$$

ρ^* = Base density shifted to IPTS-68 60 deg F basis (kg/m^3)
ρ_{60} = Base density at 60 deg F and 0 psig (kg/m^3)

δ_{60} = Temperature shift value (deg F) = 0.01374979457
K_0 = Liquid specific constants ((kg^2/m^6)/deg F)
K_1 = Liquid specific constants ((kg/m^3)/deg F)
K_2 = Liquid specific constants (/deg F)

$$\rho_{60} = \frac{\rho_{15}}{CCF_{60}}$$

ρ_{60} = Base density at 60 deg F and 0 psig (kg/m^3)
ρ_{15} = Base density at 15 deg C and 0 psig (kg/m^3)
CCF_{60} = Combined correction factor at 60 deg F and 0 psig

$$\alpha_{60} = \left(\frac{K_0}{\rho^*} + K_1\right)\frac{1}{\rho^*} + K_2$$

Where:
α_{60} = Coefficient of thermal expansion of the liquid (/deg F)
K_0 = Liquid specific constants ((kg^2/m^6)/deg F)
K_1 = Liquid specific constants ((kg/m^3)/deg F)
K_2 = Liquid specific constants (/deg F)
ρ^* = Base density corrected to 60 deg F (kg/m^3)

$$\Delta t_d = t^*{}_d - 60.0068749$$

Where:
Δt_d = Alternate temperature minus the base temperature
$t^*{}_d$ = Alternate temperature (deg F)

$$C_{TL}^* = EXP\{-\alpha_{60}\Delta t[1 + 0.8\alpha_{60}(\Delta t + \delta_{60})]\}$$

Where:
$C^*{}_{TL}$ = CTL correcting base density at 60 deg F to observed conditions
α_{60} = Coefficient of thermal expansion of the liquid (/deg F)
Δt = Alternate temperature minus the base temperature
δ_{60} = Temperature shift value (deg F) = 0.01374979457

$$F_P^* = EXP\left(-1.9947 + 0.00013427 \times t^*{}_d + \frac{793920 + 2326.0 \times t^*{}_d}{\rho^{*2}}\right)$$

Where:
$F^*{}_P$ = Compressibility factor (/psi)
$t^*{}_d$ = Alternate temperature (deg F)
ρ^* = Base density corrected to 60 deg F (kg/m^3)

$$CPL_d = \frac{1}{1-(10^{-5}F_P^*(P^* - P_e))}$$

Where:

CPL_d = Correction factor for the effect of pressure on the liquid

F^*_P = Compressibility factor (/psi)

P^* = Alternate pressure (psig)

P_e = Equilibrium vapour pressure (psig)

Step 4 – Calculate the correction factors for the metric base temperature

$$CTL_d = \frac{C^*_{TL}}{CTL_{60}}$$

Where:

CTL_d = Correction factor for the effect of temperature on the liquid

C^*_{TL} = CTL correcting base density at 60 deg F to meter conditions

CTL_{60} = CTL correcting base density at 60 deg F to 15 deg C

$$F_P = \frac{F^*_P}{0.06894757}$$

Where:

F_P = Compressibility factor (/bar)

F^*_P = Compressibility factor (/psi)

Note: The Liquid specific constants used in the above equations depend upon the commodity group:

Product	Density Range	K_0	K_1	K_2
A CRUDE	610.6 <= ρ_{60} < 1163.5	341.0957	0.0	0.0
B REFINED	838.3127 <= ρ_{60} < 1163.5	103.8720	0.2701	0.0
B REFINED	787.5195 <= ρ_{60} < 838.3127	330.3010	0.0	0.0
B REFINED	770.3520 <= ρ_{60} < 787.5195	1489.0670	0.0	-0.0086840
B REFINED	610.6 <= ρ_{60} < 770.3520	192.4571	0.2438	0.0
D LUBE OILS	800.9 <= ρ_{60} < 1163.5	0.0	0.34878	0.0

Table – Liquid Coriolis Flow Computer Application Liquid Specific Constants

3.2.12.14 Base Density (kg/m^3)

$$\rho_{std} = \frac{\rho_d}{CTL_d \times CPL_d}$$

Where:
ρ_d = Observed (measured) density (kg/m^3)
CTL_d = Correction factor for the effect of temperature on the liquid
CPL_d = Correction factor for the effect of pressure on the liquid

3.2.12.15 Correction Factor for the Effect of Temperature and Pressure on the Liquid (Base to Meter)

Method to correct a density from metric base conditions to alternate conditions reference API section 11.1.7.1

For CCFm, CTLm and CPLm the alternate temperature and pressure are at the meter.

Step 1 – Convert the metric base temperature (deg C to deg F), alternate temperature (deg C to deg F) and alternate pressure (barg to psig) reference API section 11.1.5.1

$$t^*_{std} = 1.8 \times T_{std} + 32$$

Where:
t^*_{std} = Base temperature (deg F)
T_{std} = Base temperature (deg C)

$$t^* = 1.8 \times T + 32$$

Where:
t^* = Alternate temperature (deg F)
T = Alternate temperature (deg C)

The input temperatures must be altered to comply with the IPTS-68 temperature scale (reference API section 11.1.3.11), which was superseded by the ITS-90 temperature scale and generally results in the temperature shifting slightly. The shift in temperature is defined as:

$$\Delta_t = t_{c90} - t_{c68} \equiv \sum_{i=1}^{8} a_i \left(\frac{t_{c90}}{630} \right)^i$$

Where:
Δ_t = Difference between equivalent temperatures (deg C)
t_{c90} = Temperature in the ITS-90 temperature scale (deg C)
t_{c68} = Temperature in the IPTS-68 temperature scale (deg C)
a_i = Constant coefficients given in the a_i constants table

Firstly, calculate the scaled temperature for both the base and alternate temperatures using the following:

$$\tau = \frac{t_{c90}}{630}$$

Where:
τ = Scaled temperature value
t_{c90} = Temperature, ITS-90 scale (deg C)

$$\Delta_t = (a_1 + (a_2 + (a_3 + (a_4 + (a_5 + (a_6 + (a_7 + a_8\tau)\tau)\tau)\tau)\tau)\tau)\tau)\tau$$

Where:

i	a_i
1	-0.148759
2	-0.267408
3	1.080760
4	1.269056
5	-4.089591
6	-1.871251
7	7.438081
8	-3.536296

Table – Liquid Coriolis Flow Computer Application a_i Constants

This can be used to calculate the IPTS-68 corrected temperature:

$$t_{c68} = t_{c90} - \Delta_t$$

Where:
t_{c68} = IPTS-68 corrected base temperature (deg C)
t_{c90} = Temperature, ITS-90 scale (deg C)
Δ_t = Shift in base temperature

$$t_{f68} = 1.8t_{c68} + 32$$

Where:
t_{f68} = IPTS-68 corrected base temperature (deg F)
t_{c68} = IPTS-68 corrected base temperature (deg C)

Apply this to the given base and alternate temperatures to provide:

t^*_{std} = IPTS-68 corrected base temperature (deg F)
t^* = IPTS-68 corrected alternate temperature (deg F)

The alternate pressure can be converted to metric units:

$$P^* = \frac{P}{0.06894757}$$

Where:
P^* = Alternate pressure (psig)
P = Alternate pressure (barg)

Step 2 – Calculate the correction factors for the density at 60 deg F corresponding to the metric base density reference API section 11.1.6.2. The pressure correction need not be calculated since the metric base pressure barg is the same as the base pressure in psig.

$$\rho^{*} = \rho_{60}\left\{1+\frac{EXP\left[A(1+0.8A)\right]-1}{1+A(1+1.6A)B}\right\}$$

Where:

$$A=\frac{\delta_{60}}{2}\left[\left(\frac{K_0}{\rho_{60}}+K_1\right)\frac{1}{\rho_{60}}+K_2\right]$$

$$B=\frac{2K_0+K_1\rho_{60}}{K_0+\left(K_1+K_2\rho_{60}\right)\rho_{60}}$$

ρ^{*}	=	Base density shifted to IPTS-68 60 deg F basis (kg/m^3)
ρ_{60}	=	Base density at 60 deg F and 0 psig (kg/m^3)
δ_{60}	=	Temperature shift value (deg F) = 0.01374979457
K_0	=	Liquid specific constants ((kg^2/m^6)/deg F)
K_1	=	Liquid specific constants ((kg/m^3)/deg F)
K_2	=	Liquid specific constants (/deg F)

$$\rho_{60}=\frac{\rho_{15}}{CCF_{60}}$$

ρ_{60}	=	Base density at 60 deg F and 0 psig (kg/m^3)
ρ_{15}	=	Base density at 15 deg C and 0 psig (kg/m^3)
CCF_{60}	=	Base density at 60 deg F and 0 psig (kg/m^3)

Note: The iterative section of the calculation is demonstrated here as ρ60 is calculated by correcting the base density at 60 deg F, 0 psig. The iterative method is according to API section 11.1.6.2A. This requires the calculation of CCF60, shown below.

$$CCF_{60}=CTL_{60}\times CPL_{60}$$

While CPL60 is 1 since no correction is needed, CTL60 is worked out using parameters being calculated simultaneously.

Rounding set to OFF; in the flow computer application for the base to meter density calculation.

$$\alpha_{60}=\left(\frac{K_0}{\rho^{*}}+K_1\right)\frac{1}{\rho^{*}}+K_2$$

Where:

α_{60} = Coefficient of thermal expansion of the liquid (/deg F)
K_0 = Liquid specific constants ((kg^2/m^6)/deg F)
K_1 = Liquid specific constants ((kg/m^3)/deg F)
K_2 = Liquid specific constants (/deg F)
ρ^* = Metric base density corrected to 60 deg F (kg/m^3)

$$\Delta t_{std} = t^*_{std} - 60.0068749$$

Where:
Δt_{std} = Metric base temperature minus the base temperature
t^*_{std} = IPTS-68 corrected metric base temperature (deg F)

$$CTL_{60} = EXP\left\{-\alpha_{60}\Delta t_{std}\left[1+0.8\alpha_{60}\left(\Delta t_{std}+\delta_{60}\right)\right]\right\}$$

Where:
CTL_{60} = Correction factor for the effect of temperature on the liquid
α_{60} = Coefficient of thermal expansion of the liquid (/deg F)
Δt_{std} = Alternate temperature (metric base) minus the base temperature
δ_{60} = Temperature shift value (deg F) = 0.01374979457

Step 3 – Calculate the density at alternate conditions reference API section 11.1.6.1

$$\rho^* = \rho_{60}\left\{1+\frac{EXP\left[A\left(1+0.8A\right)\right]-1}{1+A\left(1+1.6A\right)B}\right\}$$

Where:

$$A = \frac{\delta_{60}}{2}\left[\left(\frac{K_0}{\rho_{60}}+K_1\right)\frac{1}{\rho_{60}}+K_2\right]$$

$$B = \frac{2K_0 + K_1\rho_{60}}{K_0 + \left(K_1 + K_2\rho_{60}\right)\rho_{60}}$$

ρ^* = Base density shifted to IPTS-68 60 deg F basis (kg/m^3)
ρ_{60} = Base density at 60 deg F and 0 psig (kg/m^3)
δ_{60} = Temperature shift value (deg F) = 0.01374979457
K_0 = Liquid specific constants ((kg^2/m^6)/deg F)
K_1 = Liquid specific constants ((kg/m^3)/deg F)
K_2 = Liquid specific constants (/deg F)

$$\rho_{60} = \frac{\rho_{15}}{CCF_{60}}$$

ρ_{60} = Base density at 60 deg F and 0 psig (kg/m^3)

ρ_{15} = Base density at 15 deg C and 0 psig (kg/m^3)
CCF_{60} = Combined correction factor at 60 deg F and 0 psig

$$\alpha_{60} = \left(\frac{K_0}{\rho^*} + K_1 \right) \frac{1}{\rho^*} + K_2$$

Where:
α_{60} = Coefficient of thermal expansion of the liquid (/deg F)
K_0 = Liquid specific constants ((kg^2/m^6)/deg F)
K_1 = Liquid specific constants ((kg/m^3)/deg F)
K_2 = Liquid specific constants (/deg F)
ρ^* = Base density corrected to 60 deg F (kg/m^3)

$$\Delta t = t^* - 60.0068749$$

Where:
Δt = Alternate temperature minus the base temperature
t^* = Alternate temperature (deg F)

$$C_{TL}^* = EXP\{-\alpha_{60}\Delta t[1 + 0.8\alpha_{60}(\Delta t + \delta_{60})]\}$$

Where:
C^*_{TL} = CTL correcting base density at 60 deg F to observed conditions
α_{60} = Coefficient of thermal expansion of the liquid (/deg F)
Δt = Alternate temperature minus the base temperature
δ_{60} = Temperature shift value (deg F) = 0.01374979457

$$F_P^* = EXP\left(-1.9947 + 0.00013427 \times t^* + \frac{793920 + 2326.0 \times t^*}{\rho^{*2}} \right)$$

Where:
F^*_P = Compressibility factor (/psi)
t^* = Alternate temperature (deg F)
ρ^* = Base density corrected to 60 deg F (kg/m^3)

$$CPL = \frac{1}{1 - (10^{-5} F_P^* (P^* - P_e))}$$

Where:
CPL = Correction factor for the effect of pressure on the liquid
F^*_P = Compressibility factor (/psi)
P^* = Alternate pressure (psig)
P_e = Equilibrium vapour pressure (psig)

Step 4 – Calculate the correction factors for the metric base temperature

$$CTL = \frac{C^*_{TL}}{CTL_{60}}$$

Where:
CTL = Correction factor for the effect of temperature on the liquid
C^*_{TL} = CTL correcting base density at 60 deg F to alternate conditions
CTL_{60} = CTL correcting base density at 60 deg F to 15 deg C

$$F_P = \frac{F^*_P}{0.06894757}$$

Where:
F_P = Compressibility factor (/bar)
F^*_P = Compressibility factor (/psi)

$$CCF = CPL \times CTL$$

Where:
CPL = Correction factor for the effect of pressure on the liquid
CTL = Correction factor for the effect of temperature on the liquid

Note: The Liquid specific constants used in the above equations depend upon the commodity group:

Product	Density Range	K_0	K_1	K_2
A CRUDE	610.6 <= ρ_{60} < 1163.5	341.0957	0.0	0.0
B REFINED	838.3127 <= ρ_{60} < 1163.5	103.8720	0.2701	0.0
B REFINED	787.5195 <= ρ_{60} < 838.3127	330.3010	0.0	0.0
B REFINED	770.3520 <= ρ_{60} < 787.5195	1489.0670	0.0	-0.0086840
B REFINED	610.6 <= ρ_{60} < 770.3520	192.4571	0.2438	0.0
D LUBE OILS	800.9 <= ρ_{60} < 1163.5	0.0	0.34878	0.0

Table – Liquid Coriolis Flow Computer Application Liquid Specific Constants

3.2.12.16 Meter Density (kg/m^3)

$$\rho_m = \rho_{std} \times CPL_m \times CTL_m$$

Where:
ρ_{std} = Base (standard) density (kg/m^3)
CPL_m = Correction factor for the effect of pressure on the liquid at the meter
CTL_m = Correction factor for the effect of temperature on the liquid at the meter

3.2.12.17 Linearisation

$$MF_{(calc)} = \left[\frac{(X - lowerX_p)(higherY_p - lowerY_p)}{(higherX_p - lowerX_p)} \right] + lowerY_p$$

Where:

$$X = \frac{f}{KF} \times 3600 \times TPF$$

Where:

f	=	Coriolis meter frequency (Hz)
KF	=	K-Factor (pls/t)
TPF	=	Totals pressure correction factor
X_p	=	Flow rate co-ordinates (t/h)
Y_p	=	Factor co-ordinates

3.2.12.18 Flow Weighted Averaging (FWA)

For each period type (i.e. hourly and daily) the task relies upon the elapsed primary total for the period, multiplied by the present FWA value to give the ‘weight’ for the average. The latest measure value (of the variable being averaged), multiplied by the elapsed total since the last FWA calculation was performed, gives the new ‘weight’ to be incorporated into the whole.

This is only calculated when the period total is greater than zero.

$$FWA_{Var(n)} = \frac{\left(P\_Total * \ FWA_{Var(p)}\right) + Var_{Meas} * Total_{Inc}}{P\_Total * Total_{Inc}}$$

Where:

$FWA_{Var(n)}$	New flow weighted average of variable (Var)
P_Total	Period total (t)
$FWA_{Var(p)}$	Previously calculated flow weighted average of the variable (Var)
Var_{Meas}	Current measured value of the variable (Var)
$Total_{Inc}$	Increase in period total since $FWA_{Var(p)}$ was calculated (t)

Note: The following variables are averaged in this configuration. An average is calculated for each period interval, e.g. minute, hourly and daily:

Master Meter Pressure (Barg)
Master Meter Temperature (DegC)
Meter Density (kg/m3)
Base Density (kg/m3)
K-Factor (pls/t)
Meter Factor

3.2.12.19 Time Weighted Averaging (TWA)

For each period type (i.e. hourly and daily) the task relies upon the elapsed time for the period, multiplied by the present TWA value to give the ‘weight’ for the average. The latest measured value (of the variable being averaged), multiplied by the elapsed time since the last TWA calculation was performed, gives the new ‘weight’ to be incorporated into the whole.

This is only calculated when the flow rate is greater than zero.

$$TWA_{Var(n)} = \frac{\left(P\_Elapsed * \ TWA_{Var(p)}\right) + Var_{Meas} * Time_{Inc}}{P\_Elapsed * Time_{Inc}}$$

Where:

$TWA_{Var(n)}$	New time weighted average of variable (Var)
P_Elapsed	Time since period began
$TWA_{Var(p)}$	Previously calculated flow weighted average of the variable (Var)
VAR_{Meas}	Current measured value of the variable (Var)
$Time_{Inc}$	Time elapsed since $TWA_{Var(p)}$ was calculated

Note: The following variables are averaged in this configuration. An average is calculated for each period interval, e.g. hourly and daily:

Gross Uncorrected Volume Flow Rate (m3/h)
Gross Uncorrected Volume Flow Rate (bbl/h)
Gross Standard Volume Flow Rate (Sm3/h)
Gross Standard Volume Flow Rate (Sbbl/h)
Mass Flow Rate (t/h)

3.2.13 Master Meter Proving

3.2.13.1 Pulse Measurement

The primary function of the master meter is to calculate an accurate Meter Factor for the meter under prove. The master meter does this by counting the number of pulses from the stream meter and equating them to a calculated mass determined from the number of pulses at the master meter during the prove.

The stream flow computer receives pulses from its meter and transmits a pulse train output (‘Raw Pulse Output’) which represents the number of pulses received, including bad pulse correction. The prove sequence commands the selected stream to turn on its Raw Pulse Output, which allows the prover computer to monitor the pulses from the meter.

When the proof run completes, the prover calculates a meter factor for the stream meter based on the master meter’s meter factor and the ratio of the corrected stream output pulse count and the master meter’s pulse count.

For a master meter prove, a run’s duration is determined by counting a set number of pulses (typically 10000).

Pulse Gating

The Prover module independently and synchronously snapshots and counts the master meter’s pulses together with the raw pulse input from the meter under prove.

3.2.13.2 Prove Sequence and Control

The prove control is implemented in two tasks, a ‘prover sequence’ task which sets up the prove environment, and a ‘run control’ task which drives the hardware, counts pulses and performs the meter factor calculations.

The sequence control entries and statuses are described below:

Field	Description
SEQ CTL	Operator commands for sequence control (outer loop): START TERMINATE ABORT CONTINUE
SEQ STR NO	Enter the designated stream number to be proved. For remote streams this could be the slave number in the Modbus master map.
SEQ STAGE INDEX	Shows current sequence stage as the sequence progresses.
SEQ STAGE PREV	Indicates the sequence stage number immediately prior to the current stage. If an abort occurs, use this value to help identify the source of the abort.
SEQ ABORT INDEX	In the event of a sequence error, an abort reason index is provided.

Table – Master Meter Flow Computer Application Sequence Control

The run control entries and statuses are described below:

Field	Description
RUN CTL	Operator commands for run control (inner loop): INITIALISE STABILISE START RUNS TERMINATE
RUN STAGE INDEX	Shows current run stage as the run progresses.
RUN ABORT INDEX	In the event of a run error, an abort reason index is provided.

Table – Master Meter Flow Computer Application Run Control

Following a successful prove, the prover computer passes the prove results to the relevant stream flow computer. However, the stream does not use the data until accepted either locally (at the FloBoss S600+) or via a supervisory computer.

Flow balancing

A standard PID algorithm performs flow control. The required flow rate set point may be operator entered or be a 'snapshot' of the current flow rate.

Flow balancing is only performed on streams which have their FCV mode set to “Auto”. The current states of all stream FCVs are recorded at the beginning of a proof and restored at the end of the proof.

No flow balancing is performed on a re-prove - the proof is performed at the existing flow rate.

The following parameters are used within the prove sequence whilst flow balancing:

Flow rate mode ‘Snapshot’ where the required flow rate is snapshot from the proving streams current flow rate. ‘Preset’ where the required flow rate is taken from the keypad (or downloaded) preset value.

Preset This value is used when the flow rate mode is set to preset.

O/P Initialisation This is the initial percentage open position of the FCV at the prover before flow is routed through the prover.

Tolerance Band This is the allowable band between the gross observed flow rate and the required flow rate.

Offset This is to compensate for flow resistance in the prover loop. This value is added to the preset or snapshot flow rate (depending upon mode of operation) to achieve the required flow rate.

Wait Time This is the maximum time allowed for the prover to achieve the required flow rate. If it does not achieve the required flow rate in this time, the prove will be aborted.

Hold Time This is the time the flow rate is required to stay within the tolerance band prior to the proof runs commencing.

Adj Interval This is the settling time between adjustments of the non-proving streams FCV’s allowed by the prover in order for process transients to exit the system.

Prove Sequence Stages

The prover sequence functions in stages. The sequence stages for the application's normal, reprove, and abort situations are shown below.

If an abort occurs either automatically or by operator command the prove sequence stage changes to Aborted. No further action is taken until the computer receives either a Continue command to initiate a re-prove or a Terminate command to finish the sequence.

Stage	Display	Description
0	IDLE	**Halted: Idle** Wait for a command to start the sequence, then proceed to the next stage.
1	INITIALISE	**Validate Prover Status and Initialise Sequence** Verify: 1. The proving stream is flowing. 2. Telemetry to the proving stream is OK. If conditions allow a prove to take place, then: 1. Copy the proving stream meter variables into the proving set. 2. Initialise proof run date (via Initialise command to run control Task). 3. Determine required proof flow rate from current rate (snapshot) or preset flow rate. 4. Save all the stream FCV settings. Proceed to next stage.
2	PULSES ON	**Turn Proving Stream Pulses On** Command all online streams to turn pulses off. Command proving stream to turn pulses on. Wait for pulses to be aligned then proceed to next stage. Abort: 1. If an Abort command is issued. 2. If no flow at proving stream. 3. If proving stream telemetry fails.
3	PRV FCV INIT	**Set Prover FCV** Set prover FCV manual output to initial output. Set prover FCV mode to manual. Set prover FCV set point to required flow rate + offset. Request proving stream FCV tracking to on. Request proving stream FCV mode to manual. Proceed to next stage. Abort: 1. If Abort command is issued. 2. If no flow at proving stream. 3. If proving stream telemetry fails.
4	PRV OPEN O-VLV	**Open Prover Outlet Valve** Request the prover outlet valve to open. Wait for the prover outlet valve to open and then proceed to next stage. Abort: 1. If Abort command is issued. 2. If no flow at proving stream. 3. If proving stream telemetry fails.
5	NPS CLOSE PRV I-VLV	**Close Non Proving Stream Prover Inlet Valves** Request all non proving streams close their prover inlet valves. Wait for the stream prover inlet valves to close and then proceed to next stage. Abort: 1. If Abort command is issued. 2. If no flow at proving stream. 3. If proving stream telemetry fails.

Stage	Display	Description
6	PS OPEN PRV I-VLV	**Open Proving Stream Prover Inlet Valve** Request the proving streams prover inlet valve to open. Wait for the proving streams prover inlet valve to open and then proceed to next stage. Abort: 1. If Abort command is issued. 2. If no flow at proving stream. 3. If proving stream telemetry fails. 4. If non proving streams prover inlet valves not closed.
7	PS CLOSE STR O-VLV	**Close Proving Stream Outlet Valve** Request the proving streams outlet valve to close. Wait for the proving streams outlet valve to close and then proceed to next stage. Abort: 1. If Abort command is issued. 2. If no flow at proving stream. 3. If proving stream telemetry fails. 4. If non proving streams prover inlet valves not closed. 5. If proving streams prover inlet valve is closed.
8	SEAT SPHERE A	Not used
9	NPS FCVS TRACK	**Set Flow Control For Non Proving Streams To Tracking** Request non proving streams tracking to on. Proceed to next stage. Abort: 1. If Abort command is issued. 2. If no flow at proving stream. 3. If proving stream telemetry fails. 4. If non proving streams prover inlet valves not closed. 5. If proving streams prover inlet valve is closed. 6. If proving streams outlet valve is not closed.

Stage	Display	Description
10	NPS FLOW BALANCE	**Flow Balancing For Non Proving Streams** Initiate flow balancing for non proving streams. Flow error = proving stream flow rate – (required flow rate + offset). If the error is within tolerance (tolerance band) then proceed to stage 14. If the error is too low then: – If there are no on line streams then go to abort stage. – Turn down value = abs (error / no. of on line non proving streams). – For each on line non proving stream, new set point = current rate – turn down. If all new set points (for each stream) are above the stream's low flow range then download the new set points and delay for adjustment prior to rechecking the flow error. If any new set point is less than the low flow range then go to the 'halted: operator to close a stream' stage 12 If the error is too high then: – If there are no on line streams then go to abort stage – Turn up value = error / no. of on line non proving streams – For each on line non proving stream, new set point = current rate + turn up If all new set points (for each stream) are below the stream's high flow range then download the new set points and delay for adjustment prior to rechecking the flow error. If any new set point is higher than the high flow range then go to the 'halted: operator to open a stream' stage 13 Proceed to next stage on achieving flow balance. Abort: 1. On balance timeout. 2. If Abort command is issued. 3. If no flow at proving stream. 4. If proving stream telemetry fails. 5. If non proving streams prover inlet valves not closed. 6. If proving streams prover inlet valve is closed. 7. If proving streams outlet valve is not closed.
11	RESERVED	Not used
12	CLOSE SUSPEND	**Halted: Operator To Close A Stream** Idle, awaiting a stream to be closed followed by an operator command. Go to the abort stage if 'abort' command is issued. Return to the flow balancing stage if 'continue' command issued.
13	OPEN SUSPEND	**Halted: Operator To Open A Stream** Idle, awaiting a stream to be opened followed by an operator command. Go to the abort stage if 'abort' command is issued. Return to the flow balancing stage if 'continue' command issued.
14	NPS FCVS_MANUAL	**Flow Control For Non Proving Streams To Manual** Request all non proving streams FCV tracking to off. Request all non proving stream FCV mode to manual. Proceed to the next stage. Abort: 1. If Abort command is issued. 2. If no flow at proving stream. 3. If proving stream telemetry fails. 4. If non proving streams prover inlet valves not closed. 5. If proving streams prover inlet valve is closed.

Stage	Display	Description
15	PRV FLOW STAB	**Hold Steady Flow Rate Through The Prover** Set prover FCV set point to required flow rate + offset. Set prover FCV mode to auto. Set prover FCV tracking to on. If the proving stream's flow rate is within tolerance for hold time, then proceed to next stage. Abort: 1. If proving stream flow rate exceeds tolerance. 2. If Abort command is issued. 3. If no flow at proving stream. 4. If proving stream telemetry fails. 5. If non proving streams prover inlet valves not closed. 6. If proving streams prover inlet valve is closed.
16	PRV FLOW/T/P STAB	**Stability Checks** Wait to achieve stability (via Stabilise command to run control task – stage 6) for temperatures, pressure rate of change. After achieving stability, wait for stability to be held for a user configurable time, then proceed to the next stage. Abort: 1. If stability not achieved. 2. If stability not maintained. 3. If Abort command is issued. 4. If no flow at proving stream. 5. If proving stream telemetry fails. 6. If non proving stream telemetry fails. 7. If the valves are not correctly aligned.
17	PRV FCV MANUAL	**Fix Prover FCV To Manual** Set prover FCV tracking off. Set prover FCV mode to manual. Proceed to next stage.
18	PROOF RUN	**Perform Proof Runs** Start the prove runs (via Start command to run control task). On success proceed to next stage. Abort: 1. If a run fails (such as a timeout for a sphere switch). 2. If Abort command is issued. 3. If no flow at proving stream. 4. If proving stream telemetry fails. 5. If non proving stream telemetry fails. 6. If the valves are not correctly aligned.
19	MF DOWNLOAD	**Meter Factor Download** Copy proof meter factor and flow rate into proving stream data points for subsequent telemetry download. Note that the stream metering calculations do not use these values until commanded separately. Proceed to the next stage.
20	AWAIT REPROVE	**Halted: Prove Runs Complete, Await Operator Command** Go to the next stage if the Terminate command is issued. Go to stage 29 (Re-check Stability) if the Continue (Reprove) command is issued.
21	SEAT SPHERE B	Not used
22	PS OPEN STR O-VLV	**Open Proving Stream Outlet Valve** Request the proving streams outlet valve to open. Wait for the proving streams outlet valve to open and then proceed to next stage. Abort: 1. If Abort command is issued. 2. If no flow at proving stream. 3. If proving stream telemetry fails. 4. If proving streams prover inlet valve is closed.

Stage	Display	Description
23	PS CLOSE PRV I-VLV	**Close Proving Stream Prover Inlet Valve** Request the proving streams prover inlet valve to close. Wait for the proving streams prover inlet valve to close and then proceed to next stage. Abort: 1. If Abort command is issued. 2. If no flow at proving stream. 3. If proving stream telemetry fails.
24	RESTORE FCVS	**Restore FCV Settings** Restore all the stream FCV settings and proceed to next stage.
25	PS PULSE OFF	**Turn Off Pulses** Command proving stream to turn pulses off. Wait for the pulses to be turned off then proceed to stage 0 (Idle). Abort: 1. If Abort command is issued.
26	ABORTED STAGE	**Halted: Sequence Aborted, Await Operator Command** An abort condition has occurred. Go to the next stage if the Terminate command is issued. Go to the Re-Check Stability stage (29) if the Continue (Reprove) command is issued.
27	RESERVED	Not used
28	RE SEAT SPHERE A	Not used
29	RE STAB CHECKS	**Re-Check Stability (Following Reprove Command)** Wait to achieve stability (via Stabilise command to run control task – stage 6) for temperatures, pressure rate of change. Upon achieving stability, wait for stability to be held for a user configurable time, then proceed to stage 18 (Proof Run).
30	TERMINATE	**Terminate** Ensure the run control sequence terminates. Return to stage 0 (Idle).

Table – Master Meter Flow Computer Application Prove Sequence

Prove Sequence Stages

Following an abort the sequence will go to stage 26. The operator then has the following options based on the sequence stage when the abort occurred:

Abort Stage		Operator Command			
Index	**Display**	**CONTINUE**	**ABORT**	**TERMINATE**	**START**
0	IDLE	-	-	-	-
1	INITIALISE	-	-	-	-
2	PULSES ON	2	-	25	2
3	PRV FCV INIT	3	-	24	3
4	PRV OPEN O-VLV	4	-	24	4
5	NPS CLOSE PRV I-VLV	5	-	24	5
6	PS OPEN PRV I-VLV	6	-	23	6
7	PS CLOSE STR O-VLV	7	-	22	7
8	SEAT SPHERE A	NOT CONFIGURED			
9	NPS FCVS TRACK	9	-	22	9
10	NPS FLOW BALANCE	10	-	22	10
11	RESERVED	NOT USED			
12	CLOSE SUSPEND	10	-	22	10
13	OPEN SUSPEND	10	-	22	10
14	NPS FCVS_MANUAL	14	-	22	14
15	PRV FLOW STAB	15	-	22	15
16	PRV FLOW/T/P STAB	16	-	22	16
17	PRV FCV MANUAL	17	-	22	17
18	PROOF RUN	29	-	22	29
19	MF DOWNLOAD	19	-	22	19
20	AWAIT REPROVE	29	-	22	29
21	SEAT SPHERE B	NOT USED			
22	PS OPEN STR O-VLV	22	-	23	22
23	PS CLOSE PRV I-VLV	23	-	24	23
24	RESTORE FCVS	24	-	25	24
25	PS PULSE OFF	25	-	0	25
26	ABORTED STAGE	NOT APPLICABLE			
27	RESERVED	NOT USED			
28	RE SEAT SPHERE A	NOT USED			

Abort Stage		Operator Command			
Index	**Display**	**CONTINUE**	**ABORT**	**TERMINATE**	**START**
29	RE STAB CHECKS	29	-	22	29
30	TERMINATE	-	-	-	-

Table – Master Meter Flow Computer Application Abort Stage

Prove Sequence Abort Index

The abort values of the prove sequence are shown below:

Index	Display	Description
0	NULL	No Abort.
1	OP ABORT	Operator Requested Abort.
2	INVALID MTR NO	Invalid Meter No.
3	PS TELEM FAIL	Proving Stream Telemetry Fail.
4	RUN CTL BUSY	Run Control Task Busy.
5	METER NO FLOW	No Flow at Meter.
6	RUN CTL ABORT	Run Control Task Aborted.
7	ILLEGAL PULSES	More than one stream has raw pulses enabled.
8	ANY TELEM FAIL	Non Proving Stream Telemetry Fail.
9	NPS PRV I-VLV OPEN	Non Proving Stream Prover Valve Not Closed.
10	PS PRV I-VLV CLOSED	Proving Stream Prover Prover Valve Not Open.
11	PS STR O-VLV OPEN	Proving Stream Outlet Valve Not Closed.
12	RESERVED	
13	RESERVED	
14	PS IN MAINT	Proving Stream Is In Maintenance Mode.
15	FBAL TIMEOUT	Flow Balance Timeout.
16	FBAL NO NPS ON LINE	Flow Balance Error - No Non Proving Streams On-line.
17	FBAL NO NPS IN AUTO	Flow Balance Error - No Non Proving Streams In Auto.
18	FBAL HOLD FAIL	Flow Balance Error - Stability Not Achieved.

Table – Master Meter Flow Computer Application Sequence Abort Index

Prove Run Control Stages

The Run Control sequence is specific to the type of prover (such as a bi-direction or uni-directional [ball] prover, a compact prover, or a master meter). The Run Control sequence initiates the prove runs and performs the calculations that produce a K-factor and meter factor when the runs complete.

Normally the sequence runs when commanded by the Prove Sequence at stage 18 (Perform Proof Run). However, it can be initiated from the FloBoss S600+ front panel.

The run stages for the master meter prove are shown below:

Index	Display	Description
0	IDLE	**Idle** Wait for the Initialise command to start the run control sequence. Proceed to next stage only if the prove is permitted (that is, the run control stage is ‘idle’ or ‘final’).
1	INITIALISE	**Initialise Run Data** Zero down all run data and arrays. Proceed to next stage.
2	AWAIT STAB CMD	**Halted: Await Stabilise Command** Wait for Stabilise command then proceed to next stage. Abort: 1. If the prove is no longer permitted. 2. If the master meter number has changed. 3. If the Terminate command is issued.
3	WAIT STAB	**Wait Until Stability Is Achieved** Proceed to next stage if stability override is on. Set stability wait timer running. Continuously monitor deviations for: 1. meter pressure vs. master meter pressure 2. meter temperature vs. master meter temperature Continuously monitor (over 5-second periods) rates of change for: 1. master meter pressure 2. master meter temperature 3. meter flow rate Proceed to next stage when stability is achieved. Abort: 1. If the prove is no longer permitted. 2. If the master meter number has changed. 3. If Terminate command is issued. 4. If stability wait timer expires.
4	HOLD STAB	**Hold Stability For Entered Period** Proceed to next stage if stability override is on. Set stability hold timer running. Repeat the stability checks from the previous stage to ensure stability is maintained for the given period. Proceed to next stage when stability hold timer expires. Abort: 1. If the prove is no longer permitted. 2. If the master meter number has changed. 3. If the Terminate command is issued. 4. If any of the stability checks fail.

Index	Display	Description
5	AWAIT RUN CMD	**Halted: Await Start Runs Command** Wait for Start Runs command then proceed to next stage. Abort: 1. If the prove is no longer permitted. 2. If the master meter number has changed. 3. If the Terminate command is issued.
6	START RUN	**Start Run** Start the pulse counters. Proceed to next stage. Abort: 1. If the prove is no longer permitted. 2. If the master meter number has changed. 3. If the Terminate command is issued.
7	COUNT PULSES	**Count Pulses** Set flight timer running. Count and monitor the pulses. Average meter and prover data. Check stability is maintained for duration of the prove run by repeating the stability checks from the wait stability stage. Proceed to next stage when the required number of pulses has been counted, or the required volume/mass has been metered, or the specified run duration has elapsed. Abort: 1. If the prove is no longer permitted. 2. If the master meter number has changed. 3. If the Terminate command is issued. 4. If master meter K-factor equals 0. 5. If master meter and meter under prove bad pulse counts differ. 6. If stability checks fail. 7. If flight timer expires.
8	RUN CALCS	**Perform Run Calculations** Based on data averaged during the run. Proceed to next stage if calculations are all valid. Abort if there is a calculation failure (such as K-factor out of range).
9	AVG CALCS	**Perform Run Average Calculations** Average the individual run data over the last n good runs and store the results. Proceed to the next stage.
10	STD RPT CHECKS	**Perform Repeatability Checks** If the required number of runs has not been performed then proceed to next stage. If the required number of runs has been performed then check each of the last n run's K-factor against the average. If each K-factor is within tolerance then proceed to the Await Reprove/Terminate stage (11). If any K-factors are outside tolerance and the maximum number of runs has been exceeded then proceed to the Await Reprove/Terminate stage (11), otherwise proceed to Check Runs Exceeded stage (13).
11	FINAL	**Halted: Final - Await Terminate/Reprove Command** End of prove. If: 1. Run control command is Initialise, proceed to Initialise stage (1). 2. Run control command is Terminate, proceed to Idle stage (0).
12	RESERVED	Not used.
13	CHECK RUNS EXCEEDED	**Check Runs Exceeded** Check the number of runs executed against the maximum allowed. If yes proceed to Final Average stage (14) otherwise proceed to Start Run stage (6).

Index	Display	Description
14	FINAL AVG	**Perform Final Average Calculations** Calculate the final (average) meter factor. Proceed to Print Report stage (17).
15	RESERVED	Not used.
16	RESERVED	Not used.
17	PRINT REPORT	**Print Proof Report**. Proceed to Final stage (11).

Table – Master Meter Flow Computer Application Run Sequence

Run Stage Abort Index

The abort index of the run stages are shown below:

Index	Display	Description
0	NULL	No Abort.
1	OPERATOR	Operator Abort.
2	RESERVED	
3	STAB WAIT	Temperature/Pressure/Flow rate wait stability timeout
4	STAB HOLD	Temperature/Pressure/Flow rate hold stability timeout
5	RESERVED	
6	RUN CALC	Error occurred when performing run calculations. For details refer to Run Stage Calc Index.
7	RUNS EXCEEDED	Maximum number of runs exceeded.
8	RESERVED	
9	RESERVED	
10	RESERVED	
11	KF/MF RANGE	K-factor or meter factor out of range, even if alarms not configured. To resolve, check the high and low limits for the meter factor, the K-factor, and pulse count objects.
12	RESERVED	
13	RESERVED	
14	INVALID CONSTANTS	Master meter K-factor = 0 or selection option invalid
15	BAD PULSES	Master meter received bad pulses during prove runs.
16	MM NO CHANGED	Master meter number changed during prove runs.
17	INV CALC	Unsupported volume/mass calculation.

Table – Master Meter Flow Computer Application Run Abort Index

Run Stage Calculation Error Index

The calculation error index of the run stages are shown below:

Index	Display	Description
0	NULL	No calculation errors.
1-19	RESERVED	
20	K-FACTOR	The calculation to determine the K-factor failed because the value is outside low/high alarm limits
21	METER FACTOR	The calculation to determine the Meter factor failed because the value is outside low/high alarm limits
22	PRV FLOWRATE	The calculation to determine the flow rate at the prover failed because the flight time equalled 0
23	MTR FLOWRATE	The calculation to determine the flow rate at the meter failed because the flight time equalled 0
24-30	RESERVED	
31	PRV PCF	The calculation to determine the pressure correction factor (PCF) at the prover failed.
32	PRV MASS	The calculation to determine the mass at the prover failed because the K-factor, pulse count, or pressure correction factor was 0
33	MTR MASS	The calculation to determine the mass at the meter failed because the K-factor, pulse count, or pressure correction factor was 0.
34	METER FACTOR	As 21, the calculation to determine the Meter factor failed because the value is outside low/high alarm limits
35	PRV FLOWRATE	As 22, the calculation to determine the flow rate at the prover failed because the flight time equalled 0
36	MTR FLOWRATE	As 23, the calculation to determine the flow rate at the meter failed because the flight time equalled 0
37	K-FACTOR	As 20, the calculation to determine the K-factor failed because the value is outside low/high alarm limits

Table – Master Meter Flow Computer Application Run Calculation Error Index

3.2.13.3 Proving Calculations

This section provides information on the calculations used in the prove procedure.

Averaging Calculations

Run Average Data

$$X_{run} = \frac{\sum X_{inst}}{S_{run}}$$

Where:
X_{run} = Average value of the variable for a single run
X_{inst} = Instantaneous sample value of variable being averaged
S_{run} = Number of samples during the run

The sampled variables (X_{inst}) are:

1. Master meter temperature
2. Master meter pressure
3. Meter temperature
4. Meter pressure
5. Master meter meter factor

Final Average Data (Over Consecutive Good Runs)

$$X_{final} = \frac{\sum X_{run}}{N_{run}}$$

Where:
X_{final} = Final average value of a variable for *N* consecutive good runs
X_{run} = Value of the variable for a single run
N_{run} = Number of consecutive good runs

The final average variables (X_{final}) are:

1. Master meter pulse count
2. Meter pulse count
3. Flight time
4. Master meter temperature
5. Master meter pressure
6. Meter temperature
7. Meter pressure
8. Meter pressure correction factor
9. Master meter meter factor

Stability Calculations

Meter/Master Meter Discrepancy Checks

$$X_{diff} = X_A - X_B$$

Where:

X_A, X_B = Variables being compared

The variables compared are:

1. Master meter temperature – Meter temperature
2. Master meter pressure – Meter pressure

Variable Rate of Change

$$X_{rate} = \frac{X_{new} - X_{old}}{Period}$$

Where:

X_{rate} = rate of the variable
X_{new} = new sample value
X_{old} = old sample value
Period = sampling interval

The variables compared are:

1. Master meter temperature
2. Master meter pressure
3. Meter flow rate

Prover Calculations

Prover Pressure Correction Factor

$$PCFp = 1 + Ktpfl \times \left(P_{run} - P_{cal}\right)$$

Where:

P_{run} = Master meter pressure (barg)
P_{cal} = Master meter calibration pressure (barg)
Ktpfl = Master meter totals pressure correction factor constant

Prover Mass (t)

$$Mp_{run} = \frac{PCp_{run}}{KFp_{run}} \times MFp_{run} \times PCFp_{run}$$

Where:

PCp_{run} = Run pulse count for the master meter (pls)
KFp_{run} = Run master meter K-factor (pls/t)
MFp_{run} = Run master meter factor
$PCFp_{run}$ = Run master meter pressure correction factor

Meter Pressure Correction Factor

$$PCFm = 1 + Ktpfl \times \left(P_{run} - P_{cal}\right)$$

Where:
P_{run} = Meter pressure (barg)
P_{cal} = Meter calibration pressure (barg)
$Ktpfl$ = Meter totals pressure correction factor constant

Meter Mass (t)

$$Mm_{run} = \frac{PCm_{run}}{KFm_{run}} \times PCFm_{run}$$

Where:
PCm_{run}= Run pulse count for the meter (pls)
KFm_{run}= Run meter K-factor (pls/t)
$PCFm_{run}$= Run meter pressure correction factor

Meter Factor

$$MF_{run} = \frac{Mp_{run}}{Mm_{run}}$$

Where:
Mp_{run} = Master meter mass (t)
Mm_{run} = Meter mass (t)

K-Factor (pls/t)

$$KF_{run} = \frac{KFp_{run}}{MF_{run}}$$

Where:
KFp_{run} = Run master meter K-factor (pls/t)
MF_{run} = Run meter factor

Meter Mass Flowrate (t/h)

$$MFRm_{run} = \frac{Mm_{run}}{\Delta t} \times 3600$$

Where:
Mm_{run} = Mass for the meter (t)
Δt = Meter run flight time (s)

Deviation Calculations

When the required number of consecutive good runs has been achieved, the program checks each individual run's meter factor (which make up the N consecutive good runs) to see how far it deviates from the average. If any run's meter factor deviates by more than the allowable limit then additional runs are performed and the test is repeated.

When all meter factors for the required runs fall within the deviation limit, the prove is considered successful and a final average data is calculated. At the same time the program stores the single maximum deviation value (repeatability) of the good run meter factors as an indication of how well the prove fell within the deviation tolerance.

MX-MN/MN

$$MF_{dev} = \frac{\left(MF_{\max} - MF_{\min}\right)}{MF_{\min}} \times 100$$

Where:
MF_{max} = Maximum Meter Factor of *N* consecutive runs
MF_{min} = Minimum Meter Factor of *N* consecutive runs

STATISTICAL

$$MF_{dev} = 200 \times t_{N-1} \times \frac{S_{N-1}}{MF_{avg} \times \sqrt{N}}$$

Where:
t_{N-1} = Uncertainty band confidence level student-t distribution (95%)
S_{N-1} = Sample standard deviation
MF_{avg} = Average meter factor of N consecutive runs
N = Number of runs in valuation

Difference Calculation

$$MF_{diff} = \frac{(MF_{cur} - MF_{new})}{MF_{cur}} \times 100$$

Where:
MF_{cur} = Current meter factor
MF_{new} = New meter factor

3.2.14 Sampling

3.2.14.1 Sampler Operation

The FloBoss S600+ is configured to control and monitor one dual can sampler.

The stream gross uncorrected volume flow rates read via the prover to stream serial link are summated into a station flow rate. This station flow rate is integrated over time to generate a representative station total for sampling purposes. A pulse output (grab control) is generated proportional to the station total. The pulse output is activated for two seconds and is controlled by the sampler task.

A sampler select output is provided to energise a relay. The flow computer outputs will be routed to the appropriate field sampler based on operator selection. In the de-energised state, the relay will send the grab command to the duty sampler cell, in the energised state the relay will send the grab command to the standby sampler cell. Two sampler receivers (Cans) are provided. The changeover between cans is controlled by a digital output from the flow computer and is a manual operation. Can 1 is selected when the Can select digital output is clear and Can 2 is selected when the Can select digital output is set. The selected can will not automatically change upon achieving can full status.

3.2.14.2 Sampler Calculations

$$Grabs = \frac{CanV}{Gsize}$$

Where:
Grabs = Total number of grabs required to fill the can
CanV = Can volume (m^3)
Gsize = Grab size (m^3)

Flow Proportional Sampling

If flow proportional sampling is selected then the required volume between samples is calculated as follows:

$$Vol = \frac{ExpVol}{Grabs}$$

Where:
Vol = Volume flow between samples (m^3)
ExpVol = Expected volume for sample period (m^3)
Grabs = Total number of grabs required to fill the can

Whenever the volume metered since the last sample was taken exceeds the required volume between samples, a sample grab is issued, but only if the time since the last sample exceeds the minimum time between samples.

If sample grabs are being requested too quickly, then an over speed alarm shall be raised, and a count of the outstanding sample grabs will be maintained. These will be output whenever possible.

To enable a change in the required volume between samples, the operator may modify the expected production at any time during the sampling period.

Time Proportional Sampling

If time proportional sampling is selected then can fill period is used to determine the time between grabs.

$$Time = \frac{ExpT}{Grabs}$$

Where:
Time = Time between samples (secs)
ExpT = Expected sample period (secs)
Grabs = Total number of grabs required to fill the can

If this is less that the minimum time between samples then the minimum time between samples will be used to determine when a sample grab is issued.

3.2.14.3 Sampler Parameters

The sampler parameters entries are described below:

Field	Units	Description
Sampler Method		Allows the operator to select the sampler mode as either FLOW PROP1 or TIME PROP. In FLOW PROP1 the sampler grabs are calculated based on the number of grabs required to fill the can to determine a volume throughput per pulse. In TIME PROP mode use the can fill period and number of grabs required to fill the can to determine a time interval per pulse.
Can Fill Indicator		Allows the operator to select the can full method as either Grab Count or Analog I/P. Grab Count uses the number of pulses output to the sampler and can high high limit to determine when the can is full. Analog, I/P uses an analogue input and can high high limit to determine when the can is full.
Disable Can Full		Enable to automatically disable the sampling process when the can is full.
Disable F/R Limit		Enable to automatically disable the sampling process when the flow rate is less than the flow rate limit.
Auto Restart		Enable to automatically restart the sampling process following an automatic disabling.
Expected Volume	m^3	The flow volume during which samples are taken (FLOW PROP ONLY).
Can Fill Period	*Hrs*	The amount of time required to fill the sampling can (TIME PROP ONLY).
Minimum Interval	*secs*	The minimum amount of time between grabs. If the calculated sampler grab rate is faster than this limit then an over speed alarm will result.

Field	Units	Description
Can Volume	m^3	The volume of the sampling can.
Grab Volume	m^3	The volume of the sampling grab.

Table – Master Meter Flow Computer Application Sampler Parameters

Sampler Control

The sampler control entries are described below:

Field	Description
Start Command	The control function allows the operator to select either START or STOP the sampling function
Can Reset	The control function allows the operator to reset the calculated can volume.

Table – Master Meter Flow Computer Application Sampler Control

Sampler Stages

The sampler stages are shown below:

Stage	Display	Description
0	IDLE	Idle
1	MONITOR	Monitor
2	DIGOUT ON	Digital Output On
3	MIN INTVL	Minimum Interval
4	POST PULSE	Post Pulse
5	STOPPED MANUALLY	Stopped Manually
6	STOPPED CAN FULL	Stopped Can Full / Max Grabs
7	STOPPED LOW FLOW	Stopped Low Flow
8	INITIAL TIME	Initial Time
9	CHECK FLOW SWITCH	Check Flow Switch (Not Used)
10	STOPPED FLOW SWITCH	Stopped Flow Switch (Not Used)
11	STOPPED PRESS SWITCH	Stopped Pressure Switch (Not Used)
12	STOPPED INITIALISE	Stopped Initialise
13	CAN SWITCH OVER	Can Switch Over

Table – Master Meter Flow Computer Application Sampler Stages

The following alarms and events are raised on this input.

Alarms	Can 1 Full Can 1 High Can 2 Full Can 2 High Low Flow Speed
Events	Each Mode change (manual to automatic) etc.

3.2.15 Reports

The following reports can be requested from the flow computer front panel or via the web browser interface.

The following report can be requested at any time:

```
================================================================================
                     CURRENT REPORT                          XX/XX/XXXX XX:XX:XX
================================================================================
STREAM  1

             CUMULATIVE                  FLOW RATE
GUVOL                X.XX       m3             X.XX   m3/h
GUVOL                X.XX       bbl            X.XX   bbl/h
GSVOL                X.XX       Sm3            X.XX   Sm3/h
GSVOL                X.XX       Sbbl           X.XX   Sbbl/h
MASS                 X.XX       t              X.XX   t/h

================================================================================
```

3.2.15.1 Maintenance Report

The following report is generated on entry to and exit from maintenance mode. The last 5 reports are historically stored.

```
================================================================================
                     MAINTENANCE REPORT                      XX/XX/XXXX XX:XX:XX
================================================================================
STREAM  1                               X

            CUMULATIVE        MAINTENANCE              FLOW RATE
GUVOL                X.XX                X.XX     m3              X.XX   m3/h
GUVOL                X.XX                X.XX     bbl             X.XX   bbl/h
GSVOL                X.XX                X.XX     Sm3             X.XX   Sm3/h
GSVOL                X.XX                X.XX     Sbbl            X.XX   Sbbl/h
MASS                 X.XX                X.XX     t               X.XX   t/h

================================================================================
```

3.2.15.2 Multi-Minute Report

The following report is generated at multi-minute end. The last 60 reports are historically stored.

```
================================================================================
                     MULTI-MINUTE REPORT (BASETIME XX:XX)    XX/XX/XXXX XX:XX:XX
================================================================================
STREAM  1

            CUMULATIVE       PERIOD                  FLOW RATE
GUVOL                 X.XX              X.XX    m3             X.XX   m3/h
GUVOL                 X.XX              X.XX    bbl            X.XX   bbl/h
GSVOL                 X.XX              X.XX    Sm3            X.XX   Sm3/h
GSVOL                 X.XX              X.XX    Sbbl           X.XX   Sbbl/h
MASS                  X.XX              X.XX    t              X.XX   t/h

MTR PRESS     :      X.XXX  barg
MTR TEMP      :       X.XX  Deg.C
MTR DENS      :      X.XXX  kg/m3
BASE DENS     :      X.XXX  kg/m3
K-FACTOR      :     X.XXXX  pls/t
MTR FACTOR    :    X.XXXXX

GUVOL FR      :       X.XX  m3/h
GUVOL FR      :       X.XX  bbl/h
GSVOL FR      :       X.XX  Sm3/h
GSVOL FR      :       X.XX  Sbbl/h
MASS FR       :       X.XX  t/h

================================================================================
```

3.2.15.3 Hourly Report

The following report is generated each hour. The last 24 reports are historically stored.

```
================================================================================
                     HOURLY REPORT (BASETIME XX:XX)          XX/XX/XXXX XX:XX:XX
================================================================================
STREAM  1

            CUMULATIVE        PERIOD                  FLOW RATE
GUVOL                X.XX               X.XX    m3              X.XX   m3/h
GUVOL                X.XX               X.XX    bbl             X.XX   bbl/h
GSVOL                X.XX               X.XX    Sm3             X.XX   Sm3/h
GSVOL                X.XX               X.XX    Sbbl            X.XX   Sbbl/h
MASS                 X.XX               X.XX    t               X.XX   t/h

MTR PRESS     :     X.XXX  barg
MTR TEMP      :      X.XX  Deg.C
MTR DENS      :     X.XXX  kg/m3
BASE DENS     :     X.XXX  kg/m3
K-FACTOR      :    X.XXXX  pls/t
MTR FACTOR    :   X.XXXXX

GUVOL FR      :      X.XX  m3/h
GUVOL FR      :      X.XX  bbl/h
GSVOL FR      :      X.XX  Sm3/h
GSVOL FR      :      X.XX  Sbbl/h
MASS FR       :      X.XX  t/h

================================================================================
```

3.2.15.4 Daily Report

The following report is generated each day at 06:00. The last 35 daily reports are historically stored.

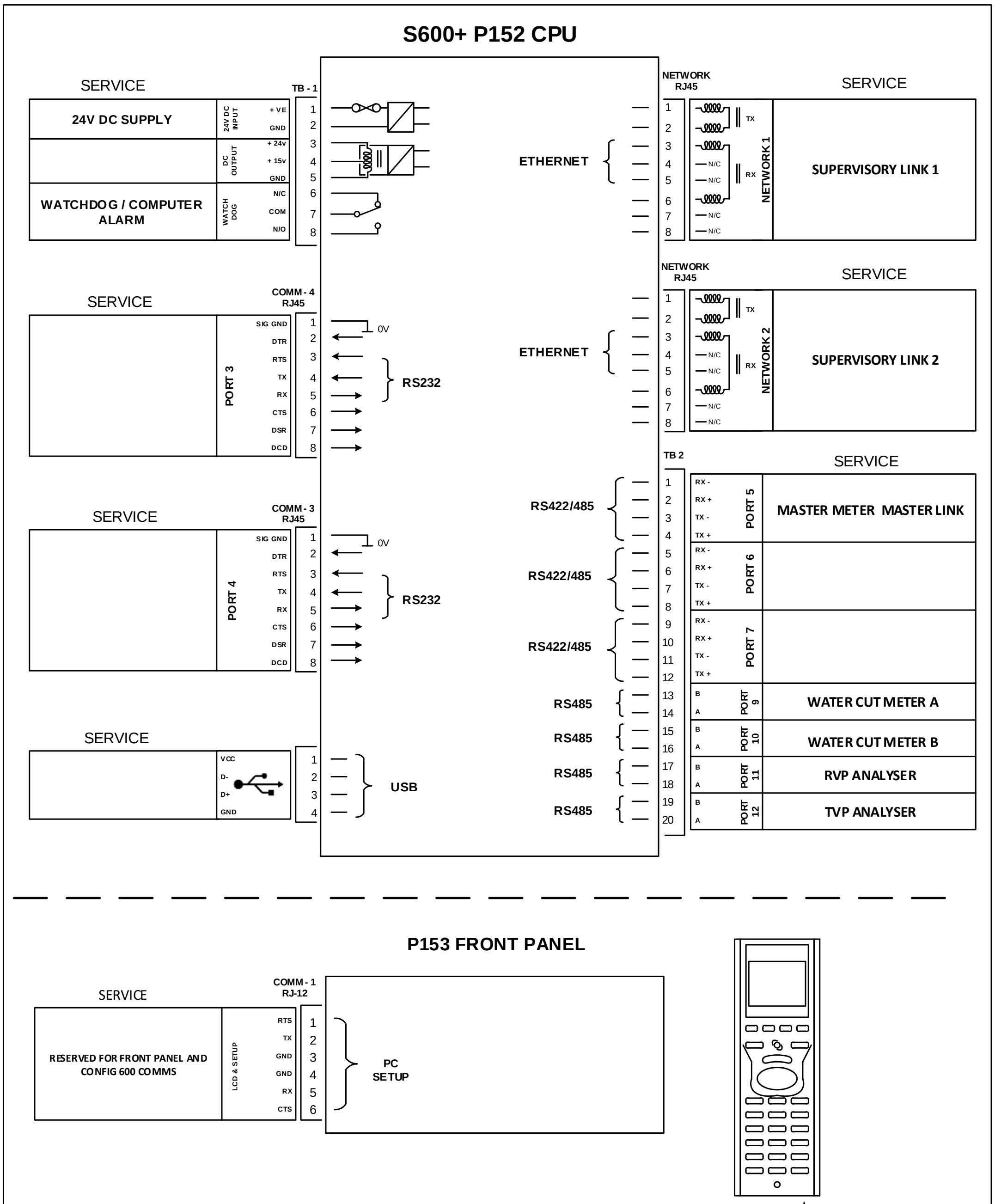
The daily report has the same layout as the hourly report, however, it contains daily figures.

3.2.15.5 Prove Report

The following report is generated at end of prove. The last 24 reports are stored.

```
================================================================================
                     METER PROOF REPORT                      XX/XX/XXXX XX:XX:XX
================================================================================
STREAM ON PROOF    :      X              TOL ALGORITHM   : MX-MN/MN
PROVING RATE       :      X.XX  t/h

BASE DENSITY       :     X.XXX  kg/m3
STREAM TEMPERATURE :      X.XX  Deg.C    STREAM PRESSURE :     X.XXX barg
MMETER TEMPERATURE :      X.XX  Deg.C    MMETER PRESSURE :     X.XXX barg

      STREAM  STREAM    MMETER  MMETER    MMETER   STREAM   FLIGHT
TRIAL TEMP    PRESSURE  TEMP    PRESSURE  PULSES   PULSES   TIME
No.   (Deg.C)   (barg)  (Deg.C)   (barg)                    (s)
 1      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
 2      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
 3      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
 4      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
 5      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
 6      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
 7      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
 8      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
 9      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
10      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
11      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
12      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
13      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
14      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
15      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
16      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
17      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
18      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
19      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
20      X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX
AVE     X.XX    X.XXX     X.XX    X.XXX      X.X      X.X   X.XXXXXX

       MMETER   MMETER   STREAM   STREAM     METER
       PCF      MASS     MASS     FLOWRATE   FACTOR
No.             (t)      (t)      (t/h)
 1     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
 2     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
 3     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
 4     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
 5     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
 6     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
 7     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
 8     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
 9     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
10     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
11     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
12     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
13     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
14     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
15     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
16     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
17     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
18     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
19     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
20     X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX
AVE    X.XXXXX  X.XXX    X.XXX    X.XX       X.XXXXX

MMETER K-FACTOR   :         X.XXXX  pls/t    REPEATABILITY     :        X.XXXXX  %
CURRENT K-FACTOR  :         X.XXXX  pls/t    DIFFERENCE        :        X.XXXXX  %
NEW METER FACTOR  :        X.XXXXX
================================================================================
```

3.2.16 I/O Schedule



COMM - 1
LOCATION

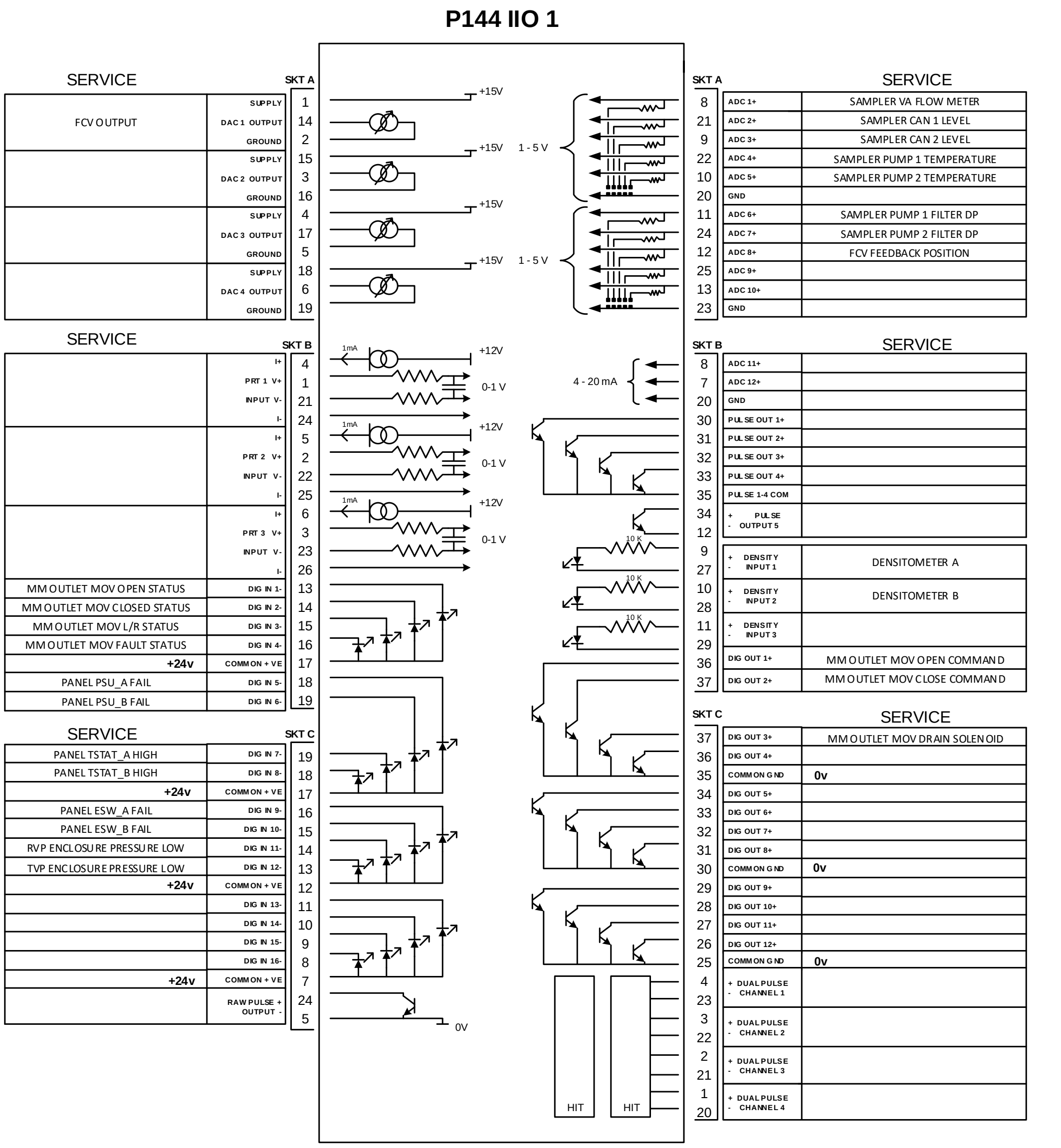
ISS	DATE	CHANGE	CHKD	APPD
02	11/07/18	Issued for Acceptance	SN	DJ
01	12/04/18	Issued for Acceptance	SN	DJ
00	07/03/18	Issued for Comment	SN	DJ

REF No.	ORIG SCALE	NTS	A4
	DIMENSIONS IN		N/A

TITLE: FLOBOSS S600+ I/O CONNECTION SCHEDULES

DRAWING NUMBER: CORAL MM, SH 1 OF 4

ISSUE: 02



ISS	DATE	CHANGE	CHKD	APPD
02	11/07/18	Issued for Acceptance	SN	DJ
01	12/04/18	Issued for Acceptance	SN	DJ
00	07/03/18	Issued for Comment	SN	DJ

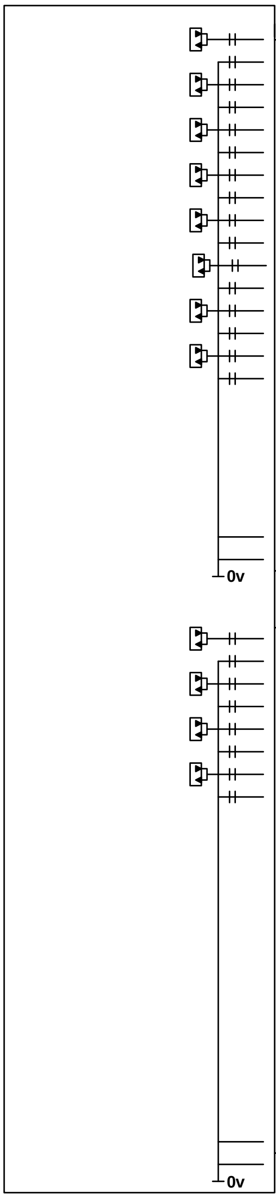
REF No.	ORIG SCALE	NTS	A4
	DIMENSIONS IN		N/A

TITLE **FLOBOSS S600+ I/O CONNECTION SCHEDULES**

DRAWING NUMBER **CORAL MM** SH 2 OF 4

ISSUE 02

P188 IIO 2 - HART



SKT A - J5
25 'D' Male

Pin		SERVICE: SENSOR 1	SENSOR 2
1	CHANNEL 1 +	MM PRESSURE TX-A	
14	CHANNEL 1 -		
2	CHANNEL 2 +	MM PRESSURE TX-B	
15	CHANNEL 2 -		
3	CHANNEL 3 +	MM TEMPERATURE TX-A	
16	CHANNEL 3 -		
4	CHANNEL 4 +	MM TEMPERATURE TX-B	
17	CHANNEL 4 -		
5	CHANNEL 5 +		
18	CHANNEL 5 -		
6	CHANNEL 6 +	MM OUTLET MOV CAVITY PRESSURE (LEAK)	
19	CHANNEL 6 -		
7	CHANNEL 7 +	SAMPLER PRESSURE TX-A	
20	CHANNEL 7 -		
8	CHANNEL 8 +	SAMPLER PRESSURE TX-B	
21	CHANNEL 8 -		
10	COM2 TXD	NOT IN USE	
11	COM2 RXD		
23	COM2 RTS		
24	COM2 CTS		
12	NC		
13	NC		
25	NC		
9	GND		
22	GND		

SKT B - J6
25 'D' Female

Pin		SERVICE: SENSOR 1	SENSOR 2
13	CHANNEL 9 +	SAMPLER TEMPERATURE TX-A	
25	CHANNEL 9 -		
12	CHANNEL 10 +	SAMPLER TEMPERATURE TX-B	
24	CHANNEL 10 -		
11	CHANNEL 11 +	INLET HEADER PRESSURE	
23	CHANNEL 11 -		
10	CHANNEL 12 +	INLET HEADER TEMPERATURE	
22	CHANNEL 12 -		
9	NC		
21	NC		
8	NC		
20	NC		
7	NC		
19	NC		
6	NC		
18	NC		
4	COM3 TXD	NOT IN USE	
3	COM3 RXD		
1	NC		
2	NC		
14	NC		
15	NC		
16	NC		
5	GND		
17	GND		

ISS	DATE	CHANGE	CHKD	APPD
02	11/07/18	Issued for Acceptance	SN	DJ
01	12/04/18	Issued for Acceptance	SN	DJ
00	07/03/18	Issued for Comment	SN	DJ

REF No.	ORIG SCALE	NTS	A4
	DIMENSIONS IN		N/A

TITLE: **FLOBOSS S600+ I/O CONNECTION SCHEDULES**

DRAWING NUMBER: **CORAL MM**

ISSUE: 02

P154 IIO 3 - Prover

SERVICE (SKT D)

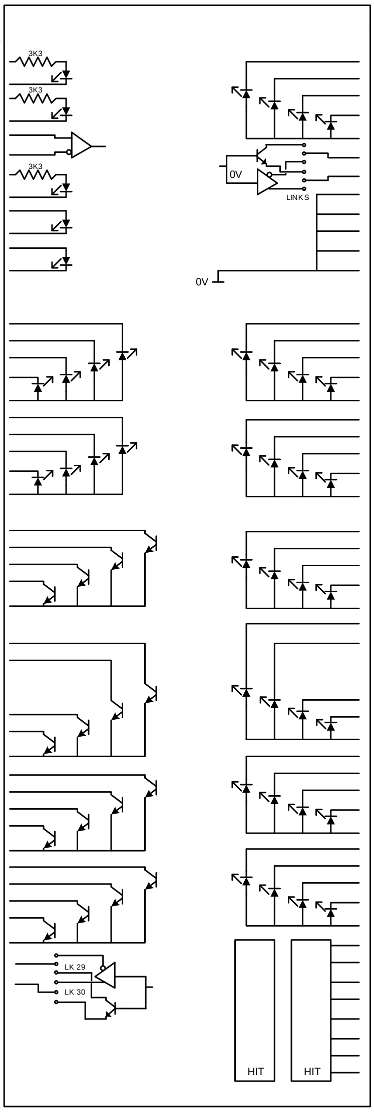
SERVICE		SKT D
RAW PULSE BUS	RAW PULSE +	1
	INPUT 1 -	14
	RAW PULSE +	2
	INPUT 2 -	15
	RAW PULSE +	3
	INPUT 3 -	16
	PIM LOOP +	8
	INPUT -	20
	DENSITY 1 +	9
	DENSITY 1 -	21
	DENSITY 2 +	10
	DENSITY 2 -	22

SERVICE (SKT E)

SERVICE		SKT E
	DIG IN 25 -	20
	DIG IN 26 -	21
	DIG IN 27 -	22
	DIG IN 28 -	23
+24V	COMMON + VE	24
	DIG IN 29 -	25
	DIG IN 30 -	26
	DIG IN 31 -	27
	DIG IN 32 -	28
+24V	COMMON + VE	29
	PULSE OUT 1+	31
	PULSE OUT 2+	32
	PULSE OUT 3+	33
	PULSE OUT 4+	34
	COMMON GND	35
SAMPLER GRAB OUTPUT	DIG OUT 1+	36
CELL SAMPLER SELECT	DIG OUT 2+	37

SERVICE (SKT F)

SERVICE		SKT F
SAMPLER CAN CHANGE	DIG OUT 3+	37
PUMP 1 START COMMAND	DIG OUT 4+	36
OV	COMMON GND	35
PUMP 1 STOP COMMAND	DIG OUT 5+	34
PUMP 2 START COMMAND	DIG OUT 6+	33
PUMP 2 STOP COMMAND	DIG OUT 7+	32
PUMP 1 TRIP COMMAND	DIG OUT 8+	31
OV	COMMON GND	30
PUMP 2 TRIP COMMAND	DIG OUT 9+	29
	DIG OUT 10+	28
	DIG OUT 11+	27
	DIG OUT 12+	26
OV	COMMON GND	25
	PIM PULSE +	24
	OUTPUT -	5



SERVICE (SKT D)

SKT D		SERVICE
17	SWITCH 1 -	
5	SWITCH 2 -	
18	SWITCH 3 -	
6	SWITCH 4 -	
4	COMMON + VE	+24V
11	+ RAW PULSE	
23	- OUTPUT	
12	GND	
13	GND	
19	GND	
24	GND	
25	GND	

SERVICE (SKT E)

SKT E		SERVICE
1	DIG IN 17 -	PUMP 1 RUNNING STATUS
2	DIG IN 18 -	PUMP 1 AVAILABLE STATUS
3	DIG IN 19 -	PUMP 1 TEST POSITION
4	DIG IN 20 -	PUMP 2 RUNNING STATUS
5	COMMON + VE	+24V
6	DIG IN 21 -	PUMP 2 AVAILABLE STATUS
7	DIG IN 22 -	PUMP 2 TEST POSITION
8	DIG IN 23 -	
9	DIG IN 24 -	
10	COMMON + VE	+24V
13	DIG IN 1 -	
14	DIG IN 2 -	
15	DIG IN 3 -	
16	DIG IN 4 -	
17	COMMON + VE	+24V
18	DIG IN 5 -	
19	DIG IN 6 -	

SERVICE (SKT F)

SKT F		SERVICE
19	DIG IN 7 -	
18	DIG IN 8 -	
17	COMMON + VE	+24V
16	DIG IN 9 -	
15	DIG IN 10 -	
14	DIG IN 11 -	
13	DIG IN 12 -	
12	COMMON + VE	+24V
11	DIG IN 13 -	
10	DIG IN 14 -	
9	DIG IN 15 -	
8	DIG IN 16 -	
7	COMMON + VE	+24V
4 / 23	+ DUAL PULSE - CHANNEL 1	MM CORIOLIS PULSES A
3 / 22	+ DUAL PULSE - CHANNEL 2	MM CORIOLIS PULSES B
2 / 21	+ DUAL PULSE - CHANNEL 3	
1 / 20	+ DUAL PULSE - CHANNEL 4	

ISS	DATE	CHANGE	CHKD	APPD
02	19/09/18	Issued for Acceptance	SN	DJ
01	12/04/18	Issued for Acceptance	SN	DJ
00	07/03/18	Issued for Comment	SN	DJ

REF No. | ORIG SCALE: NTS | A4 | DIMENSIONS IN: N/A

TITLE: **FLOBOSS S600+ I/O CONNECTION SCHEDULES**

DRAWING NUMBER: **CORAL MM** SH 4 OF 4

ISSUE: 02

3.2.17 Alarm System

3.2.17.1 Introduction

The FloBoss S600+ flow computer operates a comprehensive alarm system, a summary of which is detailed below:

3.2.17.2 Visual Indication

Front Panel Display

An alarm indicator LED on the front panel is used to indicate status, as detailed below:

Flashing red	unaccepted alarm is present
Constant red	alarm condition is present; however, this has been accepted
Constant green	no alarms present

3.2.17.3 Potential Alarms

The alarms raised by the FloBoss S600+ flow computer are split into four alarm groups as detailed below:

1. Computer Alarm Group
   A fault has occurred which may affect the integrity of the flow computer, e.g. RAM FAIL

2. System Alarm Group
   A fault has occurred which affect the integrity of the system, e.g. ADC DEVICE ERROR

3. Process Alarm Group
   A process variable is outside its defined limits.

4. Telemetry Alarm Group
   Those individual alarms that are transferred to the Emerson Metering Suite via telemetry.

Note: An alarm can only be assigned to one group.

3.2.17.4 Alarm Outputs

Each alarm group has an alarm output. The alarm output indicates that one or more alarms within that group are in alarm state. The computer, system and process alarm outputs are transferred to the Emerson Metering Suite MSC via telemetry.

3.2.17.5 Alarms Transferred to the MSC

The following alarms will be transmitted to the MSC:

LF Low Flow
M Maintenance Mode

Item	Alarm	Description	Suppress	
			LF	M
SYS HOST	COLD ST	The S600+ has performed a cold start, all settings have been re-initialised.		
SYS HOST	WARM ST	The S600+ has performed a warm start, settings have been retained.		
SYS HOST	BATT FAIL	The battery voltage detected is below 2.8 volts and should be replaced as soon as possible.		
STN01 WCUT A	RX FAIL	Water cut meter failed to reply within the time out period.		
STN01 WCUT B	RX FAIL	Water cut meter failed to reply within the time out period.		
STN01 WCUT	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STN01 RVP	RX FAIL	RVP analyser failed to reply within the time out period.		
	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	ENCL PRESS L	The analyser enclosure pressure is low		
STN01 TVP	RX FAIL	TVP analyser failed to reply within the time out period.		
	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	ENCL PRESS L	The analyser enclosure pressure is low		
STN01 PRV MST LINK	LINK 1	Flow computer (slave id 1) failed to reply within the time out period.		
STN01 PRV MST LINK	LINK 2	Flow computer (slave id 2) failed to reply within the time out period.		
STN01 PRV MST LINK	LINK 3	Flow computer (slave id 3) failed to reply within the time out period.		
STN01 PRV MST LINK	LINK 4	Flow computer (slave id 4) failed to reply within the time out period.		
STR01 MTR PRESS TXA	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated		Y

Item	Alarm	Description	Suppress	
			LF	M
		4. Status code bit 7 – Device malfunction		
STR01 MTR PRESS TXB	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 MTR TEMP TXA	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 MTR TEMP TXB	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 O-VLV CAVITY PRESS	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 SMP PRESS TXA	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y

Item	Alarm	Description	Suppress	
			LF	M
STR01 SMP PRESS TXB	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 SMP TEMP TXA	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 SMP TEMP TXB	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 FCV POS	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. Device Open (flow computer HW failure) 2. Under-Range (input signal <3.5mA) 3. Over-Range (input signal >20.5mA) 4. Scaling (Transducer engineering scale invalid)		Y
STR01 I-HDR PRESS	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 I-HDR TEMP	L	In-Use Value less than low limit	Y	Y

Item	Alarm	Description	Suppress	
			LF	M
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. A communications failure to the device 2. Status code bit 0 – Primary variable out of limits 3. Status code bit 2 – Analog output saturated 4. Status code bit 7 – Device malfunction		Y
STR01 CAN 1 LVL	L	In-Use Value less than low limit		
	H	In-Use Value greater than high limit		
	DEV ERR	One or more of the following has occurred: 1. Device Open (flow computer HW failure) 2. Under-Range (input signal <3.5mA) 3. Over-Range (input signal >20.5mA) 4. Scaling (Transducer engineering scale invalid)		
STR01 CAN 2 LVL	L	In-Use Value less than low limit		
	H	In-Use Value greater than high limit		
	DEV ERR	One or more of the following has occurred: 1. Device Open (flow computer HW failure) 2. Under-Range (input signal <3.5mA) 3. Over-Range (input signal >20.5mA) 4. Scaling (Transducer engineering scale invalid)		
STR01 SMP PUMP 1 TEMP	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. Device Open (flow computer HW failure) 2. Under-Range (input signal <3.5mA) 3. Over-Range (input signal >20.5mA) 4. Scaling (Transducer engineering scale invalid)		Y
STR01 SMP PUMP 2 TEMP	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. Device Open (flow computer HW failure) 2. Under-Range (input signal <3.5mA) 3. Over-Range (input signal >20.5mA) 4. Scaling (Transducer engineering scale invalid)		Y
STR01 VA MTR	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. Device Open (flow computer HW failure)		Y

Item	Alarm	Description	Suppress	
			LF	M
		2. Under-Range (input signal <3.5mA) 3. Over-Range (input signal >20.5mA) 4. Scaling (Transducer engineering scale invalid)		
STR01 SMP PUMP 1 FILTER	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. Device Open (flow computer HW failure) 2. Under-Range (input signal <3.5mA) 3. Over-Range (input signal >20.5mA) 4. Scaling (Transducer engineering scale invalid)		Y
STR01 SMP PUMP 2 FILTER	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	DEV ERR	One or more of the following has occurred: 1. Device Open (flow computer HW failure) 2. Under-Range (input signal <3.5mA) 3. Over-Range (input signal >20.5mA) 4. Scaling (Transducer engineering scale invalid)		Y
STN01 PSEQ CTL	ABT	The prover sequence has aborted. The prover displays and error code to assist with diagnosing the cause of the abort.		
PRV01 RUN CTL	ABT	The prover run controller has aborted. The prover displays and error code to assist with diagnosing the cause of the abort.		
STN01 BASE DENS	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STN01 OBS DENS	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
	FAIL A	The densitometer frequency is below 1 Hz, or the measured period is outside the period limits, or the calculated density is negative	Y	Y
	FAIL B	The densitometer frequency is below 1 Hz, or the measured period is outside the period limits, or the calculated density is negative	Y	Y
STN01 OBS DENS	DISCRP	A value and B value differ by more than discrep limit	Y	Y
STR01 CORIOLIS	BAD PULSE	The number of bad pulses exceeds the alarm threshold	Y	Y
STR01 MASS FR	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STR01 K-FACTOR	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STR01 MTR FACTOR	L	In-Use Value less than low limit	Y	Y

Item	Alarm	Description	Suppress	
			LF	M
	H	In-Use Value greater than high limit	Y	Y
STR01 MTR PRESS	DISCRP	TXA value and TXB value differ by more than discrep limit	Y	Y
	L	Dual transmitter In-Use Value less than low limit	Y	Y
	H	Dual transmitter In-Use Value greater than high limit	Y	Y
STR01 MTR TEMP	DISCRP	TXA value and TXB value differ by more than discrep limit	Y	Y
	L	Dual transmitter In-Use Value less than low limit	Y	Y
	H	Dual transmitter In-Use Value greater than high limit	Y	Y
STR01 SMP PRESS	DISCRP	TXA value and TXB value differ by more than discrep limit	Y	Y
	L	Dual transmitter In-Use Value less than low limit	Y	Y
	H	Dual transmitter In-Use Value greater than high limit	Y	Y
STR01 SMP TEMP	DISCRP	TXA value and TXB value differ by more than discrep limit	Y	Y
	L	Dual transmitter In-Use Value less than low limit	Y	Y
	H	Dual transmitter In-Use Value greater than high limit	Y	Y
STR01 MTR DENS	L	In-Use Value less than low limit	Y	Y
	H	In-Use Value greater than high limit	Y	Y
STR01 O-VLV	ILLEGAL	Valve status inputs indicate the is not in a valid position (i.e. Not open, closed or moving)		
	SEAL FAIL	Valve has not sealed during the test period		
	MOVE FAIL	Valve has not reached the required position within the allowable timeout period		
	FAULT	Valve fault input is set		
STR01 SMP START	CAN 1 FULL	The can is full		
STR01 SMP START	CAN 1 HIGH	The calculated can volume exceeds the high limit		
STR01 SMP START	CAN 2 FULL	The can is full		
STR01 SMP START	CAN 2 HIGH	The calculated can volume exceeds the high limit		
STR01 SMP START	SPEED	The pulse output cannot match the requested pulse rate. The number of pulses to output has exceeded the pulse reservoir		
STR01 SMP START	STOPPED	The sampler has stopped		
STR01 SMP START	LOW FLOW	The sampler low flow switch is active		
STR01 PSU A	FAIL	The panel 24v PSU_A has failed		
STR01 PSU B	FAIL	The panel 24v PSU_B has failed		
STR01 TSTAT A	HIGH	The panel thermostat A is high		
STR01 TSTAT B	HIGH	The panel thermostat B is high		
STR01 ESW A	FAIL	The panel Ethernet switch A has failed		
STR01 ESW B	FAIL	The panel Ethernet switch A has failed		

Additional alarms will exist at the FloBoss S600+ to diagnose faults. The following alarm outputs are transmitted to the MSC indicating that one or more alarms within a particular group are present.

Item	Alarm	Description	Suppress	
			LF	M
ALM GRP 1	COMP	One or more ‘computer group’ alarms are present.		
ALM GRP 2	PROC	One or more ‘process group’ alarms are present.		
ALM GRP 3	SYS	One or more ‘system group’ alarms are present.		

Table – Liquid Coriolis Flow Computer Application Alarms To MSC

4 EMERSON METERING SUITE OVERVIEW

4.1 Overview

Emerson Metering Suite is a centrally located set of data servers and packages designed to obtain data from metering systems and manipulate/transmit/display/trend this data.

4.2 Emerson Metering Suite Redundancy

The principle of the Emerson Metering Suite Redundancy functionality is to have two Server modules connected to field devices and connected to each other in an ethernet network. Each one of these Servers must be defined with a project configuration consisting of a list of these Servers connected to each other along with an intervention timeout.
Each one of these servers must also be equipped with a runtime license enabled with the redundancy option.

Normal working conditions
During normal working conditions, the Primary Server is connected to the field devices and manages the data and data recording. The other Servers are operative, provide Realtime data and record information in the exact same way in perfect synchronization with the Primary Server. They do not communicate with the field even though they are predisposed to do so.

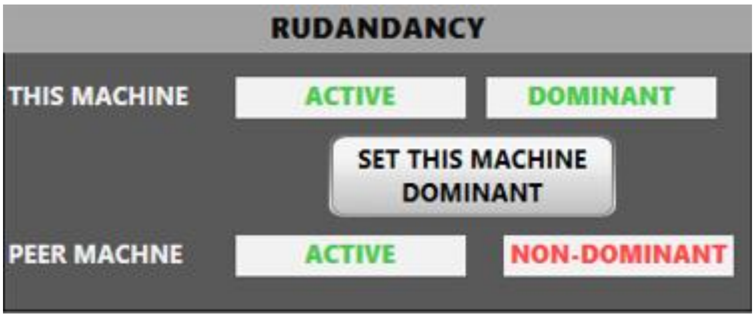
Emergency working conditions
In the event of a fault on the Primary Server, the next Secondary Server in line (in a list of backup servers) steps in to communicate directly with the field devices and record data. It will also automatically notify the other Servers on the list that it has taken over as Primary Server. All the other Secondary Servers will adapt accordingly.
If the new Primary Server should go into fault, the next Server in line will assume the role of Primary Server as indicated above.

Restoring normal working conditions
When a Primary Server returns back into operation it automatically restores the local historical situation and acquires all active information. Once synchronization has taken place the restored primary server will start to communicate with the field devices resuming its primary function. As a consequence the Server, that was active when this happened, will return to its 'secondary' operative condition in accordance to the data provided by its Primary Server.

Client connections
The data display client stations, connect to the system servers, are permanently and automatically connected to one of the active servers according to the load balancing principle. Therefore, if a Client station is connected to a Server that goes out of service, the Client will automatically search for the next Server station to ensure continuous service in automatic mode.

4.2.1 Redundancy Status

The redundancy status provides a visual indication of the redundancy status and allows control of the machine's dominance.



This Machine – The current viewed machine

Active	Indicates this machine is Alive and actively running servers.
Dominant	Font color is green when this machine is dominant
Dominance Button	Selecting this button forces this machine to take dominance

Table – Emerson Metering Suite Redundancy (This Machine)

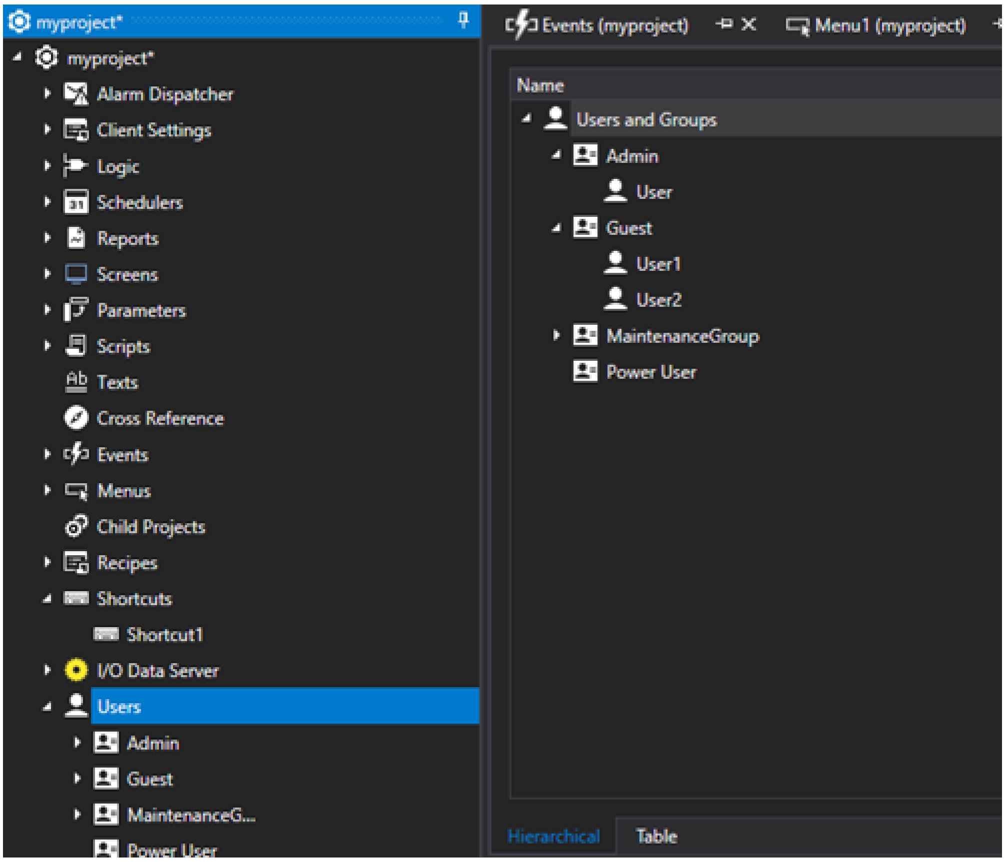
Peer- The other machine

Alive	Font is red when system is not alive, green when detected.
Active	Green indicates this machine is actively running servers.
Dominant	Font color is green when this machine is dominant

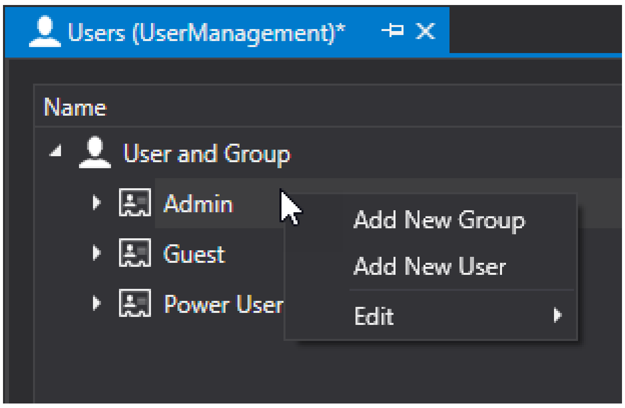
Table - Emerson Metering Suite Redundancy (Peer)

4.3 User Management in the development environment

The project's Users management Editor can be accessed from the "Users" resource from the project's tree structure. This editor is used for setting the User Manager's general properties, or for entering and configuring users and their access rights to project commands. The users that are defined in the project will also be created automatically in the Membership Provider's SQL repository at the startup of Movicon in runtime if not already existing in the Provider's list of users. In this case the Provider Membership user settings will not be overwritten by the properties set in the project for local users.



The commands for editing Users and Groups are made available after selecting the Project's "Users" resource from the Project > Users menu, or the contextual menu, within the development environment.



Add New Group
This command allows you to add a new User Group to the project's user list. When clicking on Add New Group a popup window will appear containing the Group properties.

Add New User

This command allows you to add a new User to the project's user list. The User will need to be added to a Group. When clicking on Add New User a popup window will appear containing the user properties.

Delete

This command is used to delete the selected User or Group. This command is only available in design mode.

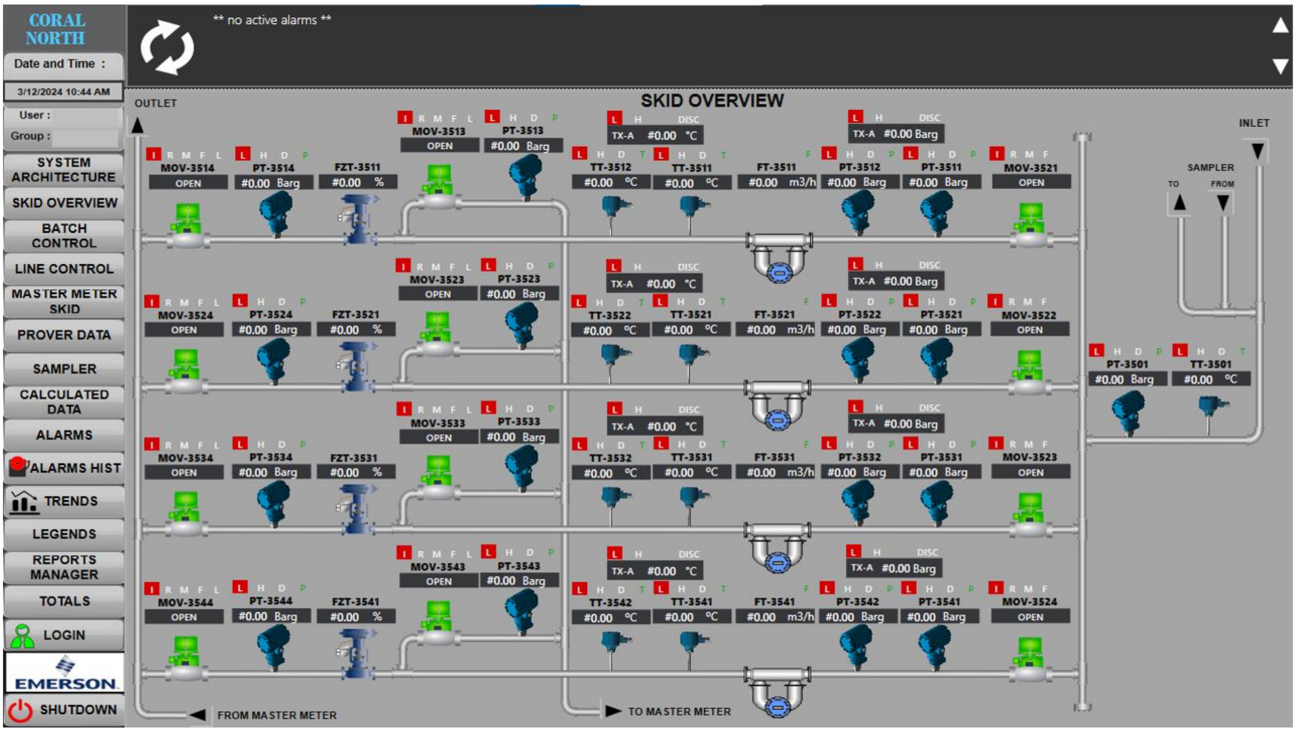
4.4 Emerson Metering Suite Displays

4.4.1 Metering Mimic

General overview of the metering skid, this screen will allow the operator to view the current in use values for the transmitters and valves on the metering streams.

Clicking a transmitter's data group will automatically open the relevant detail page.

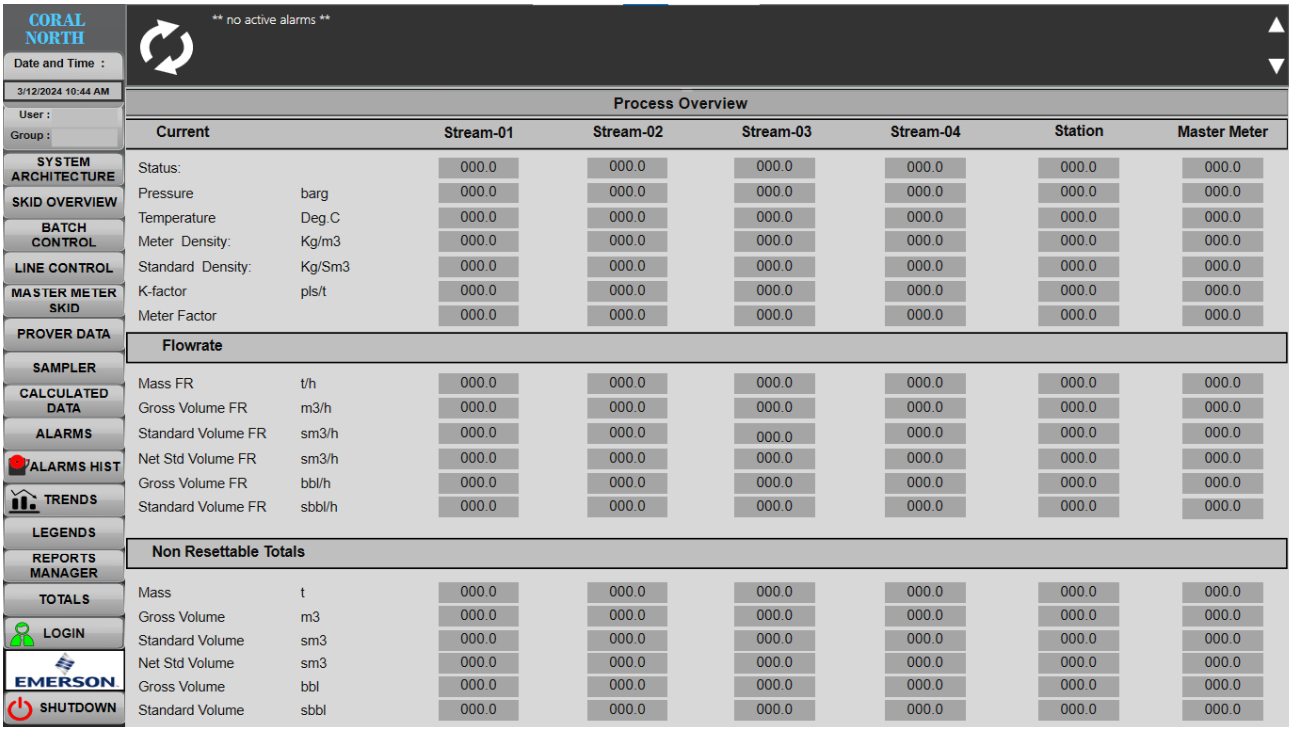
Data groups for each transmitter contain the in-use value, units and alarm indication in the method of light grey text when inactive and red text when active.



Display – Metering Mimic

4.4.2 Process Overview

The process overview of the metering skid display will allow the operator to view each stream’s current in use process data, flow rates and non-resettable totals. The station non-resettable totals shall also be shown.

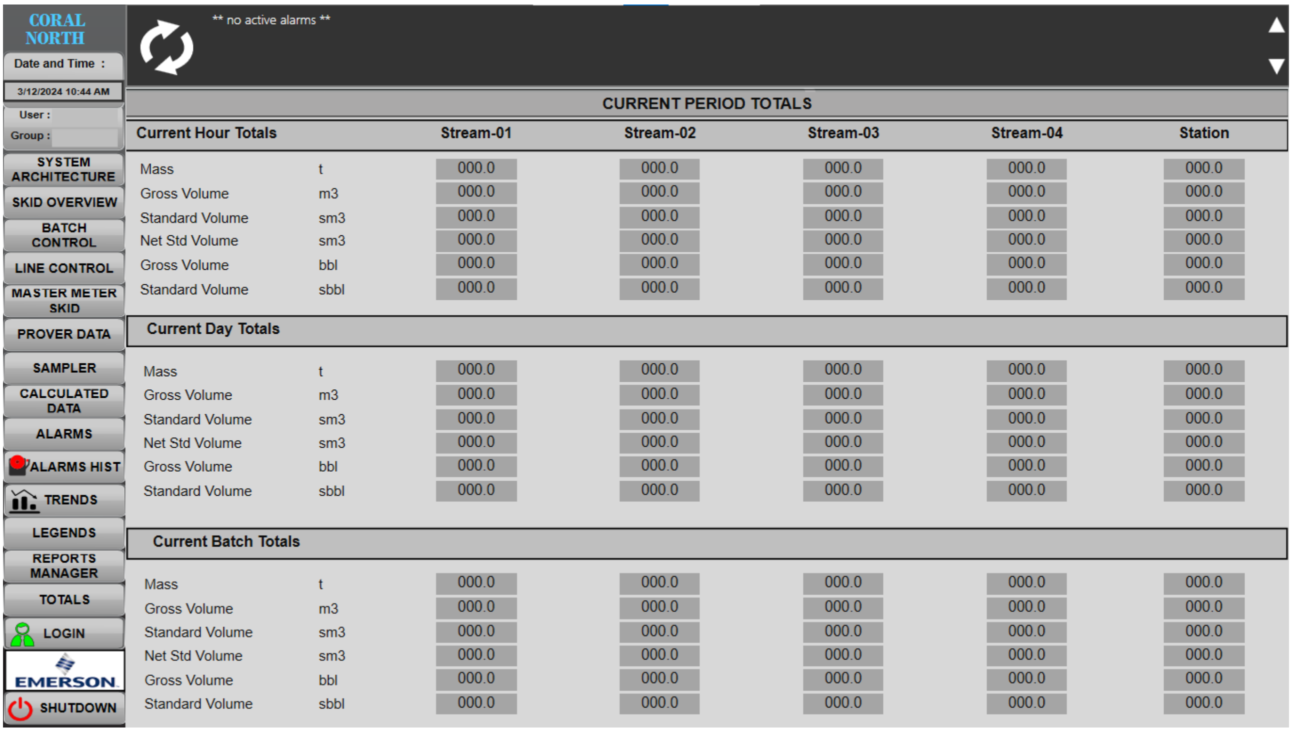


Current		Stream-01	Stream-02	Stream-03	Stream-04	Station	Master Meter
Status:		000.0	000.0	000.0	000.0	000.0	000.0
Pressure	barg	000.0	000.0	000.0	000.0	000.0	000.0
Temperature	Deg.C	000.0	000.0	000.0	000.0	000.0	000.0
Meter Density:	Kg/m3	000.0	000.0	000.0	000.0	000.0	000.0
Standard Density:	Kg/Sm3	000.0	000.0	000.0	000.0	000.0	000.0
K-factor	pls/t	000.0	000.0	000.0	000.0	000.0	000.0
Meter Factor		000.0	000.0	000.0	000.0	000.0	000.0
Flowrate							
Mass FR	t/h	000.0	000.0	000.0	000.0	000.0	000.0
Gross Volume FR	m3/h	000.0	000.0	000.0	000.0	000.0	000.0
Standard Volume FR	sm3/h	000.0	000.0	000.0	000.0	000.0	000.0
Net Std Volume FR	sm3/h	000.0	000.0	000.0	000.0	000.0	000.0
Gross Volume FR	bbl/h	000.0	000.0	000.0	000.0	000.0	000.0
Standard Volume FR	sbbl/h	000.0	000.0	000.0	000.0	000.0	000.0
Non Resettable Totals							
Mass	t	000.0	000.0	000.0	000.0	000.0	000.0
Gross Volume	m3	000.0	000.0	000.0	000.0	000.0	000.0
Standard Volume	sm3	000.0	000.0	000.0	000.0	000.0	000.0
Net Std Volume	sm3	000.0	000.0	000.0	000.0	000.0	000.0
Gross Volume	bbl	000.0	000.0	000.0	000.0	000.0	000.0
Standard Volume	sbbl	000.0	000.0	000.0	000.0	000.0	000.0

Display – Process Overview

4.4.3 Current Period Totals

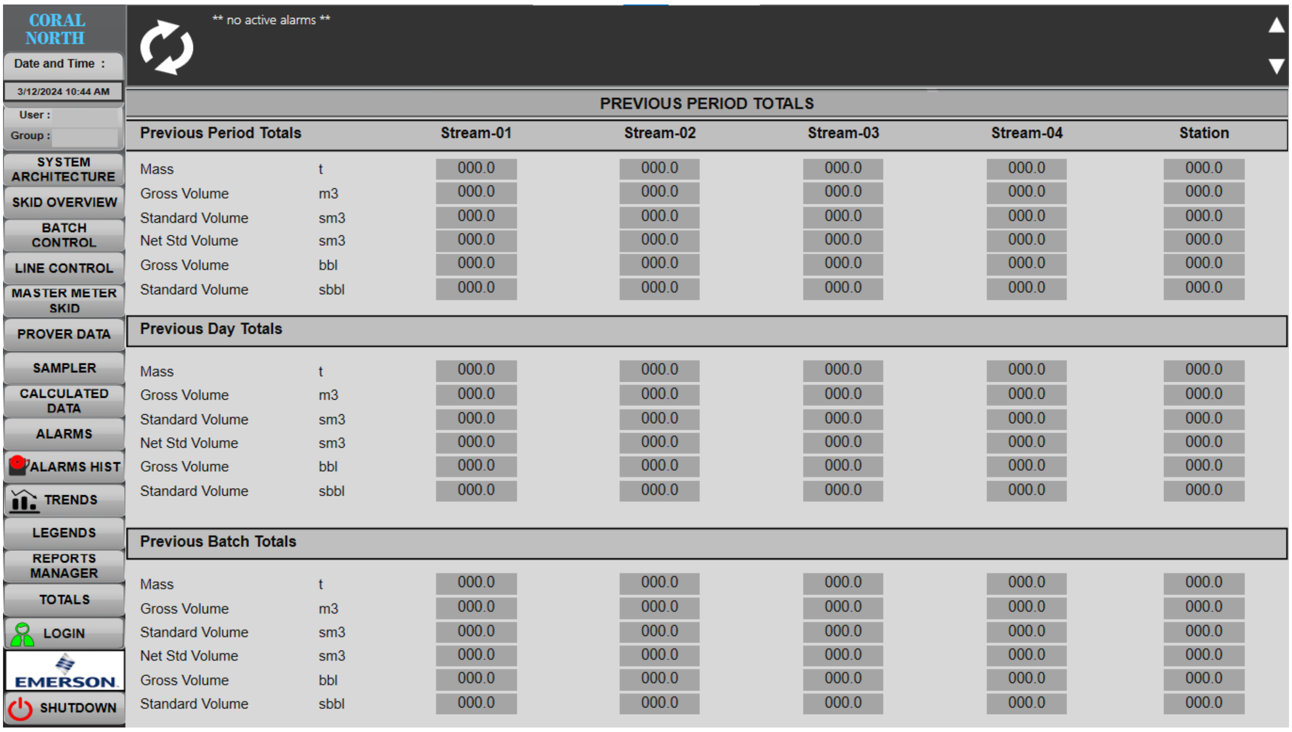
The current period totals display will show the totals registered in current periods for each stream. The station current totals shall also be shown.



Display – Current Period Totals

4.4.4 Previous Period Totals

The previous period totals display will show the totals registered in previous periods for each stream. The previous station totals shall also be shown.

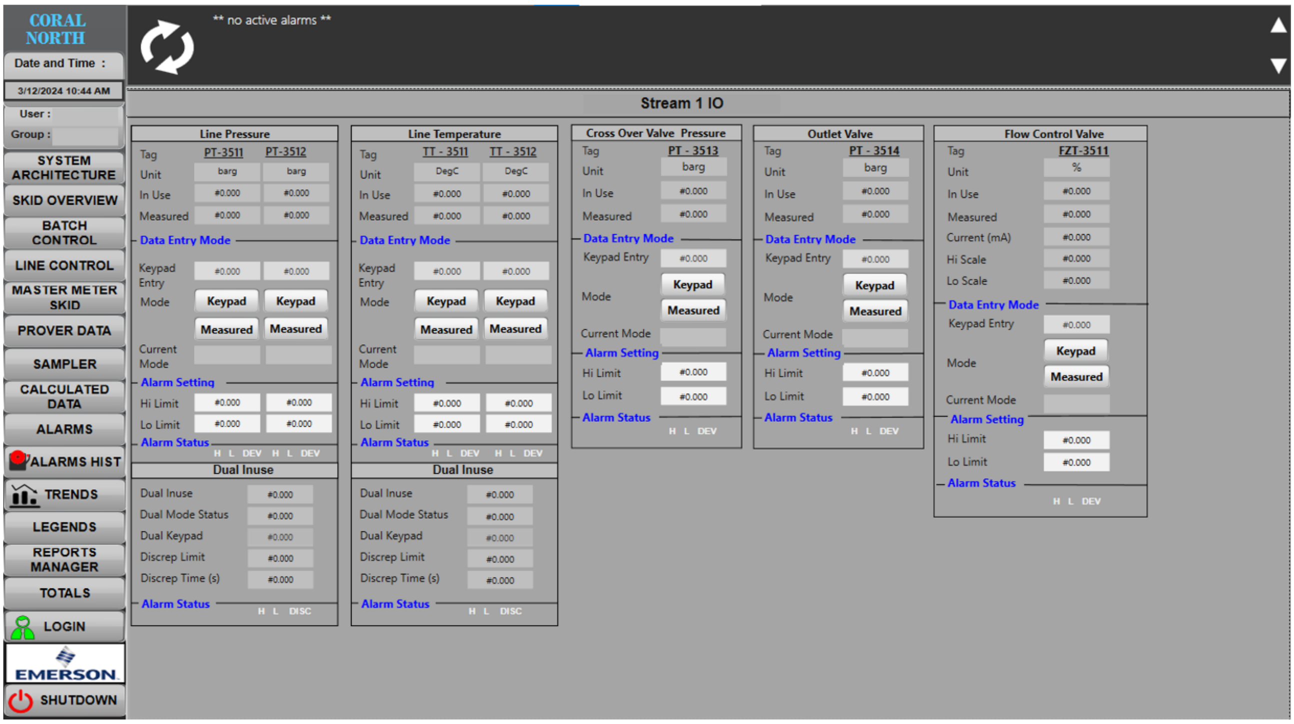


Previous Period Totals		Stream-01	Stream-02	Stream-03	Stream-04	Station
Mass	t	000.0	000.0	000.0	000.0	000.0
Gross Volume	m3	000.0	000.0	000.0	000.0	000.0
Standard Volume	sm3	000.0	000.0	000.0	000.0	000.0
Net Std Volume	sm3	000.0	000.0	000.0	000.0	000.0
Gross Volume	bbl	000.0	000.0	000.0	000.0	000.0
Standard Volume	sbbl	000.0	000.0	000.0	000.0	000.0
Previous Day Totals						
Mass	t	000.0	000.0	000.0	000.0	000.0
Gross Volume	m3	000.0	000.0	000.0	000.0	000.0
Standard Volume	sm3	000.0	000.0	000.0	000.0	000.0
Net Std Volume	sm3	000.0	000.0	000.0	000.0	000.0
Gross Volume	bbl	000.0	000.0	000.0	000.0	000.0
Standard Volume	sbbl	000.0	000.0	000.0	000.0	000.0
Previous Batch Totals						
Mass	t	000.0	000.0	000.0	000.0	000.0
Gross Volume	m3	000.0	000.0	000.0	000.0	000.0
Standard Volume	sm3	000.0	000.0	000.0	000.0	000.0
Net Std Volume	sm3	000.0	000.0	000.0	000.0	000.0
Gross Volume	bbl	000.0	000.0	000.0	000.0	000.0
Standard Volume	sbbl	000.0	000.0	000.0	000.0	000.0

Display – Previous Period Totals

4.4.5 Stream IO Display

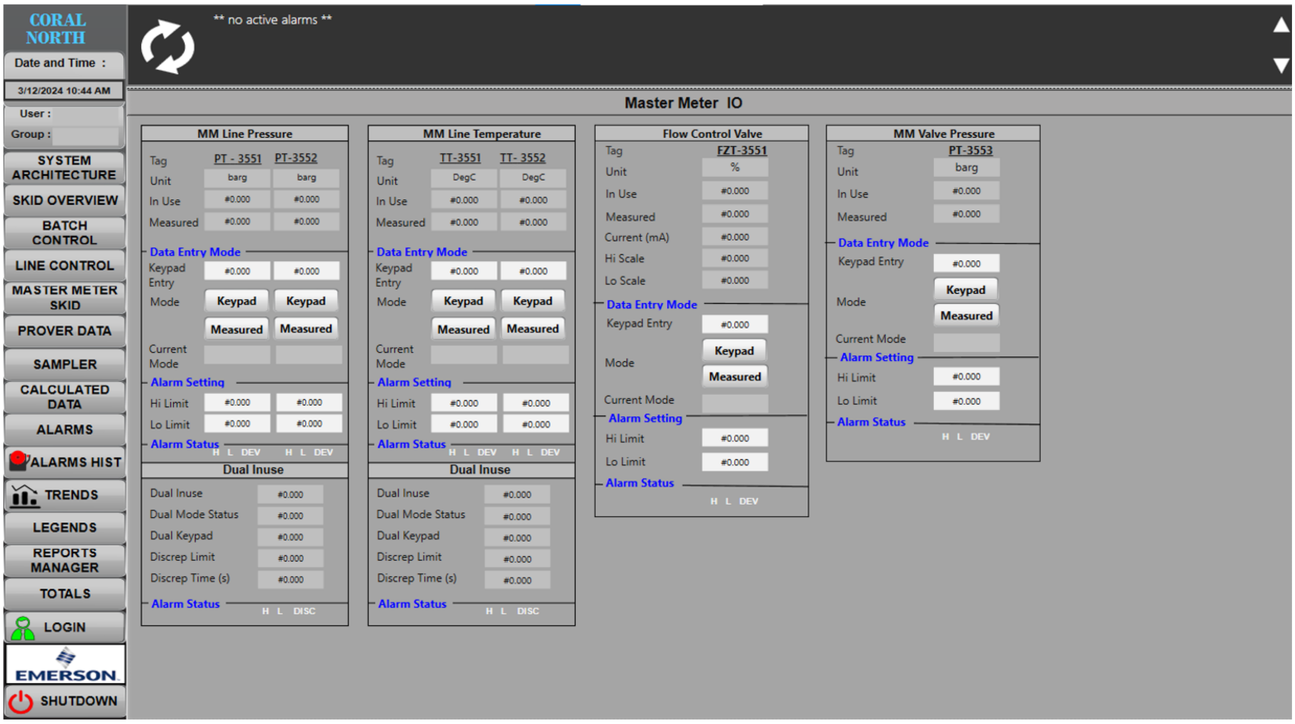
The Stream IO display will allow the operator to view each stream's transmitters in further detail. The mode status for each transmitter may be changed from this display. The Keypad value, alarm limits and transmitter scales (where applicable) may be entered from this display. Entries for the dual transmitter handling, such as in-use transmitter selection and discrepancy checking limits shall be available. The display shall also indicate which alarms are raised on each transmitter. The example below is for stream 1. Stream 2, 3 and 4 have identical displays



Display – Stream IO

4.4.6 Master Meter IO Display

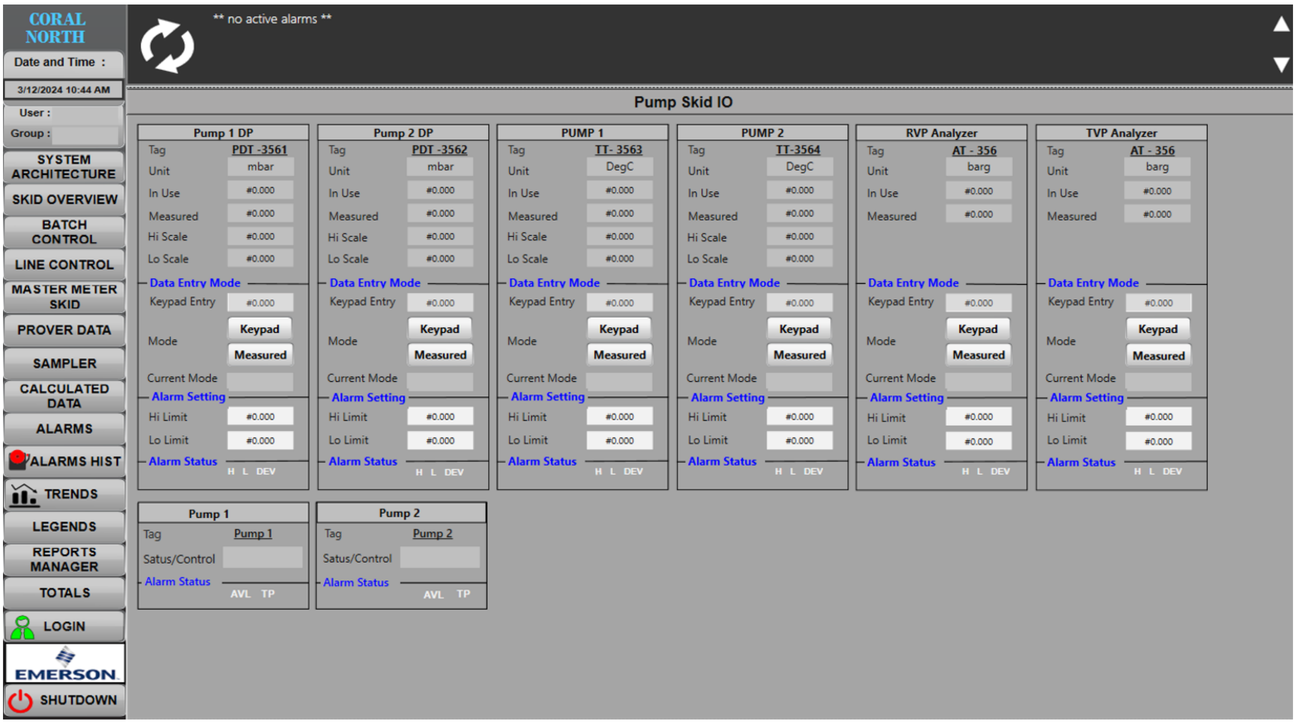
The Master Meter IO display will allow the operator to view the master meter's transmitters in further detail. The mode status for each transmitter may be changed from this display. The Keypad value, alarm limits and transmitter scales (where applicable) may be entered from this display. Entries for the dual transmitter handling, such as in-use transmitter selection and discrepancy checking limits shall be available. The display shall also indicate which alarms are raised on each transmitter.



Display – Master Meter IO

4.4.7 Pump Skid IO Display

The Pump Skid IO display will allow the operator to view the pump skid's transmitters in further detail. The mode status for each transmitter may be changed from this display. The Keypad value, alarm limits and transmitter scales (where applicable) may be entered from this display. The control and status for Pumps 1 and 2 will be displayed. The display shall also indicate which alarms are raised on each transmitter.



Display – Pump Skid IO

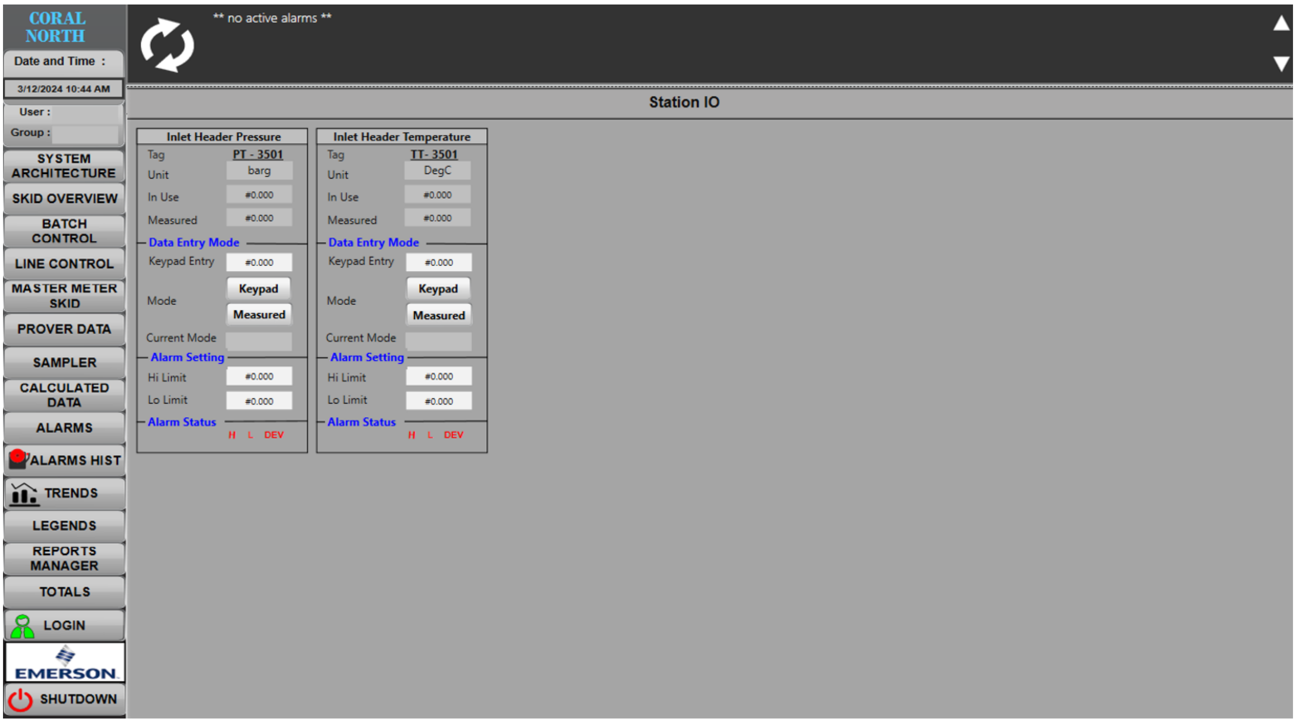
4.4.8 Sampler IO Display

The Sampler IO display will allow the operator to view the sampler system's transmitters in further detail. The mode status for each transmitter may be changed from this display. The Keypad value, alarm limits and transmitter scales (where applicable) may be entered from this display. Entries for the dual transmitter handling, such as in-use transmitter selection and discrepancy checking limits shall be available. The display shall also indicate which alarms are raised on each transmitter. Selections for the in-use densitometer and in-use watercut meter shall be available.

Display – Sampler IO

4.4.9 Station IO Display

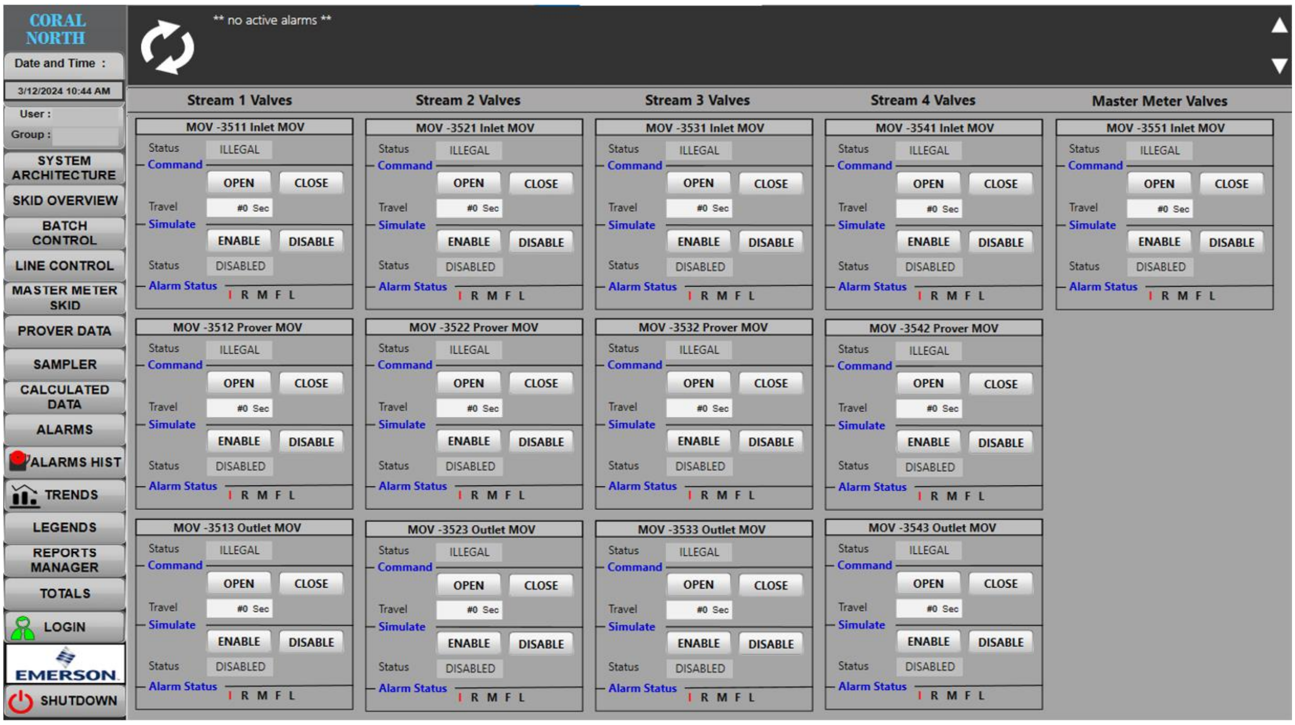
The Station IO display will allow the operator to view the skid's header and pressure transmitters in further detail. The mode status for each transmitter may be changed from this display. The Keypad value and alarm limits may be entered from this display. The display shall also indicate which alarms are raised on each transmitter.



Display – Station IO

4.4.10 Valves Display

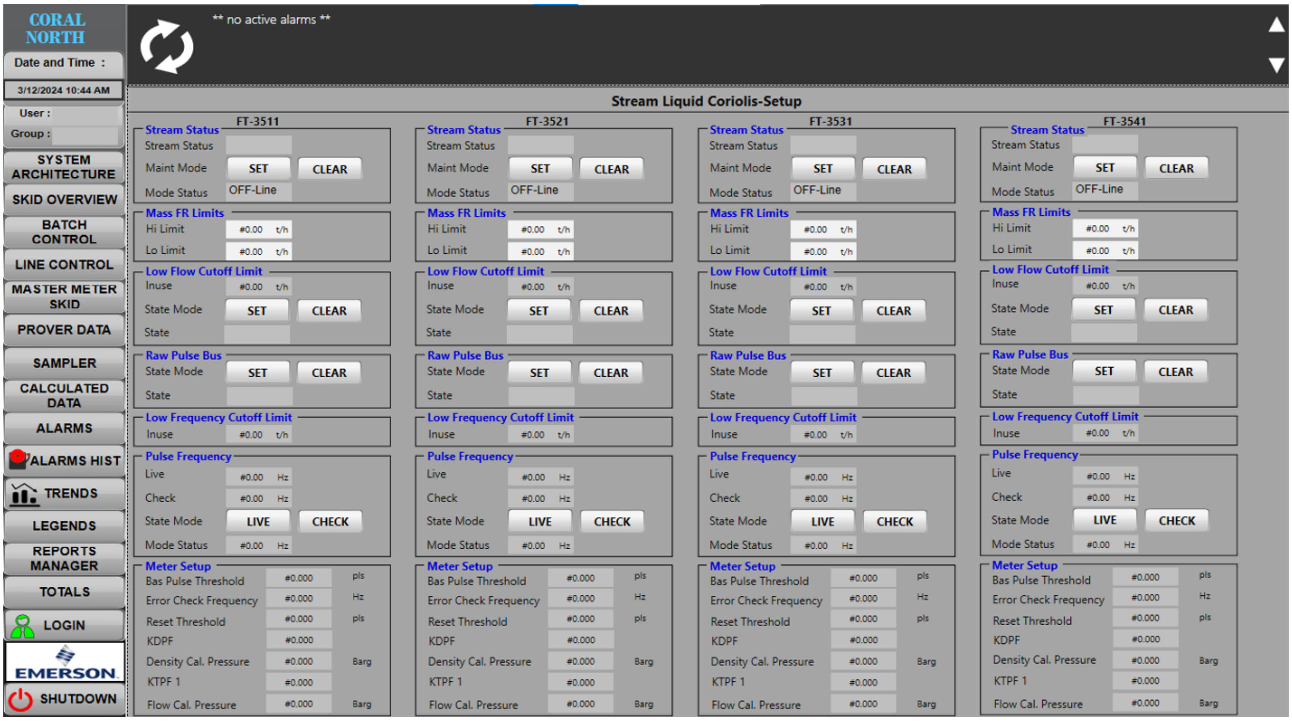
The valves display will allow the operator to view each stream's valves in further detail. The travel time and simulate mode may be changed from this display. The display shall also indicate which alarms are raised on each valve.



Display – Valves

4.4.11 Stream Liquid Coriolis Setup Display

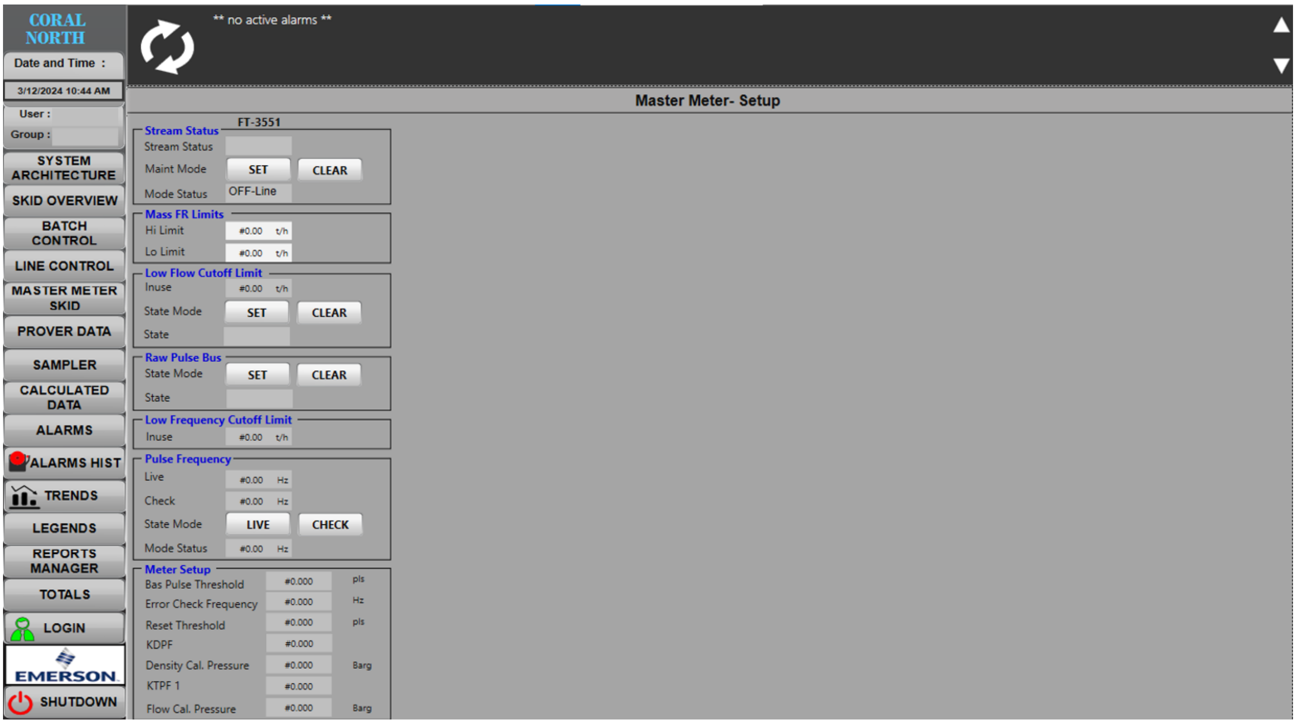
The stream liquid Coriolis setup display will allow the operator to view each Coriolis meter's IO and setup data in further detail. The live pulse frequency from the Coriolis meter is shown. The operator is provided with entries to configure bad pulse handling, low flow cut-off, low frequency cut-off and Coriolis pressure correction.



Display – Stream Liquid Coriolis Setup

4.4.12 Master Meter Liquid Coriolis Setup Display

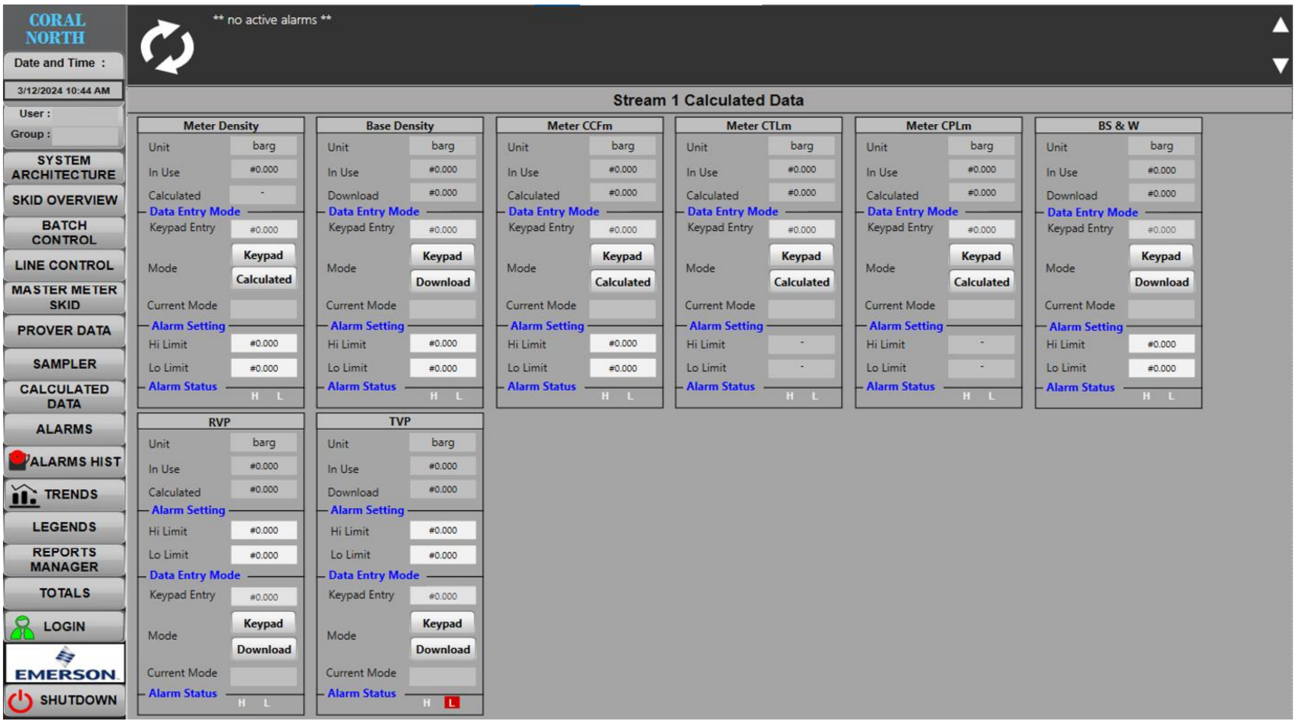
The master meter liquid Coriolis setup display will allow the operator to view the master meter's IO and setup data in further detail. The live pulse frequency from the Coriolis meter is shown. The operator is provided with entries to configure bad pulse handling, low flow cut-off, low frequency cut-off and Coriolis pressure correction.



Display – Master Meter Liquid Coriolis Setup

4.4.13 Stream Liquid Coriolis Calculated Data

The liquid Coriolis calculated data displays the main calculated parameters for each Coriolis stream. The Mode Status, Keypad value and alarm limits for each calculated parameter may be entered from this display. The display shall also indicate if a high or low alarm is raised for each of the parameters. The example below is for stream 1. Stream 2, 3, 4 and the master meter have identical displays.



Display – Stream Liquid Coriolis Calculated Data

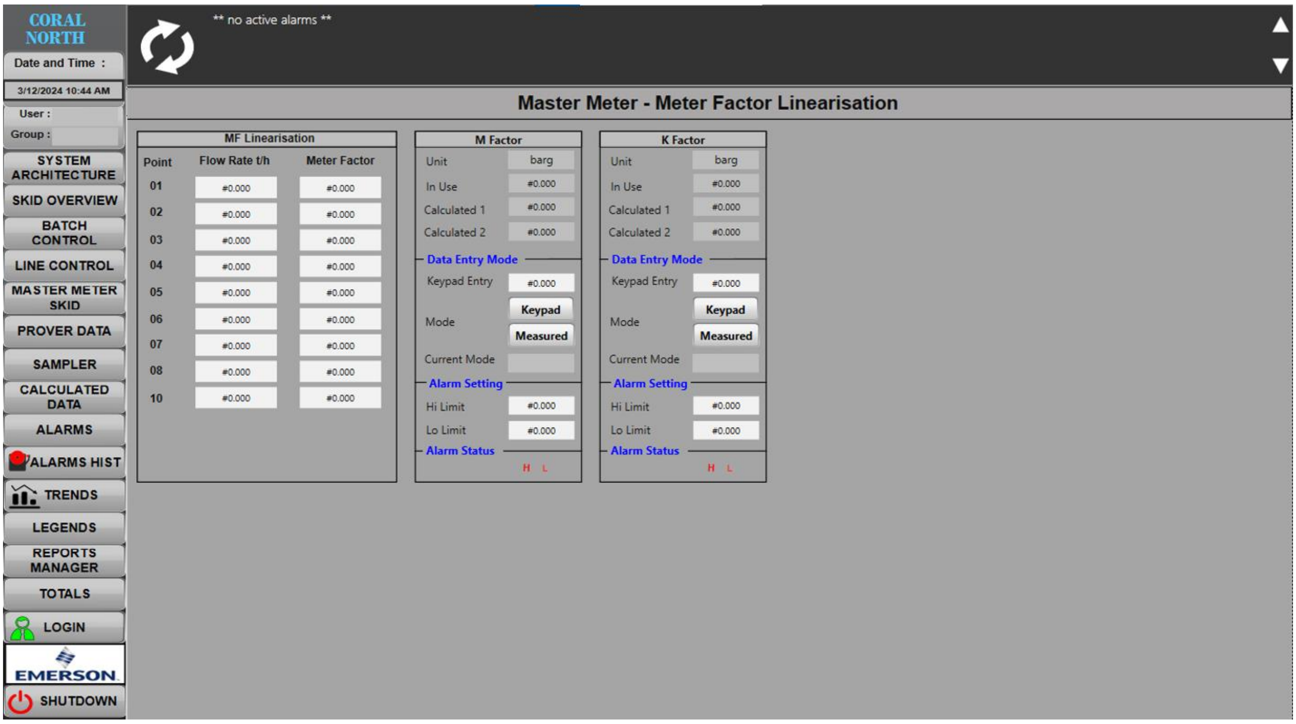
4.4.14 Stream Liquid Coriolis Meter Factor Linearisation

The stream liquid Coriolis meter factor linearisation displays the 10-point linearisation curve for the Coriolis stream meter, allowing the curve to be populated from the MSC. The last proved data from the meter is also provided, including an option for the operator to accept the new Meter Factor. The Mode Status, Keypad value and alarm limits for the Meter Factor and K-Factor may be entered from this display. The display shall also indicate if a high or low alarm is raised for the Meter Factor or K-Factor. The example below is for stream 1. Stream 2, 3, 4 and the master meter have identical displays.

Display– Stream Liquid Coriolis Meter Factor Linearisation

4.4.15 Master Meter Liquid Coriolis Meter Factor Linearisation

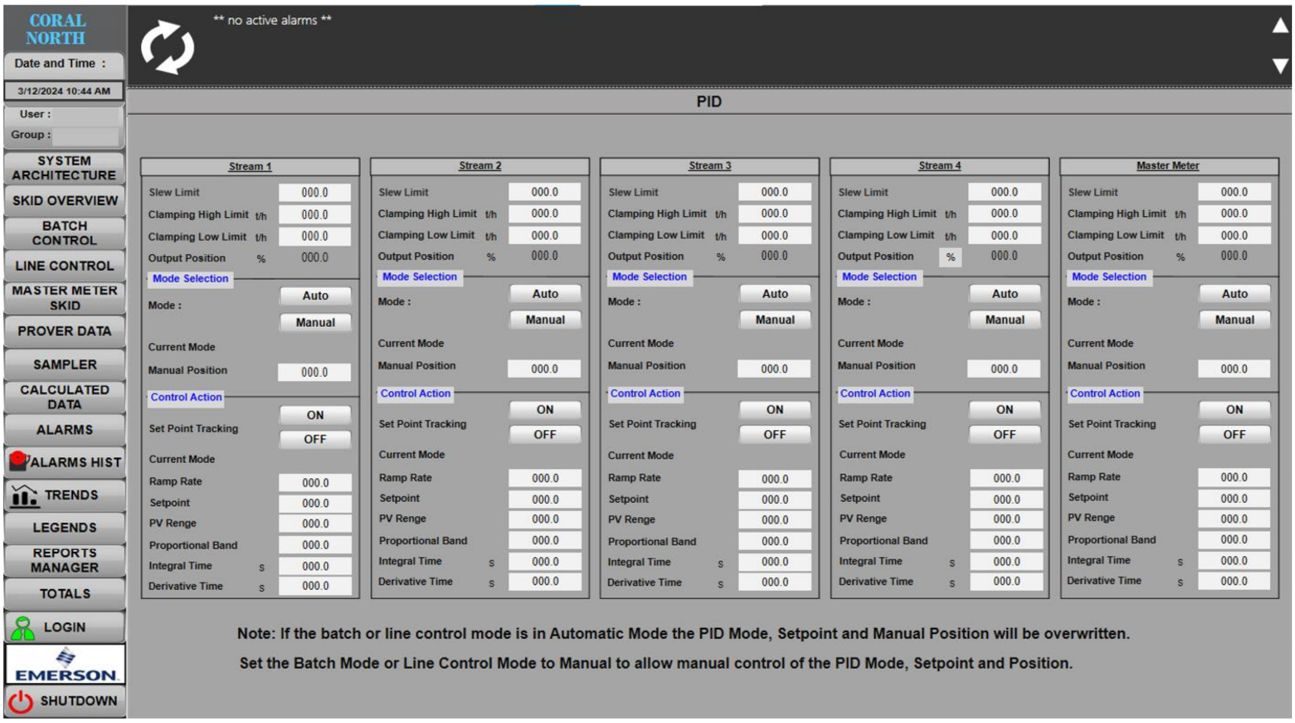
The master meter liquid Coriolis meter factor linearisation displays the 10-point linearisation curve for the Coriolis master meter, allowing the curve to be populated from the MSC. The Mode Status, Keypad value and alarm limits for the Meter Factor and K-Factor may be entered from this display. The display shall also indicate if a high or low alarm is raised for the Meter Factor or K-Factor.



Display– Master Meter Liquid Coriolis Meter Factor Linearisation

4.4.16 Liquid Coriolis FCV PID Display

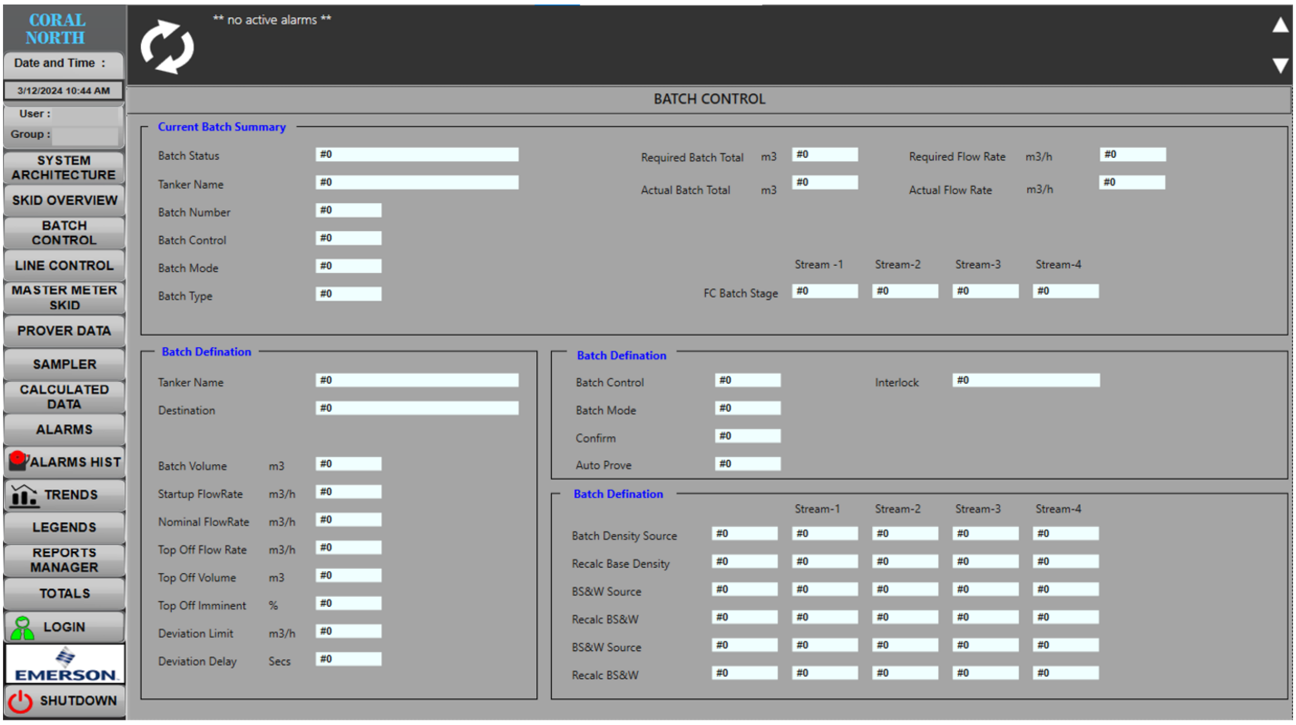
The liquid Coriolis FCV PID display allows entry of the PID parameters for the stream and master meter FCV. A selection for the mode of operation and a manual position entry are provided.



Display – Liquid Coriolis FCV PID Display

4.4.17 Liquid Coriolis Batch Control Display

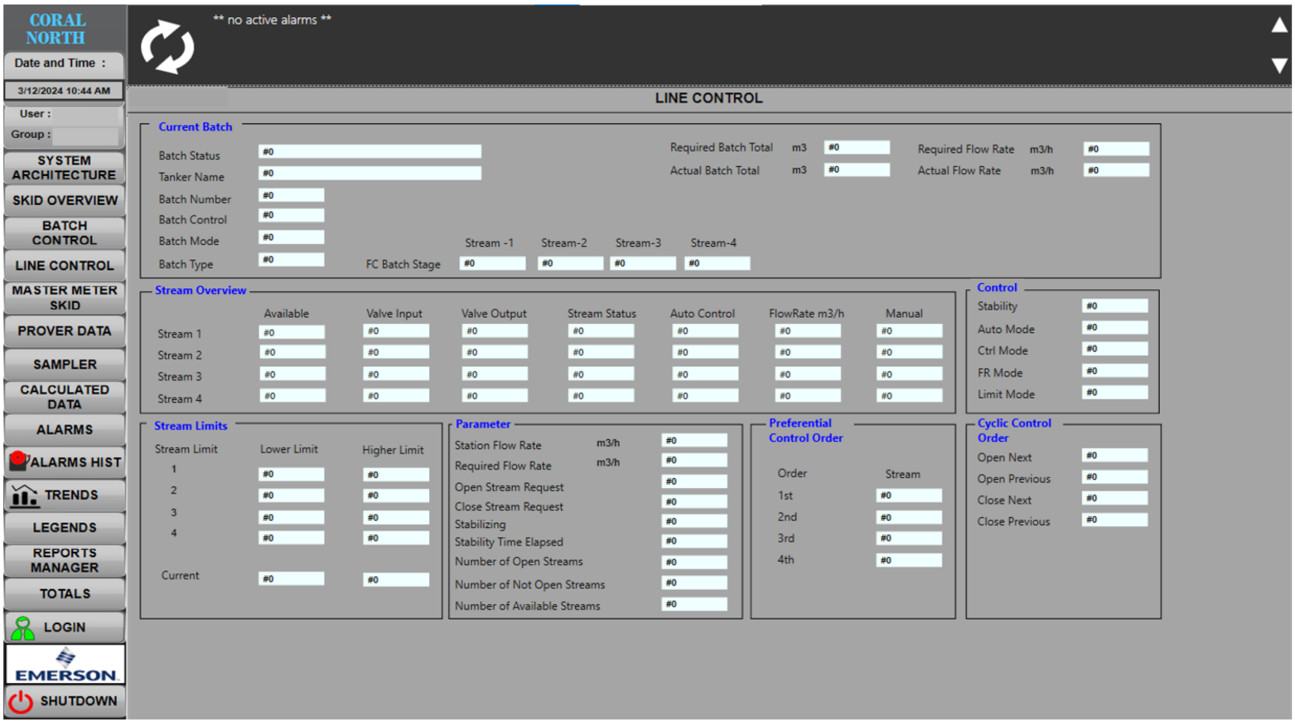
The liquid Coriolis batch control display allows setup and monitoring of the Condensate offloading batch.



Display – Liquid Coriolis Batch Control Display

4.4.18 Liquid Coriolis Line Control Display

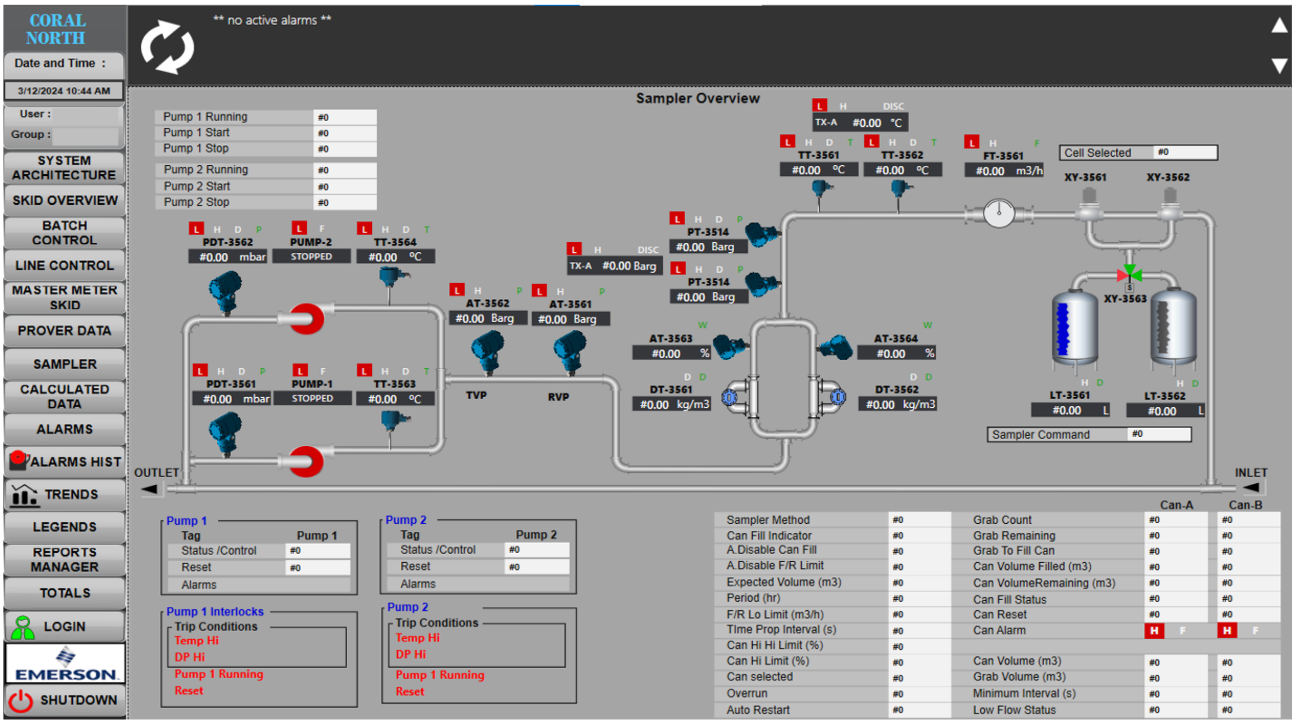
The liquid Coriolis line control display allows setup and monitoring of the automatic line control configured for the four metering streams.



Display – Liquid Coriolis Line Control Display

4.4.19 Sampling Display

The sampling display allows setup, control and monitoring of the automatic sampling system. A mimic of the sampling system and fast loop will be provided, showing the dual densitometers, dual watercut meters, dual temperature transmitters, dual pressure transmitters, dual sampler cells and dual sample receivers.



Display – Sampling Display

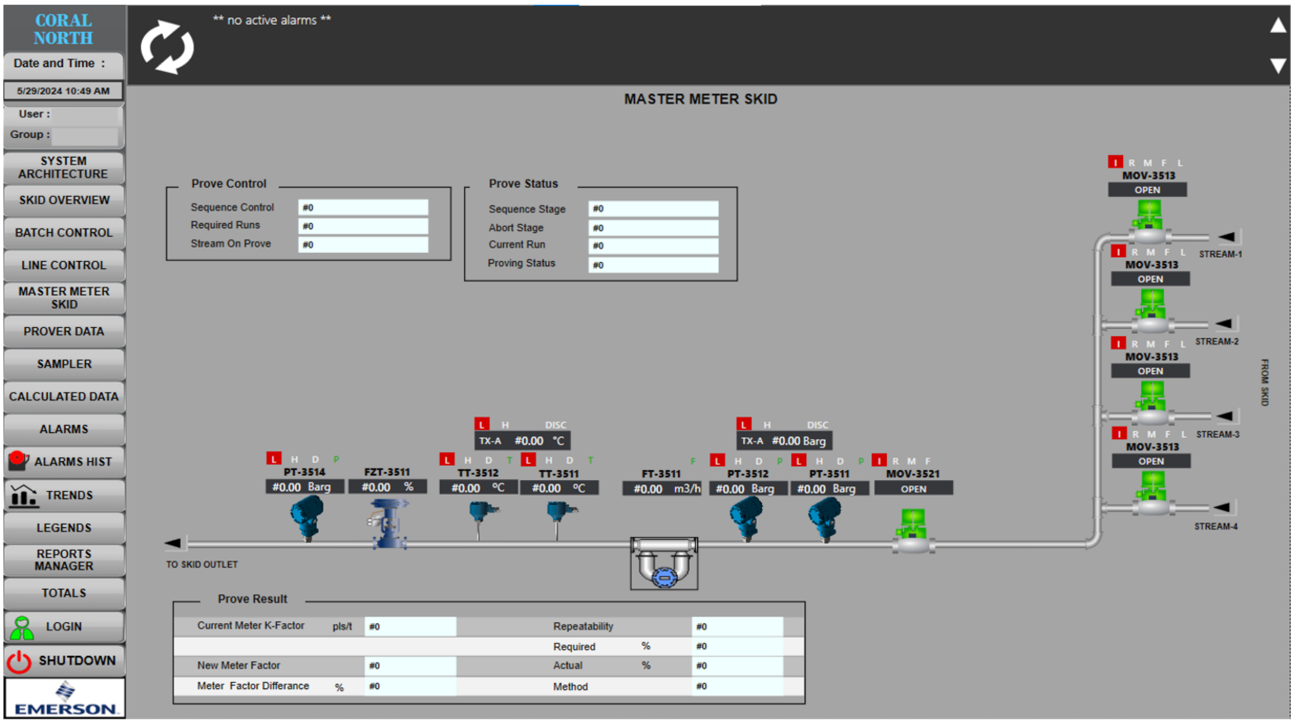
4.4.20 Master Meter Mimic

General overview of the master metering skid, this screen will allow the operator to view the current in use values for the transmitters and valves on the master meter stream. The prover offtake valves for the four metering streams are also displayed.

Clicking a transmitter's data group will automatically open the relevant detail page.

Data groups for each transmitter contain the in-use value, units and alarm indication in the method of light grey text when inactive and red text when active.

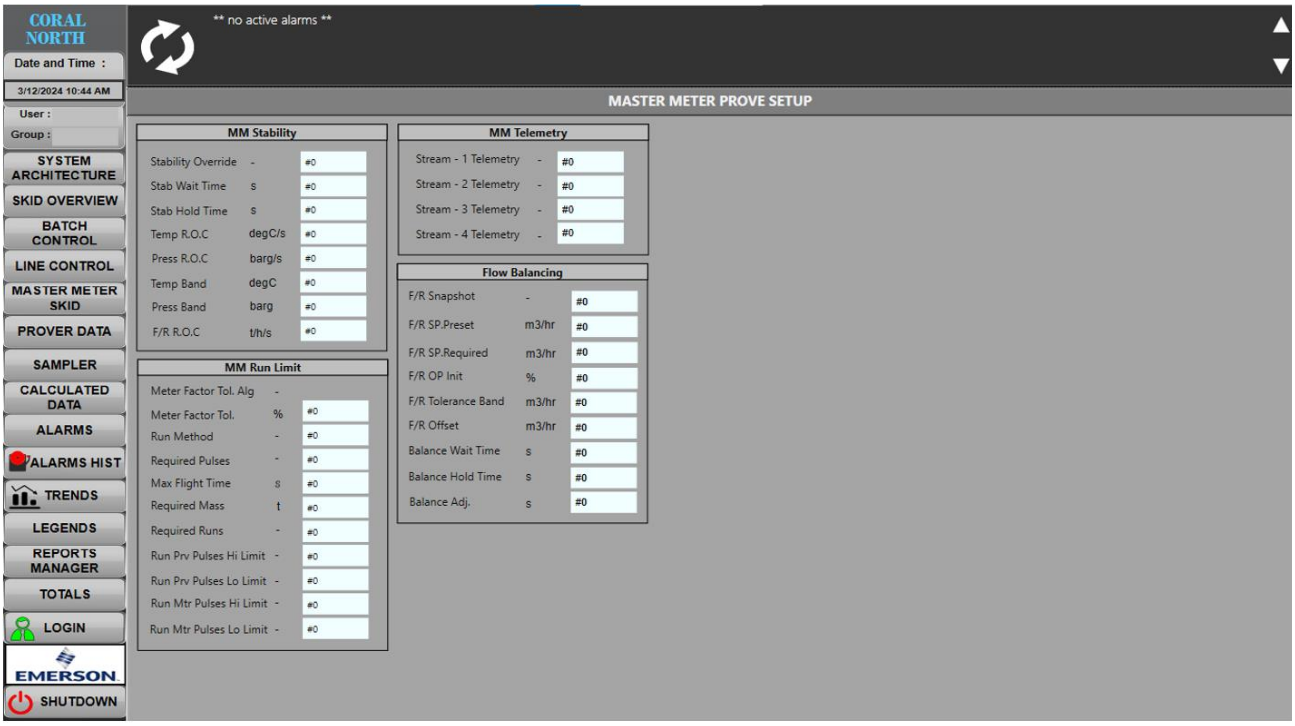
The trial run data is presented on this display.



Display – Master Meter Mimic

4.4.21 Master Meter Prove Setup

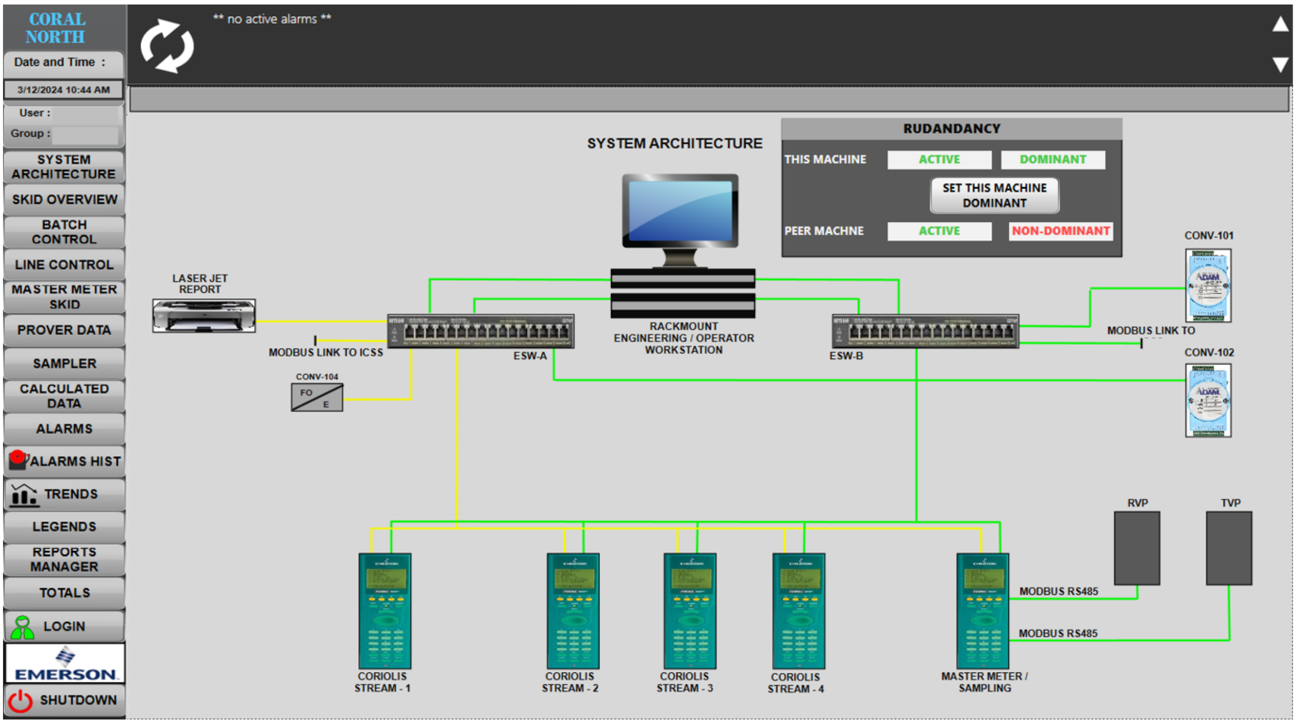
The master meter stream status display allows the operator enter constants for the master meter proving stability and run limits.



Display – Master Meter Prove Setup

4.4.22 System Display

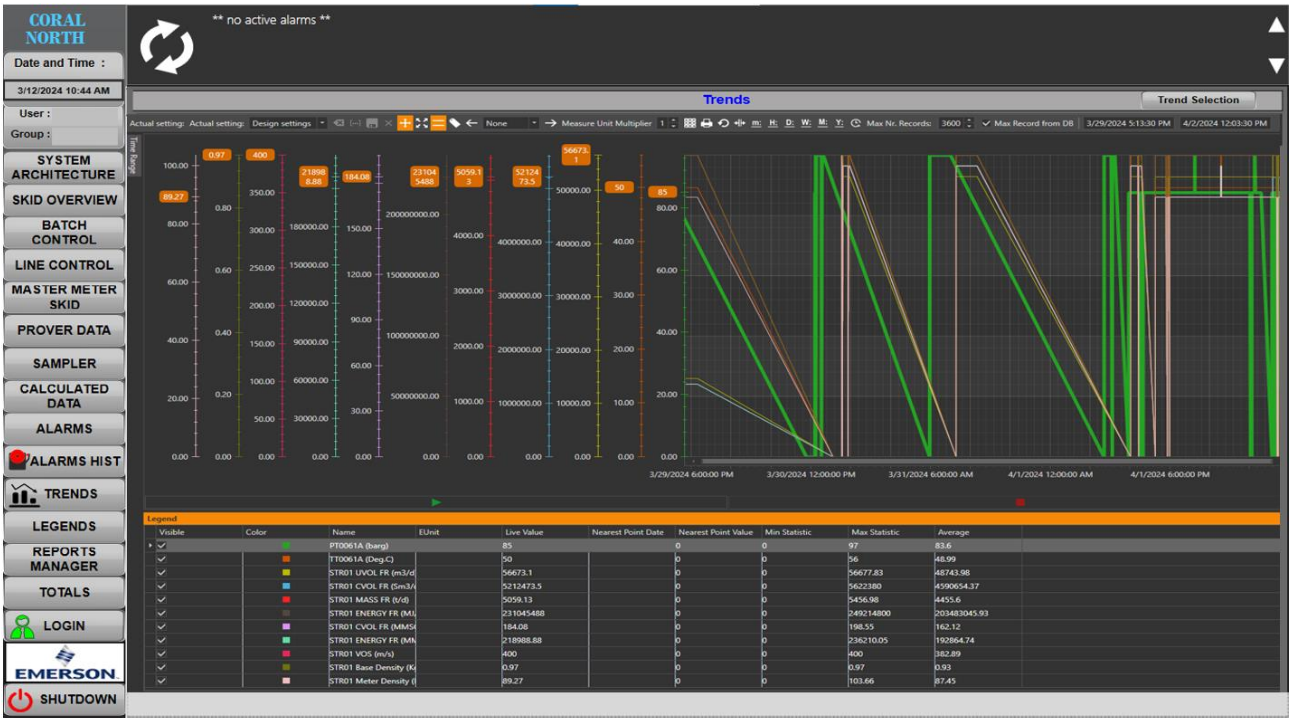
The system display provides a basic network architecture. The various communications links, networked hardware and engineering workstations are shown. Clicking on the S600+ flow computer graphic will open the Web browser for the specific flow computer. It also allows operator to check and change the status of Redundant servers.



Display – System Display

4.4.23 Trend Display

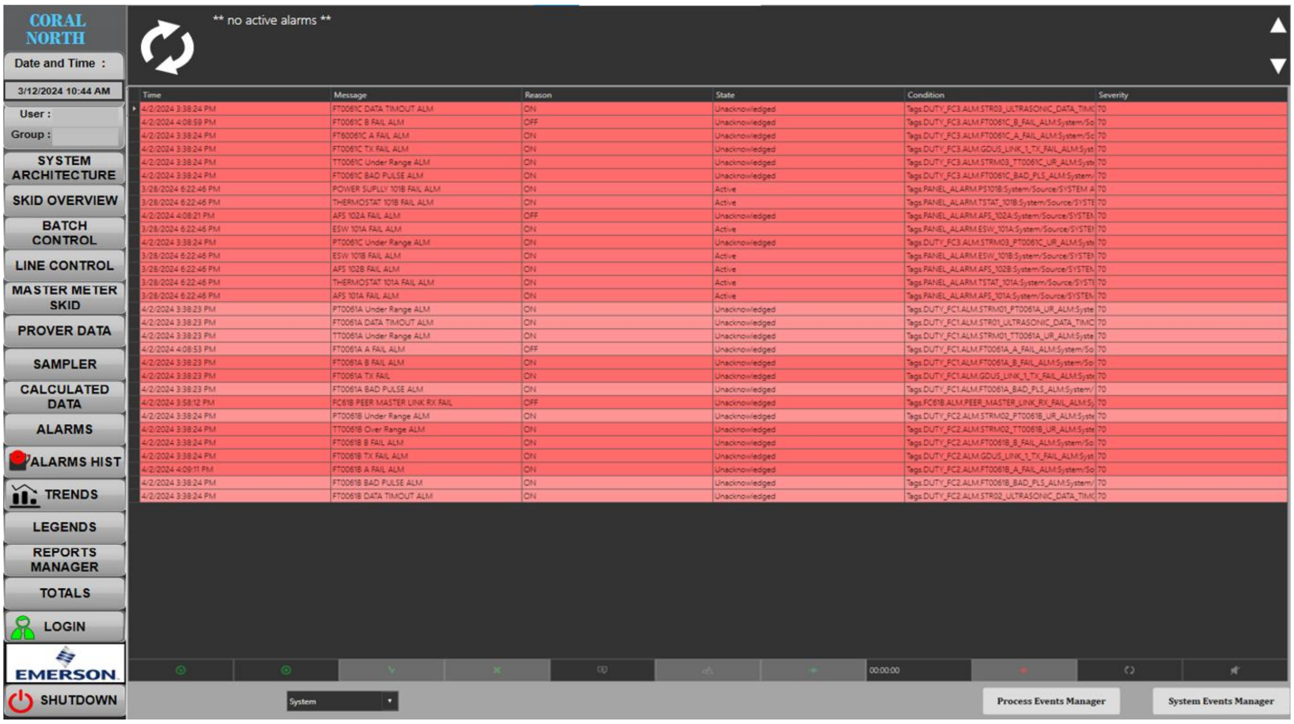
The Trending display allows operator to observe the trend data. The Trending runs continually in the background, to maintain the history of those items for which a trend has been configured. Operator can enable and disable the visibility of specific trend by selecting the check box.



Display – Trends

4.4.24 Alarm Viewer Display

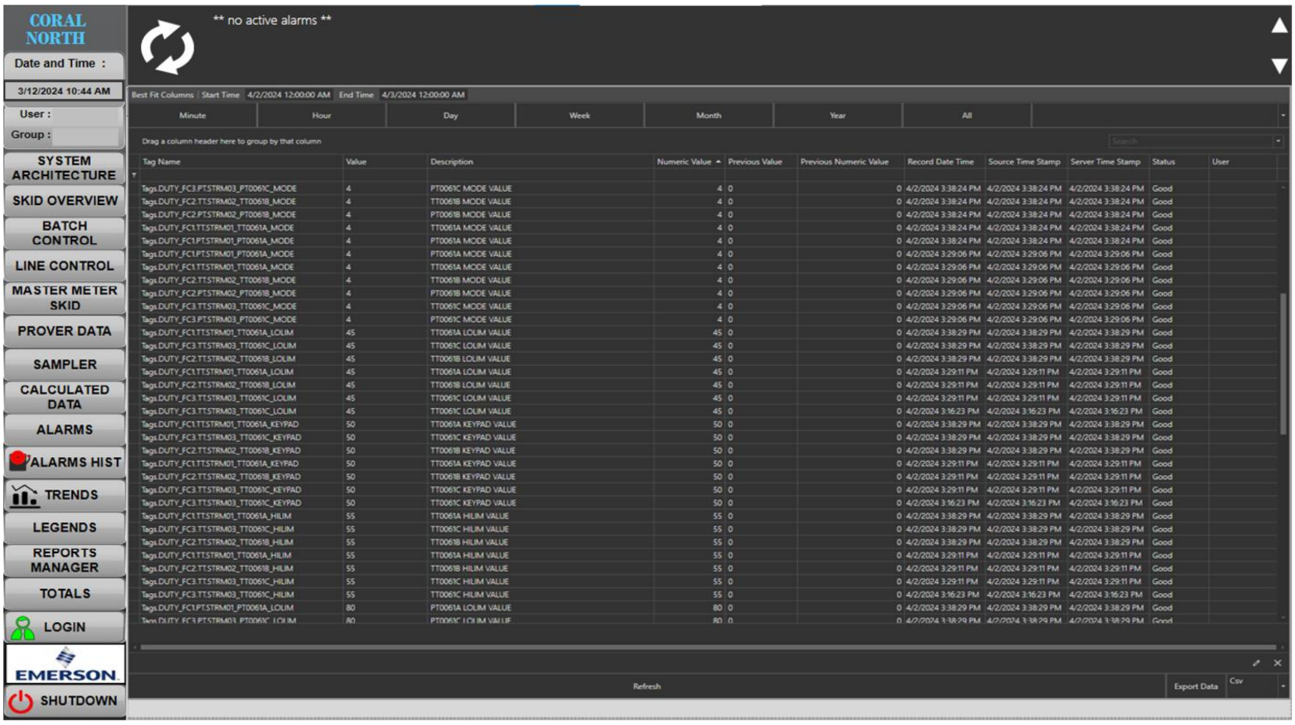
Alarm Viewer Display provides the ability to display and acknowledge all of the configured alarms in the Emerson Metering Suite.



Display – Alarm Viewer

4.4.25 Event Viewer Display

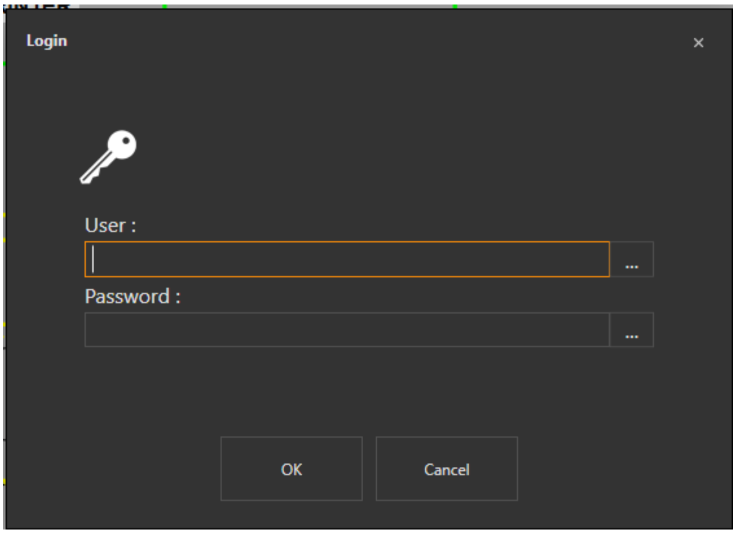
Event Viewer Display provides the ability to display the Events configured in the Emerson Metering Suite. The view is customisable and filters can be applied



Display – Event Viewer

4.4.26 User Login Window

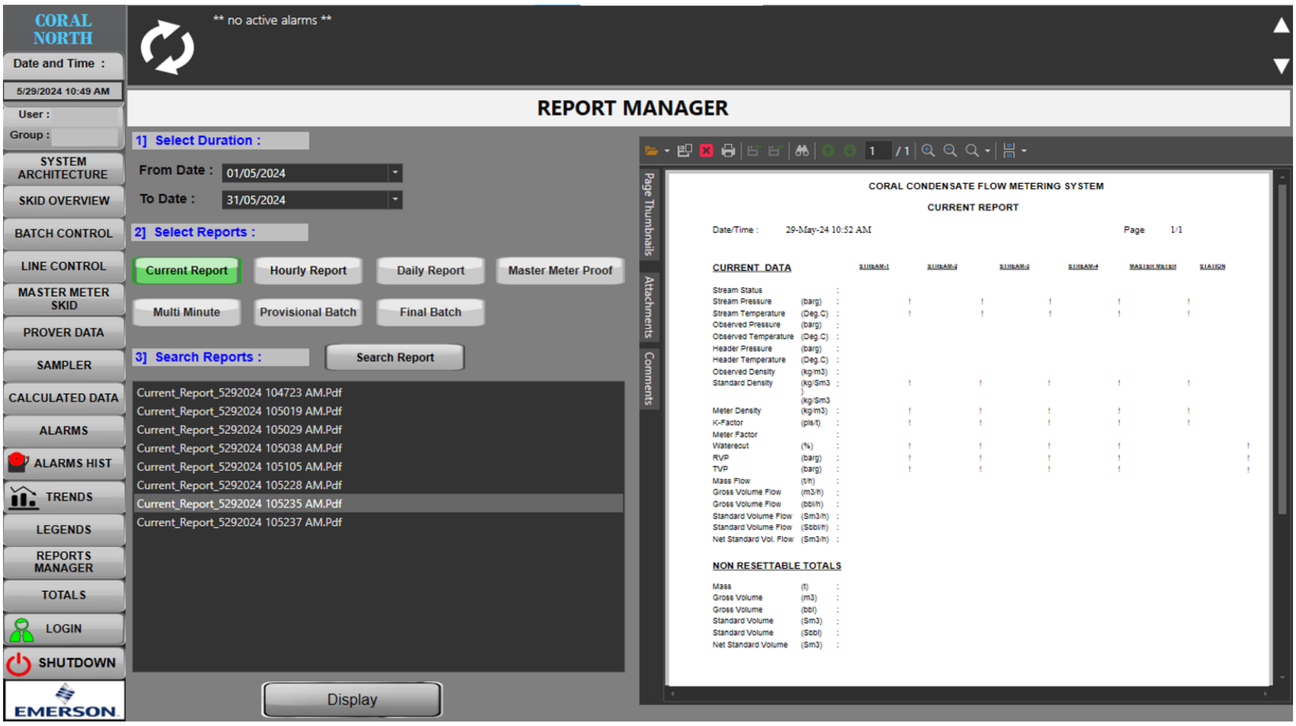
User Logon window allows the user to logon & logoff of the Emerson Metering Suite. Standalone security is configured in the Emerson Metering Suite User Manager.



Display – User Login Window

4.4.27 Report Manager Display

The Report Manager display used to open the Different reports configure in Emerson metering suite. Clicking specific button with time and date entry will provide you the list of reports within period to display.



Display – Report Manager

4.5 Emerson Metering Suite Reports

Report Types

The following reports can be requested at any time:

- Station Current Report

The following reports can be automatically generated:

- Station Multi-Minute Report
- Station Hourly Report
- Station Daily Report
- Provisional Batch Report
- Final Batch Report
- Master Meter Proof Report

4.5.1 Station Current Report

CORAL CONDENSATE FLOW METERING SYSTEM – CURRENT REPORT

PRINT DATE DD/MM/YYYY HH:MM:SS_ PAGE 1 OF 1

CURRENT DATA		STREAM 1	STREAM 2	STREAM 3	STREAM 4	MASTER METER	STATION
STREAM STATUS		XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	
STREAM PRESSURE	(BARG)	XXX.XXX	XXX.XXX	XXX.XXX	XXX.XXX	XXX.XXX	
STREAM TEMPERATURE	(DEGC)	XXX.XX	XXX.XX	XXX.XX	XXX.XX	XXX.XX	
OBSERVED PRESSURE	(BARG)						XXX.XXX
OBSERVED TEMPERATURE	(DEGC)						XXX.XX
HEADER PRESSURE	(BARG)						XXX.XXX
HEADER TEMPERATURE	(DEGC)						XXX.XX
OBSERVED DENSITY	(KG/M3)						XXX.XXX
STANDARD DENSITY	(KG/SM3)	XXX.XXX	XXX.XXX	XXX.XXX	XXX.XXX	XXX.XXX	XXX.XXX
METER DENSITY	(KG/M3)	XXX.XXX	XXX.XXX	XXX.XXX	XXX.XXX	XXX.XXX	
K FACTOR	(PLS/T)	XXXX.XXX	XXXX.XXX	XXXX.XXX	XXXX.XXX	XXX.XXX	
METER FACTOR		X.XXXXX	X.XXXXX	X.XXXXX	X.XXXXX	X.XXXXX	
WATERCUT	(%)	XX.XXX	XX.XXX	XX.XXX	XX.XXX		XX.XXX
RVP	(BARG)	XXX.XXX	XXX.XXX	XXX.XXX	XXX.XXX		XXX.XXX
TVP	(BARG)	XXX.XXX	XXX.XXX	XXX.XXX	XXX.XXX		XXX.XXX
MASS FLOW	(T/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
GROSS VOL FLOW	(M3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
GROSS VOL FLOW	(BBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
STANDARD VOL FLOW	(SBBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
NET STANDARD VOL FLOW	(SM3/H)	XXXXXXXXX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX		XXXXXX.XX
NON RESETABLE TOTALS							
MASS	(T)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
GROSS VOL	(M3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
GROSS VOL	(BBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
STANDARD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
STANDARD VOL	(SBBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
NET STD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX		

Note: A “!” indication on a current process variable indicates that the process variable is using the Keypad value.

4.5.2 Station Multi-Minute Report

CORAL CONDENSATE FLOW METERING SYSTEM – MULTI-MINUTE REPORT

PRINT DATE DD/MM/YYYY HH:MM:SS PAGE 1 OF 1
START OF PERIOD DD/MM/YYYY HH:MM:SS
END OF PERIOD DD/MM/YYYY HH:MM:SS

CURRENT DATA		STREAM 1	STREAM 2	STREAM 3	STREAM 4	MASTER METER	STATION
STREAM STATUS		XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	
STREAM PRESSURE	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
STREAM TEMPERATURE	(DEGC)	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	
OBSERVED PRESSURE	(BARG)						XXX.XXX!
OBSERVED TEMPERATURE	(DEGC)						XXX.XX!
HEADER PRESSURE	(BARG)						XXX.XXX!
HEADER TEMPERATURE	(DEGC)						XXX.XX!
OBSERVED DENSITY	(KG/M3)						XXX.XXX!
STANDARD DENSITY	(KG/SM3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!
METER DENSITY	(KG/M3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
K FACTOR	(PLS/T)	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXX.XXX!	
METER FACTOR		X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	
WATERCUT	(%)	XX.XXX!	XX.XXX!	XX.XXX!	XX.XXX!		XX.XXX!
RVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!		XXX.XXX!
TVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!		XXX.XXX!
MASS FLOW	(T/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
GROSS VOL FLOW	(M3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
GROSS VOL FLOW	(BBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
STANDARD VOL FLOW	(SBBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
NET STANDARD VOL FLOW	(SM3/H)	XXXXXXXXX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX		XXXXXX.XX
MULTI-MIN AVERAGE DATA		STREAM 1	STREAM 2	STREAM 3	STREAM 4	MASTER METER	
STREAM PRESSURE	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
STREAM TEMPERATURE	(DEGC)	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	
STANDARD DENSITY	(KG/SM3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
METER DENSITY	(KG/M3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
K FACTOR	(PLS/T)	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXX.XXX!	
METER FACTOR		X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	
WATERCUT	(%)	XX.XXX!	XX.XXX!	XX.XXX!	XX.XXX!		
RVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!		
TVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!		
MASS FLOW	(T/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
GROSS VOL FLOW	(M3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
GROSS VOL FLOW	(BBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
STANDARD VOL FLOW	(SBBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
NET STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX		
MULTI-MIN TOTALS							
MASS	(T)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(M3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(BBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SBBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
NET STD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX		XXXXXXXXX.XX
NON RESETABLE TOTALS							
MASS	(T)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
GROSS VOL	(M3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
GROSS VOL	(BBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
STANDARD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
STANDARD VOL	(SBBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
NET STD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX		

Note: A “!” indication on a current process variable indicates that the process variable is using the Keypad value. A “!” indication on an averaged process variable indicates that the process variable has been using the Keypad value at some point during the averaging period.

4.5.3 Station Hourly Report

CORAL CONDENSATE FLOW METERING SYSTEM – HOURLY REPORT

PRINT DATE DD/MM/YYYY HH:MM:SS PAGE 1 OF 1
START OF PERIOD DD/MM/YYYY HH:MM:SS
END OF PERIOD DD/MM/YYYY HH:MM:SS

CURRENT DATA		STREAM 1	STREAM 2	STREAM 3	STREAM 4	MASTER METER	STATION
STREAM STATUS		XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	
STREAM PRESSURE	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
STREAM TEMPERATURE	(DEGC)	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	
OBSERVED PRESSURE	(BARG)						XXX.XXX!
OBSERVED TEMPERATURE	(DEGC)						XXX.XX!
HEADER PRESSURE	(BARG)						XXX.XXX!
HEADER TEMPERATURE	(DEGC)						XXX.XX!
OBSERVED DENSITY	(KG/M3)						XXX.XXX!
STANDARD DENSITY	(KG/SM3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!
METER DENSITY	(KG/M3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
K FACTOR	(PLS/T)	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXX.XXX!	
METER FACTOR		X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	
WATERCUT	(%)	XX.XXX!	XX.XXX!	XX.XXX!	XX.XXX!		XX.XXX!
RVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!		XXX.XXX!
TVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!		XXX.XXX!
MASS FLOW	(T/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
GROSS VOL FLOW	(M3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
GROSS VOL FLOW	(BBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
STANDARD VOL FLOW	(SBBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
NET STANDARD VOL FLOW	(SM3/H)	XXXXXXXXX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX		XXXXXX.XX
HOURLY AVERAGE DATA		STREAM 1	STREAM 2	STREAM 3	STREAM 4	MASTER METER	
STREAM PRESSURE	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
STREAM TEMPERATURE	(DEGC)	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	
STANDARD DENSITY	(KG/SM3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
METER DENSITY	(KG/M3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
K FACTOR	(PLS/T)	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXX.XXX!	
METER FACTOR		X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	
WATERCUT	(%)	XX.XXX!	XX.XXX!	XX.XXX!	XX.XXX!		
RVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!		
TVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!		
MASS FLOW	(T/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
GROSS VOL FLOW	(M3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
GROSS VOL FLOW	(BBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
STANDARD VOL FLOW	(SBBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
NET STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX		
HOURLY TOTALS							
MASS	(T)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(M3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(BBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SBBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
NET STD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX		XXXXXXXXX.XX
NON RESETABLE TOTALS							
MASS	(T)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
GROSS VOL	(M3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
GROSS VOL	(BBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
STANDARD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
STANDARD VOL	(SBBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	
NET STD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX		

Note: A “!” indication on a current process variable indicates that the process variable is using the Keypad value. A “!” indication on an averaged process variable indicates that the process variable has been using the Keypad value at some point during the averaging period.

4.5.4 Station Daily Report

CORAL CONDENSATE FLOW METERING SYSTEM – DAILY REPORT

PRINT DATE DD/MM/YYYY HH:MM:SS PAGE 1 OF 1
START OF PERIOD DD/MM/YYYY HH:MM:SS
END OF PERIOD DD/MM/YYYY HH:MM:SS

CURRENT DATA		STREAM 1	STREAM 2	STREAM 3	STREAM 4	MASTER METER	STATION
STREAM STATUS		XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX	
STREAM PRESSURE	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
STREAM TEMPERATURE	(DEGC)	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	
OBSERVED PRESSURE	(BARG)						XXX.XXX!
OBSERVED TEMPERATURE	(DEGC)						XXX.XX!
HEADER PRESSURE	(BARG)						XXX.XXX!
HEADER TEMPERATURE	(DEGC)						XXX.XX!
OBSERVED DENSITY	(KG/M3)						XXX.XXX!
STANDARD DENSITY	(KG/SM3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!
METER DENSITY	(KG/M3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
K FACTOR	(PLS/T)	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXX.XXX!	
METER FACTOR		X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	
WATERCUT	(%)	XX.XXX!	XX.XXX!	XX.XXX!	XX.XXX!		XX.XXX!
RVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!		XXX.XXX!
TVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!		XXX.XXX!
MASS FLOW	(T/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
GROSS VOL FLOW	(M3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
GROSS VOL FLOW	(BBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
STANDARD VOL FLOW	(SBBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
NET STANDARD VOL FLOW	(SM3/H)	XXXXXXXXX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX		XXXXXX.XX

DAILY AVERAGE DATA		STREAM 1	STREAM 2	STREAM 3	STREAM 4	MASTER METER
STREAM PRESSURE	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!
STREAM TEMPERATURE	(DEGC)	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!
STANDARD DENSITY	(KG/SM3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!
METER DENSITY	(KG/M3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!
K FACTOR	(PLS/T)	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXX.XXX!
METER FACTOR		X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!
WATERCUT	(%)	XX.XXX!	XX.XXX!	XX.XXX!	XX.XXX!	
RVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
TVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
MASS FLOW	(T/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
GROSS VOL FLOW	(M3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
GROSS VOL FLOW	(BBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
STANDARD VOL FLOW	(SBBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX
NET STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	

DAILY TOTALS							
MASS	(T)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(M3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(BBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SBBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
NET STD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX		XXXXXXXXX.XX

NON RESETABLE TOTALS						
MASS	(T)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(M3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(BBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SBBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
NET STD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	

Note: A “!” indication on a current process variable indicates that the process variable is using the Keypad value. A “!” indication on an averaged process variable indicates that the process variable has been using the Keypad value at some point during the averaging period.

4.5.5 Provisional Batch Report

CORAL CONDENSATE FLOW METERING SYSTEM – PROVISIONAL BATCH REPORT

PAGE 1 OF 1

START OF BATCH DD/MM/YYYY HH:MM:SS
END OF BATCH DD/MM/YYYY HH:MM:SS

BATCH NUMBER XXXXXX

BATCH AVERAGE DATA		STREAM 1	STREAM 2	STREAM 3	STREAM 4	STATION
STREAM PRESSURE	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
STREAM TEMPERATURE	(DEGC)	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	
STANDARD DENSITY	(KG/SM3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
METER DENSITY	(KG/M3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
K FACTOR	(PLS/T)	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	
METER FACTOR		X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	
WATERCUT	(%)	XX.XXX!	XX.XXX!	XX.XXX!	XX.XXX!	
RVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
TVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
MASS FLOW	(T/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
GROSS VOL FLOW	(M3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
GROSS VOL FLOW	(BBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
STANDARD VOL FLOW	(SBBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
NET STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
BATCH TOTALS						
MASS	(T)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(M3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(BBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SBBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
NET STD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX

Note: A “!” indication on a current process variable indicates that the process variable is using the Keypad value. A “!” indication on an averaged process variable indicates that the process variable has been using the Keypad value at some point during the averaging period.

4.5.6 Final Batch Report

CORAL CONDENSATE FLOW METERING SYSTEM – FINAL BATCH REPORT

PAGE 1 OF 1

START OF BATCH	DD/MM/YYYY	HH:MM:SS
END OF BATCH	DD/MM/YYYY	HH:MM:SS
BATCH NUMBER	XXXXXX	

STANDARD DENSITY SELECTION		LIVE/LAB
LAB STANDARD DENSITY	(KG/SM3)	XXX.XXX
BSW SELECTION		LIVE/LAB
LAB BSW	(%)	XX.XXX

BATCH AVERAGE DATA		STREAM 1	STREAM 2	STREAM 3	STREAM 4	STATION
STREAM PRESSURE	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
STREAM TEMPERATURE	(DEGC)	XXX.XX!	XXX.XX!	XXX.XX!	XXX.XX!	
STANDARD DENSITY	(KG/SM3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
METER DENSITY	(KG/M3)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
K FACTOR	(PLS/T)	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	XXXX.XXX!	
METER FACTOR		X.XXXXX!	X.XXXXX!	X.XXXXX!	X.XXXXX!	
WATERCUT	(%)	XX.XXX!	XX.XXX!	XX.XXX!	XX.XXX!	
RVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
TVP	(BARG)	XXX.XXX!	XXX.XXX!	XXX.XXX!	XXX.XXX!	
MASS FLOW	(T/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
GROSS VOL FLOW	(M3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
GROSS VOL FLOW	(BBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
STANDARD VOL FLOW	(SBBL/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
NET STANDARD VOL FLOW	(SM3/H)	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	XXXXXX.XX	
BATCH TOTALS						
MASS	(T)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(M3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
GROSS VOL	(BBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
STANDARD VOL	(SBBL)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX
NET STD VOL	(SM3)	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX	XXXXXXXXX.XX

Note: A “!” indication on a current process variable indicates that the process variable is using the Keypad value. A “!” indication on an averaged process variable indicates that the process variable has been using the Keypad value at some point during the averaging period.

4.5.7 Master Meter Proof Report

CORAL CONDENSATE FLOW METERING SYSTEM – MASTER METER PROOF REPORT

PRINT DATE DD/MM/YYYY HH:MM:SS PAGE 1 OF 2

STREAM ON PROOF : XXXXXXX TOL ALGORITHM: MX-MN/MN
PROVING RATE (T/H) : XXXXXX.XX

STANDARD DENSITY (KG/SM3) : XXX.XXX
STREAM TEMPERATURE (DEG C) : XXX.XX STREAM PRESSURE (BARG) : XXX.XXX
MASTER METER TEMPERATURE (DEG C) : XXX.XX MASTER METER PRESSURE (BARG) : XXX.XXX

	STREAM		MASTER METER		STANDARD	STREAM	MM	
TRIAL No.	TEMP. (DEG C)	PRESS (BARG)	TEMP. (DEG C)	PRESS (BARG)	DENSITY (KG/SM3)	PLS	PLS	FTIME (S)
1	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
2	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
3	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
4	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
5	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
6	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
7	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
8	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
9	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
10	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
11	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
12	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
13	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
14	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
15	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
16	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
17	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
18	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
19	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
20	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX
AVE	XXX.XX	XXX.XXX	XXX.XX	XXX.XXX	XXX.XXX	XXXXXX.X	XXXXXX.X	XXXX.XXX

CORAL CONDENSATE FLOW METERING SYSTEM – MASTER METER PROOF REPORT

PRINT DATE DD/MM/YYYY HH:MM:SS PAGE 2 OF 2

STREAM ON PROOF : XXXXXXX

	MM M-FACTOR	MM PCF	STREAM PCF	MM MASS	STREAM MASS	STREAM FLOWRATE (T/H)	METER FACTOR
1	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
2	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
3	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
4	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
5	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
6	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
7	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
8	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
9	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
10	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
11	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
12	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
13	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
14	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
15	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
16	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
17	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
18	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
19	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
20	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX
AVE	X.XXXXX	X.XXXXX	X.XXXXX	XXXXXX.XXX	XXXXXX.XXX	XXXXXX.XX	X.XXXXX

CURRENT METER K-FACTOR (PLS/T) : XXXXX.XXXX REPEATABILITY
NEW METER FACTOR : XXXXX.XXXX REQUIRED (%) : X.XXXX
DIFFERENCE (%) : X.XXXXX ACTUAL (%) : X.XXXX
XXX.XXX METHOD : STATISTICAL

4.5.8 Report Destinations

Emerson metering Suite generates .pdf files for each automatic report. In addition to being stored as a PDF the report can be automatically printed. The following table shows the destinations configured for each report.

Local Drive PDF: D:\EMS\Reports
Local Printer: Automatically prints to local printer

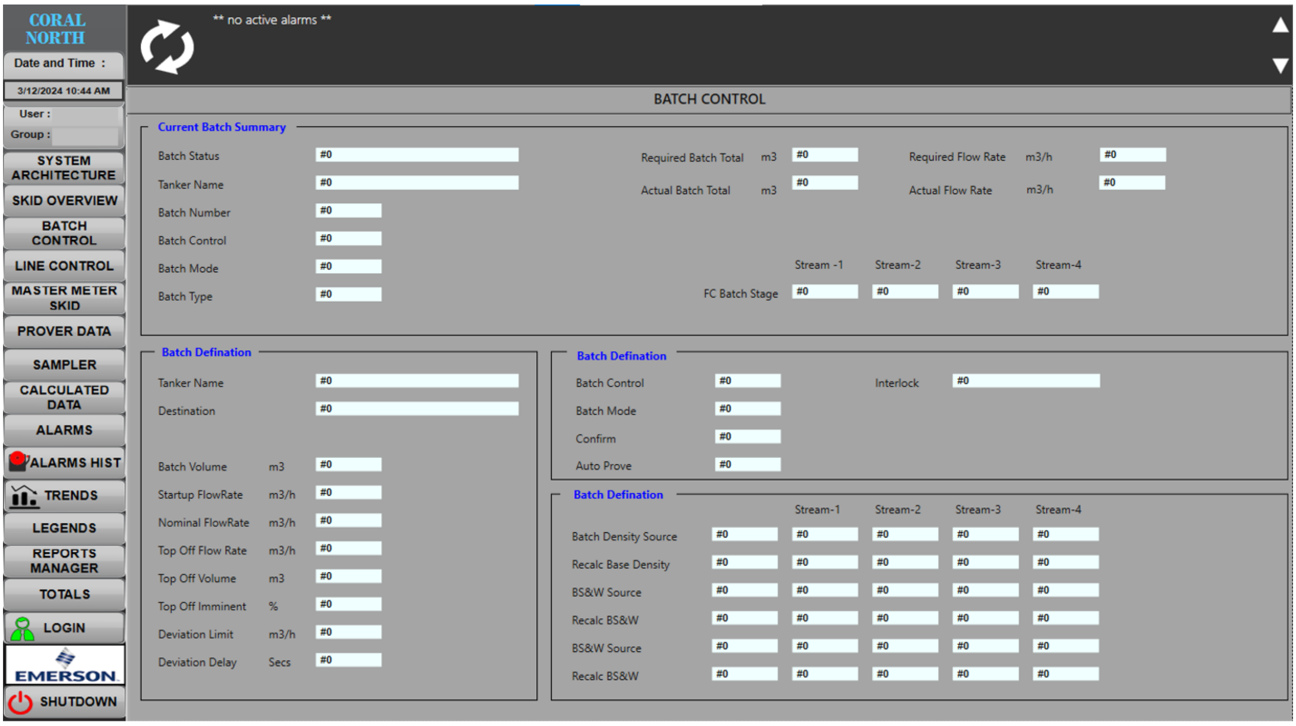
Report Name	Local Drive PDF	Local Printer
Station Multi-Minute Report	Y	N
Station Hourly Report	Y	N
Station Daily Report	Y	N
Master Meter Proof Report	Y	Y
Provisional Batch Report	Y	Y
Final Batch Report	Y	Y

Table – Emerson metering Suite Report Destinations

4.6 Emerson metering Suite Batch Control

4.6.1 Introduction

The facility to set up and control batching is provided by the Emerson Metering Suite supervisory. The batch data, required volume and flowrates for the various stages of the batch are entered from the batch control display. An example of the batch control display is shown below.



Liquid Coriolis Batch Control Display

4.6.2 Batch Control Modes

There are three batch control modes which determine the level of automation of the batch sequence. The batch control modes can be selected at any time during the batch. The batch control modes are detailed in the table below:

Mode	Description
Manual Batch Control	When operating in batch manual mode, all valve control must be initiated by the operator.
Semi-Automatic Control	When operating in batch semi-automatic mode, all line control required during a batch is requested automatically. Flow control is a manual operation, with the operator responsible for entering individual flowrate set points for the online stream FCVs.
Automatic Control	When operating in batch automatic mode, all valve controls required during a batch are requested automatically. The batch required flow rate is used to automatically determine and download the flowrate set points for the online stream FCVs, in order to maintain the required station flowrate.

Table – Emerson Metering Suite Batch Control Modes

4.6.3 Batch Control Sequence

The batch sequence is controlled by the operator using the batch control menus. The commands available to the operator are:

1. BATCH DEFINE
2. BATCH START
3. PROCEED TO LOADING RATE (NOMINAL)
4. PROCEED TO TOP-OFF RATE (TOP-OFF)
5. BATCH HOLD
6. BATCH TERMINATE

While a batch is in progress, the system monitors the current batch volume and raises alarms if the top-off volume is imminent, top-off volume is exceeded or the required batch volume is exceeded.

At the end of every batch, a provisional batch report is automatically generated and archived.

The batch can be finalised by inputting lab derived values for standard density and BSW. Alternatively, the live data determined by the online instrumentation during the batch may be used. Once the finalise command has been issued a final batch report is generated and archived.

The following describes the batch control sequence:

Step 1 - Batch Definition

To define a new batch the operator is required to set up the batch parameters, including tanker name, and then progress the batch through the three-stage batch loading sequence. The three batch stages are: start-up, loading and top-off.

The operator is required to enter data concerning the batch to be loaded prior to batch commencement.

The batch definition data required to be entered by the operator at the start of a batch is as follows:

Data Point	Description
Tanker name	The name of the tanker involved in the batch.
Batch volume (m3)	The volume to be loaded.
Start-up flow rate (m3/h)	The flow rate required for the start-up.
Loading flow rate (m3/h)	The flow rate required for the nominal period.
Top-off flow rate (m3/h)	The flow rate required for the top-off period.
Top-off volume (m3)	The volume at which top-off flowrate is to begin.
Top-off imminent %	The % of the top-off volume at which the top-off imminent alarm is set.
Deviation limit (m3/h)	The amount (m3/hr) of flowrate deviation permitted between current flowrate and required flowrate. (Only used in automatic batch mode.)
Deviation time (s)	The time (seconds) that the deviation limit must be present before any action takes place. If the deviation limit is present for longer than the permitted time, and the batch is in automatic mode, then an alarm is raised.

Table – Emerson Metering Suite Batch Definition

Once batch data has been entered the "Batch Defined" command can be issued. The following checks are performed during the batch define:

1. Check the sampler grab count is set to zero.
2. Check the sample can level is below the can empty limit.

If either of the above conditions are not met, then the operator is prompted to reset the sample can.

Each batch has a unique number assigned to it in the range 0 to 9999. This number is automatically incremented when the batch data is defined.

Step 2 - Batch Start-Up

Once the operator has entered the batch definition data, the batch start command can be issued. Note that once the batch start command has been actioned it is not possible to change the tanker name.

The batch start request is rejected, with a suitable warning message, in the following circumstances: -

- The batch is not defined (Step 1)
- One or more streams believe that a batch is in progress (i.e. they require to be sent a batch stop command)

Upon acceptance, the batch start command is downloaded to all flow computers that have communications enabled. In automatic mode the batch start up flowrate will be used to determine the number of streams required and provide flow rate setpoints to the online streams.

The batch remains in the start-up state until directed to proceed to the nominal state by the operator.

Step 3 - Batch Nominal Loading Rate

From the start-up stage the operator can proceed to the nominal loading stage. When the operator commands the batch to proceed to the nominal loading stage and the batch is in semi/automatic mode, the system automatically performs the valve control to open the required streams for the loading stage.

If batch manual mode is selected, the operator must perform the required valve control.

If automatic mode is selected, the Emerson Metering Suite uses the required batch flow rate to download a flow set point to the stream flow computers. After an operator entered time, the system compares the required flow rate to the actual flow rate. If they differ by more than an operator defined limit, a 'batch flow rate unstable' alarm is raised. This process is repeated if the operator decides to change the required batch loading flow rate.

Once the loading state has been selected, it is not possible to revert to the start-up state.

Step 4 - Batch Top-off Rate

The operator may proceed to the top off stage at any point once the batch is in the nominal loading stage. When the operator directs the batch to proceed to the top-off stage while in batch semi/automatic mode, the system automatically performs the required valve control for the top-off state. If batch manual mode is active, the operator must perform the required valve control.

Once the top-off stage has been selected, it is not possible to revert to the nominal loading stage.

If the required batch volume is exceeded, an alarm is raised.

The batch remains in the top-off stage until the operator issues a command to stop the batch.

Step 5 - Batch Terminate

The operator may issue a batch terminate command at any time. If the batch is in Semi/Automatic mode when this command is entered, all currently open streams are closed. If the batch is in manual mode then the operator will firstly have to close all the open streams before a batch stop command is accepted.

Upon selection of the ‘Batch Terminate’ command, the Emerson Metering Suite will wait for all stream outlet valves to close before initiating the command to take the flow computers out of batch mode.

When all streams have been successfully closed the Emerson Metering Suite issues the stop batch command to all flow computers and the 'provisional batch' report is automatically generated and printed.

Step 6 – Finalising the Batch

Once the batch has been stopped the operator has the option of finalising the batch data with either “Orignial” or “Laboratory” figures for the standard density and BSW values using the Bacth Recal Control entries.

If “Original” is selected for the Base Density Source and the BS&W Source then no recalculations are made to the batch totals when the “Recalc” command is set to “Yes”.

If “Lab” is selected for the Base Density Source and the BS&W Source then the operator is required to enter laboratory values for “Recalc Base Density” and “Recalc BS&W” from the Batch Recalc Control. The Emerson Metering Suite will then download these values to each of the stream flow computers. The operator is then required to set the “Recalc” command to “Yes”. If a value has been entered incorrectly, and the “Accept” command has not been issued, then the operator may enter the lab figures again and set the “Recalc” command to “Yes” to update the recalculated figures.

Once the recalculation has been performed the operator must issue the “Accept” command to finalise the recalculation and automatically generate the ‘final batch’ report.

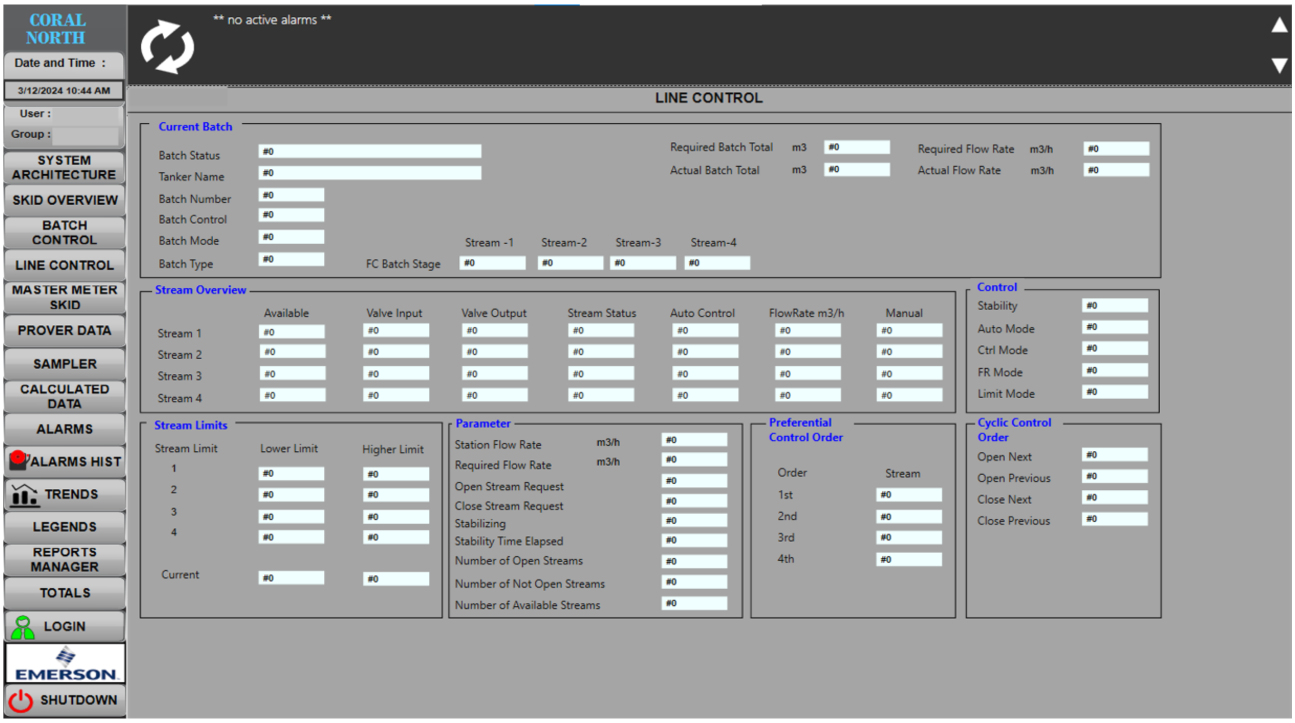
4.6.4 Batch Hold

During a batch the operator can put the batch loading on "hold". If the system is in automatic mode, all streams are closed. To continue with the batch the operator proceeds to the start-up, loading and top-off states as previously defined. The batch may be stopped when in batch hold mode by proceeding to the batch stop state. The batch hold command may be used during an offloading shutdown. When safe to do so the batch can be resumed from the batch hold stage without having to start a new batch.

4.7 Emerson Metering Suite Line Control

4.7.1 Manual Line Control

The operator can select manual line control. When this mode is selected, the operator must initiate all valve controls. Valve control can be performed either using the dedicated line control display or by clicking on the valve in the graphic mimic.



Liquid Coriolis Line Control Display

4.7.2 Automatic Line Control

The main function of automatic line control is to ensure the primary flow measurement devices for the process streams are always kept within their optimum or calibrated measurement ranges. The operator can select automatic line control. Streams will then be opened or closed based on changing flow conditions. It should be noted that when a proof/test is in progress on a station, no automatic line control is performed.

When automatic line control is selected, lines will be opened or closed, dependent upon flow conditions. On a line being controlled, no further line control is performed for a configurable delay, to allow flow conditions to stabilise.

The method of stream switching is based on the station flow rate.

For this method the streams are automatically opened or closed based on the station flow rate. Flow rate ranges for the number of open streams are used to determine when a new stream should be opened or closed. The opening and closing of streams can be performed on a cyclic, or preferred basis.

It should be noted, that when line switching is enabled, there is a potential for two streams to be closed at the same time. This would be the result of the flow conditions dictating that a line should be closed, and at the same time, an operator manually requesting a line to be closed. To safeguard against such an occurrence, the following interlocks on closing lines are provided:

1. On a manual request for a line to be closed, the stability timer is reset to zero, thus allowing flow conditions to stabilise before any further automatic control is attempted.

2. On a manual request for a line to be closed, and an automatic close control previously being issued, the manual control is ignored until the automatic line control has been actioned, or the control has timed out.

Flow Balancing

The automatic line control shall perform flow balancing between the open streams to equally distribute the flow and ensure each meter is operating within its calibrated measurement range.

The outlet motor operated valves and flow control valves for each stream will be controlled by the automatic line control. The inlet valves will be open during normal operation and will not be controlled by the automatic line control.

Low and high flow rate limits will be entered for the number of open streams as per the example below. If the required flow rate was 2500 m3/h, referring to the table below, the automatic line control would determine that two streams are required. The automatic sequence would open or close the required number of streams and set the FCV setpoints accordingly.

When Automatic line control is selected the FCV setpoints will be clipped at a pre-determined value (Default 1334 m3/h) to prevent the operating range of the Coriolis meter being exceeded.

When in Automatic line control mode the individual FCV flowrate setpoints, Manual % output and Auto/Manual mode selection cannot be changed manually. To manually change these FCV parameters the Line Control or Batching mode must be set to Manual.

Open Streams	Lower Limit (m3/h)	Higher Limit (m3/h)
1	10	1505
2	1500	3005
3	3000	4505
4	4500	6000

Table – Flow Switching Limits

Two options are available to determine the order of opening and closing streams:

Cyclic: The order is determined by the line switching algorithm and is based on flow time. The stream with the least flow time will be opened first.

Preferred: The stream order is set by the operator from the HMI.

Automatic Stream Opening and Flow Balancing Sequence

When a stream is commanded to open by the automatic line control, due to an increase in the required flow rate, the following sequence is executed:

1. Outlet motor operated valve commanded to open.

2. Receive open status from outlet motor operated valve.

3. Wait for a configurable stability time (default 30 seconds).
4. Set the stream FCV mode to automatic.
5. Issue a setpoint to the stream FCV (Required Flowrate / Number of online streams).
6. Issue a command to open another stream, if required.

Automatic Stream Closing and Flow Balancing Sequence

When a stream is commanded to close by the automatic line control, due to a decrease in the required flow rate, the following sequence is executed:

1. Outlet motor operated valve commanded to close.
2. Online stream FCV setpoints adjusted for the new, lower required flow rate.
3. Receive closed status from the outlet motor operated valve.
4. Wait for a configurable stability time (default 30 seconds).
5. Set the closed stream FCV mode to Manual.
6. Remaining online stream FCV setpoints adjusted for the required flow rate.
7. Issue a command to close another stream, if required.

Automatic Line Control with Flow Balance Example

The following example provides the sequence of events to open streams to achieve a required flow rate:

For the example the following flow switching limits are used:

Based on three streams (x3 streams and x1 spare) with a nominal flowrate of 4000 m3/h.

Note: It is assumed there are two cargo pumps. These are not part of the metering scope and will be controlled separately. The number of cargo pumps required during each stage of the batch is a recommendation only. The performance curve of the pumps should be used to determine how many are required during the various batching stages.

Open Streams	Lower Limit (m3/h)	Higher Limit (m3/h)
1	10	1305
2	1300	2605
3	2600	4005

Table – Example Flow Switching Limits

Initial Conditions:

All stream inlet valves open

All stream outlet and prover offtake valves closed

All stream FCVs in Manual mode with 0% open

All streams set available for line control

Preferred stream order set to: S1 - 1st, S2 - 2nd, S3 – 3rd

Automatic Line Control Selected

Required flow rate = 0 m3/h

Cargo Pumps Idle

Batch Definition Data:

Batch Volume: 250,000 m3

Startup Flow Rate: 1000 m3/h

Nominal Flow Rate: 3900 m3/h

Top Off Flow Rate: 2000 m3/h

Batch Startup Flow Rate Opening Sequence:

Define the batch and issue the “Start” batch command.

Batch Startup Required flow rate set to 1000 m3/h (Will require 1 stream to be opened)

Stream 1 outlet valve commanded to open

Stream 1 outlet valve status received as open

Start stability timer and wait for it to expire

Stream 1 FCV set to Automatic mode and assigned a setpoint of 1000 m3/h

Bring one Cargo Pump online once the Stream 1 FCV has received its setpoint and is returning a 100% open feedback signal.

Flow until sufficient startup quantity is offloaded then manually issue the “Nominal” batch command.

Batch Nominal Flow Rate Opening Sequence:

Issue the “Nominal” batch command

Batch Startup required flow rate set to 3900 m3/h (Will require 3 streams to be opened)

Stream 2 outlet valve commanded to open

Stream 2 outlet valve status received as open

Start stability timer and wait for it to expire

Stream 2 FCV set to Automatic mode and a setpoint of 1334 m3/h (Maximum allowable setpoint per stream)

Bring the second Cargo Pump online once the Stream 2 FCV has received its setpoint and is returning a 100% open feedback signal.

Stream 1 FCV setpoint set to 1334 m3/h (Maximum allowable setpoint per stream)

Stream 3 outlet valve commanded to open

Stream 3 outlet valve status received as open

Start stability timer and wait for it to expire

Stream 3 FCV set to Automatic mode and assigned a setpoint of 1300 m3/h

Stream 1 FCV assigned a setpoint of 1300 m3/h

Stream 2 FCV assigned a setpoint of 1300 m3/h

Three streams open, each with a FCV setpoint of 1300 m3/h to achieve the required flow rate of 3900 m3/h.

Control the setpoints of the two cargo pumps to deliver the required station flowrate of 3900 m3/h. Note this is not within the Condensate metering package scope.

Batch Topoff Closing Sequence:

When the “Top Off” entry volume has been achieved issue the “Top Off” batch command.

Three streams open, each with a FCV setpoint of 1300 m3/h to achieve the required flow rate of 3900 m3/h.

Required Top Off flow rate set to 2000 m3/h (Will require 1 stream to be closed)

Stream 3 outlet valve commanded to close

Stream 3 outlet valve status received as closed

Start stability timer and wait for it to expire

Stream 3 FCV set to manual mode and 0% output

Stream 1 FCV assigned a setpoint of 1000 m3/h

Stream 2 FCV assigned a setpoint of 1000 m3/h

Two streams open, each with a FCV setpoint of 1000 m3/h to achieve the required flow rate of 2000 m3/h.

Control the setpoints of the two cargo pumps to deliver the required station flowrate of 2000 m3/h. Note this is not within the Condensate metering package scope.

Batch Terminate Closing Sequence:

Stop one cargo Pump and reduce the output of the second cargo pump.

When the required Batch Volume has been achieved issue the “Terminate” batch command.

Required flow rate set to 0 m3/h (Will require 2 streams to be closed)

Stream 2 outlet valve commanded to close

Stop the second cargo pump, or reduce to minimum flow to keep pressure in the system.

Stream 1 FCV assigned a setpoint of 0 m3/h

Stream 2 FCV assigned a setpoint of 0 m3/h

Stream 2 outlet valve status received as closed

Start stability timer and wait for it to expire

Stream 2 FCV set to manual mode and 0% output

Stream 1 outlet valve commanded to close

Stream 1 outlet valve status received as closed

Start stability timer and wait for it to expire

Stream 1 FCV set to manual mode and 0% output

Stop the cargo pumps, if not already stopped.

4.7.3 Line Switching Alarms

Any invalid stream switching conditions detected are alarmed. The stream switching alarms raised are as follows: -

No More Lines to Open

If all available lines on a station are open and the flow rate indicates that a new stream should be opened, then an alarm is raised to indicate this situation.

No More Lines to Close

If only one stream is open and the flow rate indicates that a stream should be closed, then an alarm is raised to indicate that there are no more lines available for control. It should be noted that the last line can only be closed by the operator.

4.7.3.1 Line Switching Conflict

If invalid switching limits are set up such that one stream is indicating that a line should be closed and another stream is indicating that a line should be opened, then an alarm is raised to warn of this situation. Stream switching is not performed until the situation is cleared by a change to the flow conditions or new switching limits being entered.

If a line fails to control, then this situation is alarmed in the normal way from the stream flow computer. The automatic stream switching continues and stream control is attempted until successful or flow conditions change.

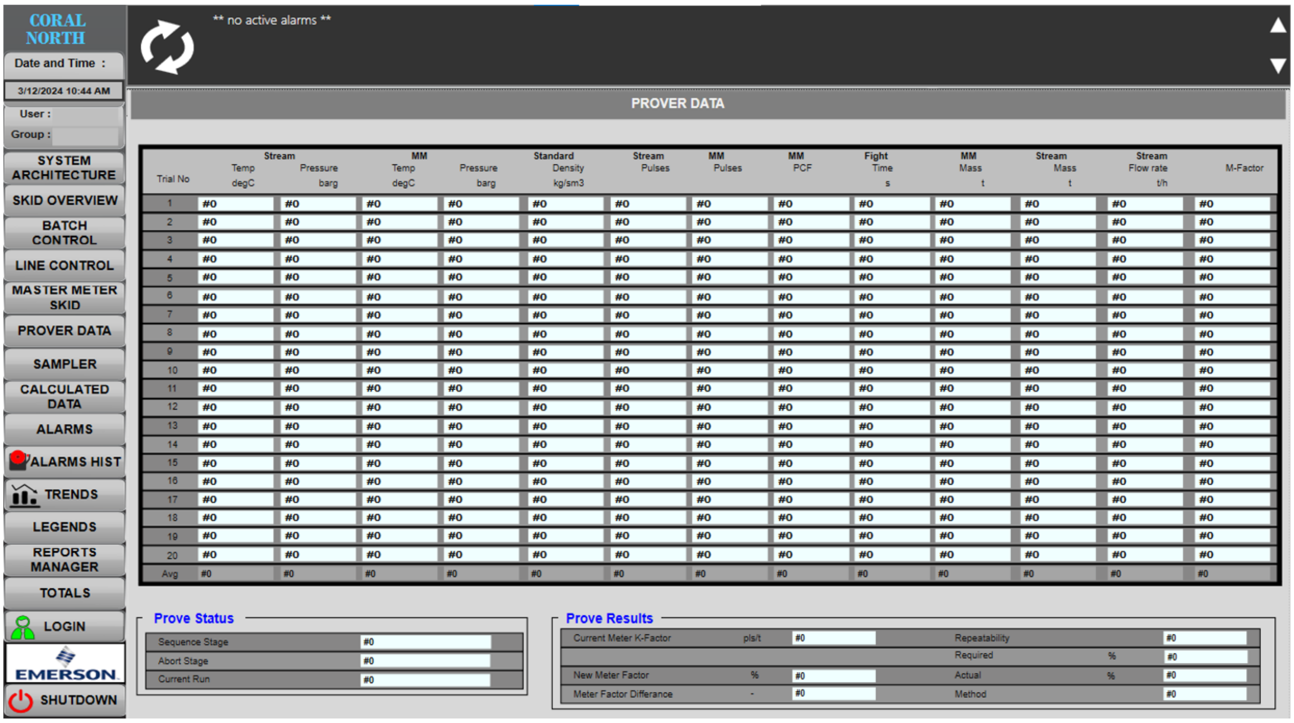
If a stream is in maintenance mode, is out of service or communications to the flow computer have failed, then this stream is regarded as being out of service for stream switching.

4.8 Emerson Metering Suite Master Metering

The Emerson Metering Suite provides operator entries and configuration options for proving control. Once a test is requested the master meter flow computer provides the control, including sequencing of valves. The Emerson Metering Suite provides two main screens, where the progress of the test can be monitored. A graphical representation of the master meter station is presented showing all valves and basic process and an alphanumeric screen to show detailed trial data as it becomes available. The current master meter state and the current master meter abort state are shown as text fields on the screens.

4.8.1 Proof Monitoring

Once the proof is requested the prover flow computer provides the control, including sequencing of valves. The Emerson Metering Suite provides two main screens, where the progress of the proof can be monitored. A graphical representation of the master meter is presented showing all valves, basic process conditions and basic trial data. The current proof state and the current proof abort state are shown as text fields on the screens.



Emerson Metering Suite – Master Meter Proof Display

4.8.1.1 Abort Proof

The operator can abort a proof at any time during the proving sequence.

4.8.1.2 Accept or Continue

If a master meter proof is successful, then the final meter factor can be accepted. An option is provided to automatically accept the meter factor if it is within the configured limits.

If this is accepted then a command is sent to the stream flow computer and the new meter factor is used in the calculations. Alternatively, a continue command can be issued to reprove this stream. If this command is given the proof is repeated.

4.9 Emerson Metering Suite Sampling

The sampler system control is executed by the master meter flow computer. The Emerson Metering Suite will provide displays for control and status of the sampler system. The display shall allow the operator to enter sampler setup data, such as expected volume, and issue the sampler start and stop commands. The sampler data, such as grabs taken, shall be displayed at the Emerson Metering Suite.

4.9.1 Sampler Pump Handling

The sampler pump motor control will be performed by the Emerson Metering Suite. The master meter flow computer shall receive digital input statuses and issue digital output commands from and to the sampler pump motors. There are two sampler pumps: Sampler Pump 1 and Sampler Pump 2. The Emerson Metering Suite Express shall provide interlock handling and automatic pump switch over in the event of a fault with the selected pump.

The following digital output control signals will be issued by the Emerson Metering Suite via the master meter flow computer:

Control Signal	Master Meter P154 DO Channel	Details
Sampler Pump 1 Start Command	DO 4	Momentary pulse from 0 to 1 to start pump.
Sampler Pump 1 Stop Command	DO 5	Momentary pulse from 1 to 0 to stop pump
Sampler Pump 2 Start Command	DO 6	Momentary pulse from 0 to 1 to start pump.
Sampler Pump 2 Stop Command	DO 7	Momentary pulse from 1 to 0 to stop pump
Sampler Pump 1 Trip Command	DO 8	Latch from 1 to 0 on trip condition
Sampler Pump 2 Trip Command	DO 9	Latch from 1 to 0 on trip condition

Table – Sampler Pump Digital Outputs

The following digital input status signals will be monitored by the Emerson Metering Suite via the master meter flow computer:

Control Signal	Master Meter P154 DI Channel	Details
Sampler Pump 1 Running Status	*DI 17*	*1 = Running, 0 = Stopped*
Sampler Pump 1 Available Status	*DI 18*	*1 = Available, 0 = Unavailable*
Sampler Pump 1 Test Position	*DI 19*	*1 = Normal, 0 = Test Position*
Sampler Pump 2 Running Status	*DI 20*	*1 = Running, 0 = Stopped*
Sampler Pump 2 Available Status	*DI 21*	*1 = Available, 0 = Unavailable*
Sampler Pump 2 Test Position	*DI 22*	*1 = Normal, 0 = Test Position*

Table – Sampler Pump Digital Inputs

The following analogue input signals will be monitored by the Emerson Metering Suite via the master meter flow computer:

Control Signal	Master Meter P144 AI Channel
Sampler Pump 1 Temperature	ADC 4
Sampler Pump 2 Temperature	ADC 5
Sampler Pump 1 Filter Differential Pressure	ADC 6
Sampler Pump 2 Filter Differential Pressure	ADC 7

Table – Sampler Pump Analogue Inputs

The pump motors will be manually started and stopped by an operator via the Emerson Metering Suite sampler display.

The Emerson Metering Suite shall determine if a trip condition exists and automatically set the tip command as per the table below. Once the trip condition has cleared a manual reset of the trip command from the Emerson Metering Suite is required by the operator. A manual reset of the trip command will not be possible if a trip condition exists.

Trip Parameter	Condition to Allow Motor Start	Condition to Set Trip Command
Sampler Pump Filter	Filter Clear	Filter Blocked Alarm
Pump Temperature	Normal	High Alarm

Table – Sampler Trip Conditions

All of the following interlocks must be satisfied for the start command to be issued to the relevant pump motor:

Interlock Parameter	Condition to Allow Motor Start	Condition to Prevent Motor Start
Sampler Pump Filter	Filter Clear	Filter Blocked Alarm
Available Status	Available	Unavailable
Trip Status	Clear	Set
Other Pump Running Status	Stopped	Running
Pump Temperature	Normal	High Alarm

Table – Sampler Pump Interlocks

No interlocks will be enforced on the motor stop command. The sampler pump motors can be commanded to stop at any time. Clearing an interlock will not result in automatic restarting of the sampler pump motor, a manual start command must be issued.

4.9.1.1 Automatic Sampler Pump Changeover

If the running sampler pump experiences a failure, the system shall automatically send a stop command to the failed pump and, if all interlocks are satisfied, issue a start command to the idle pump.

The running sampler pump will automatically be commanded to stop if it experiences one or more of the conditions in the following table:

Condition to Automatically Send Stop Command to Running Pump
Sampler Pump Filter Blocked
Sampler Pump set to Unavailable Status
Sampler Pump Temperature High

Table – Sampler Pump Automatic Stop Conditions

4.10 Emerson Metering Suite – Power Failure Recovery

4.10.1 General Case

After restoration of power from a complete power failure the flow computers will automatically power up and continue metering operations without operator / engineer inputs. They will automatically establish communications with field devices. If a field transmitter or analyser signal is unhealthy, the flow computer shall use the last good value and raise an alarm. If digital valve statuses to a motor operated valve is lost, the flow computer shall raise a valve illegal alarm.

The redundant Emerson Metering Suite engineering workstations will automatically boot upon power restoration. The workstations will automatically log in to Windows and start the Emerson Metering Suite Runtime for the Coral metering system without operator intervention. These include communications to the flow computers and Modbus slave communications to the ICSS. The Emerson Metering Suite Runtime shall automatically start and display the home page. The first redundant Emerson Metering Suite workstation to achieve start-up will assume “Dominant” status. When the second Emerson Metering Suite workstation achieves start-up, it will assume “Non-Dominant” status and the two Emerson Metering Suite workstations will synchronise.

The Emerson Metering Suite will not automatically log the Emerson Metering Suite user on. The system displays can be viewed, but no parameter or engineering changes can be made. The operator / engineer may enter user credentials into the Emerson Metering Suite User Logon to allow user privileges, such as control of certain parameters, to be enabled.

4.10.2 During Batching Operations

The stream flow computers and the Emerson Metering Suite engineering workstations both have batch functionality. The flow computers have a local batch mode. The Emerson Metering Suite Express batching function block determines which flow computers are set to batch mode, depending on the required streams for the batching stage and which streams are available.

If the Emerson Metering Suite system recovers from a complete power failure during a batch the initial recovery will be as per the “General Case” described above.

The stream flow computers will be configured to “Continue Batch” after power is resumed. Therefore, they will resume their batch totalisation from the point at which the flow computers automatically recover to normal metering operations.

Upon automatically recovering from power loss the Emerson Metering Suite workstation’s batching function block shall scan all the stream flow computers to detect if a batch is in progress at any of the stream flow computers. If a batch is detected at any of the flow computers the Emerson Metering Suite workstation will force its batching stage to “STREAM BATCH”. The batch mode and proving mode will be set to manual. The batch start time will be set to the current time. Any operator attempts to select automatic batch mode are rejected.

The Emerson Metering Suite reads the current flow rates and batch totals from the flow computers to calculate station batch flow rates and totals. The operator should either proceed to top-off (adjusting the valves accordingly) or stop the batch (having ensured that all streams are closed). Any other option is rejected. The Emerson Metering Suite then issues stop batch commands to all stream flow computers and outputs a final batch report.

4.11 Emerson Metering Suite I/O Assignment

Two redundant Emerson Metering Suite Metering Supervisory Servers are supplied for the Coral North Development FLNG condensate metering system. Each Emerson Metering Suite server reads an analogue signal from the RVP analyser and the TVP analyser.

Two ADAM-6017 8 channel analogue input Modbus TCP modules are used to allow the Emerson Metering Suite to read the field analogue inputs signals as Modbus registers.

The ADAM-6017 reads the analogue inputs from the field and makes the process variables available on Modbus TCP registers which the Emerson Metering Suite polls.

Two ADAM-6017 modules are provided. One on the primary metering network and one on the secondary metering network. The RVP and TVP analyser analogue signals are split in the panel and connected to each of the two ADAM-6017 modules.

The following table details the ADAM 6017 converter signals:

ADAM Model	Tag	I/O Channel	Allocation
6017	CONV101	Vin0	RVP Process Variable
		Vin1	TVP Process Variable
		Vin2	Spare
		Vin3	Spare
		Vin4	Spare
		Vin5	Spare
		Vin6	Spare
		Vin7	Spare
6017	CONV102	Vin0	RVP Process Variable
		Vin1	TVP Process Variable
		Vin2	Spare
		Vin3	Spare
		Vin4	Spare
		Vin5	Spare
		Vin6	Spare
		Vin7	Spare

Table - ADAM-6017 Channel Assignments

4.12 Prolink Communications to Coriolis Meters

Prolink III Basic diagnostics and engineering software for the Micromotion Coriolis meters will be installed on the primary engineering workstation. HART protocol will be used to provide communications between the Coriolis meters in the field and Prolink installed on the primary engineering workstation. Each Coriolis is assigned a unique HART address to allow multidrop communications to a Bell-202 HART modem. The primary engineering workstation will communicate with the Bell-202 HART modem via the 9 pin RS-232 port on the rear of the workstation.

Stream	Coriolis Meter Tag	HART Address
Stream 01	TT2220FT3511	1
Stream 02	TT2220FT3521	2
Stream 03	TT2220FT3531	3
Stream 04	TT2220FT3541	4
Master Meter	TT2220FT3551	5

Table – Coriolis Meter HART Addresses

Parameter	Setting
Device	1700 / 2700
Converter	RS232 to Bell 202
Protocol	HART BELL 202
PC Com Port	COM2
Master Type	Primary
Address	As per Coriolis Meter HART Addresses Table

Table – Prolink Communications Settings

Prolink III Basic provides the following functionality:

- Full transmitter configuration
- Alert notification
- Alert resolution guide
- Diagnostics / inputs / outputs display
- Load or save device configurations
- Smart meter verification launch
- Meter zero verification

4.13 Remote Access from CCR

Emerson Metering Suite Operator Workstation software shall be installed on a selected virtualised ICSS operator workstation (OWS) in the central control room (CCR). This will allow for remote access of Emerson Metering Suite reports and control and monitoring of the Emerson Metering Suite from the CCR.

Dedicated primary and secondary metering fibre optic networks will be established between the redundant Emerson Metering Suite Engineering workstations in the portside instrument room (PIR) and the Ventrix virtual servers in the LQ computer room (QCR). The virtualised ICSS OWS with Emerson Metering Suite installed will reside on the Ventrix virtual servers. A thin client in the CCR will provide access to the virtual server and the Emerson Metering Suite Operator Workstation.

This configuration shall provide the following Emerson Metering Suite functionality from the CCR:

- Access to Emerson Metering Suite reports with the ability to print reports on available printers.
- Access to Emerson Metering Suite displays with the ability to view and change data (subject to user privileges).
- Initiate, control and monitor sequences such as batching, proving and sampling.
- Access to the S600+ flow computers via the dedicated S600+ web browser.
- Remote Desktop access to the primary Engineering workstation in the PIR for access to the Prolink III Coriolis diagnostics package.

Engineering functions such as display or configuration changes shall not be possible from the Emerson Metering Suite Operator Workstation.

4.14 Emerson Metering Suite ICSS Modbus Communications

For details on the ICSS communications to the Emerson Metering Suite system see document 4424TTDIEI002DE ICSS Interface.

4.15 Time Synchronisation

The ICSS will synchronise the Emerson Metering Suite metering system via the redundant Modbus connections to the primary and secondary engineering workstations. The ICSS shall send a digital trigger as well as the current minute and second value over the Modbus link. This shall synchronise the Emerson Metering Suite system time with the ICSS. The dominant engineering workstation will be the master time server for the Emerson Metering Suite system. The non-dominant engineering workstation will be synchronised by the dominant workstation. The flow computers will be synchronised via Modbus TCP/IP from the dominant engineering workstation over the primary and secondary metering LANS.

4.16 Cyber Security

4.16.1 Physical Security

The engineering workstations and all network devices will be mounted in secure cabinets. Access will be disabled to unused USB ports and DVD drives.

4.16.2 Anti-Virus Security

The latest McAfee Endpoint Protection anti-virus software will be installed on the primary and secondary engineering workstations. Anti-virus definitions will be manually installed, when released.

McAfee Endpoint Protection provides protection from threats such as viruses, worms, trojans, targeted attacks and spyware. It combines McAfee threat protection technologies along with web and data protection.

4.16.3 Password Security

After physical access security, the next level of securing the Emerson Metering Suite system is to control user access via a password protection scheme. Emerson Metering Suite password access is multi-level and role based and is configured using Emerson Metering Suite User Manager. See section 4.3 for further details on the configuration available from Emerson Metering Suite User Manager.

Passwords must be properly maintained to prevent unauthorised access from people gaining physical access to the system.

Default passwords will be reset.

Privileges will be assigned to each user.

Generic or shared user names and passwords will not be used.

The Emerson Metering Suite Runtime will initially open in view only mode from start up. The operator is required to login with the required credentials before control is possible from the system.

The current user will be logged out after a configurable period of activity. Displays can still be viewed, but changes cannot be made.