

Description of the Bunker Metering System from Endress+Hauser



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Scope

This document provides information about the bunker metering system as offered by Endress+Hauser for installation on board of vessels. The described system is specifically designed for metering in refueling processes of ships (bunkering) and consequently for the specific process conditions and requirements such as handling of aerated fuel oil. The aim of the document is to compile information which is normally only individually available for the components in order to provide a technical overview. Ship specific considerations like piping arrangement, pump control or operating procedures are not dealt with herein.

System Description

As we all know, the traditional quantity measurement via tank gauging, for example, can be associated with a great amount of uncertainty due to error prone volume to mass calculation as well as not considered air content caused by tank stripping and the “cappuccino effect”. Very often, this leads to incorrect billing and unwanted bunker disputes between supplier and buyer.

For these reasons, ship owners and barge operators have been increasingly installing special bunker fuel metering systems that ensure transparent and highly accurate bunkering. These systems contain Coriolis flow meters, which have been tried and tested for decades in custody transfer applications. Even port authorities have begun to stipulate these measuring systems.

We at Endress+Hauser have developed a sophisticated and reliable bunker fuel metering system. Our specialists have developed a patented bunker metering system that measures highly viscous and aerated bunker fuel with great measuring accuracy. Time-consuming manual tank sounding is not necessary. In this regard, testing has confirmed that our Promass Coriolis flow meters capture high-viscosity bunker fuels with excellent accuracy.

The system contains significantly more components than normally involved in standard custody transfer applications. This has its cause in the technically demanding process conditions in bunkering where long periods of gas loaded product are encountered. This is the case during line packing, tank stripping, tank switch-over and also line clearing. Additional process information is needed for controlling the signal processing during such phases. Finally, the metering results must be properly stored and documented (metering ticket and metering profile).

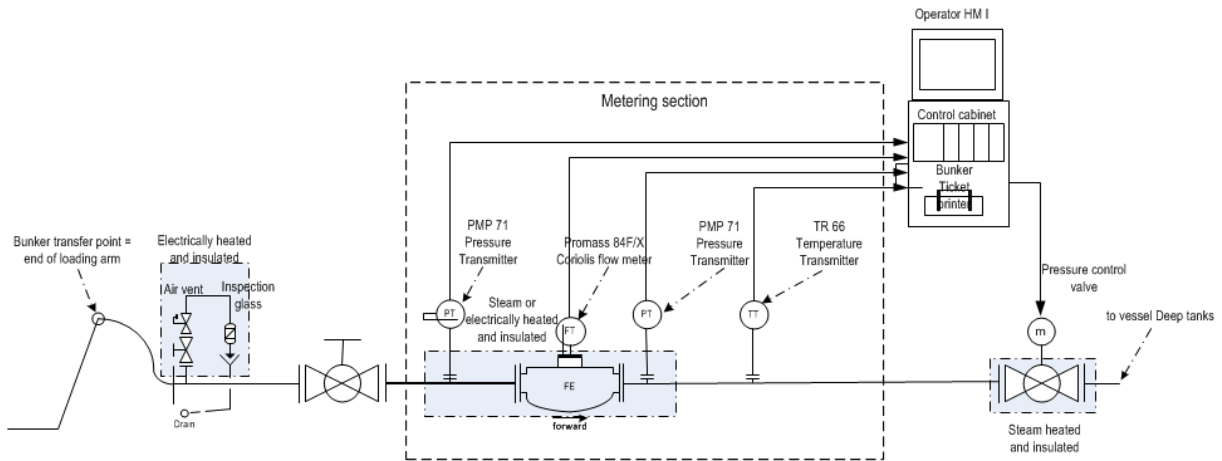
The system also allows registering and documenting of unreal readings between two bunkering operations which might be caused by remaining quantities moving in the cargo line during sailing. Such quantities are measured and respective In-Transit Variation tickets can be printed.

Description of the Bunker Metering System

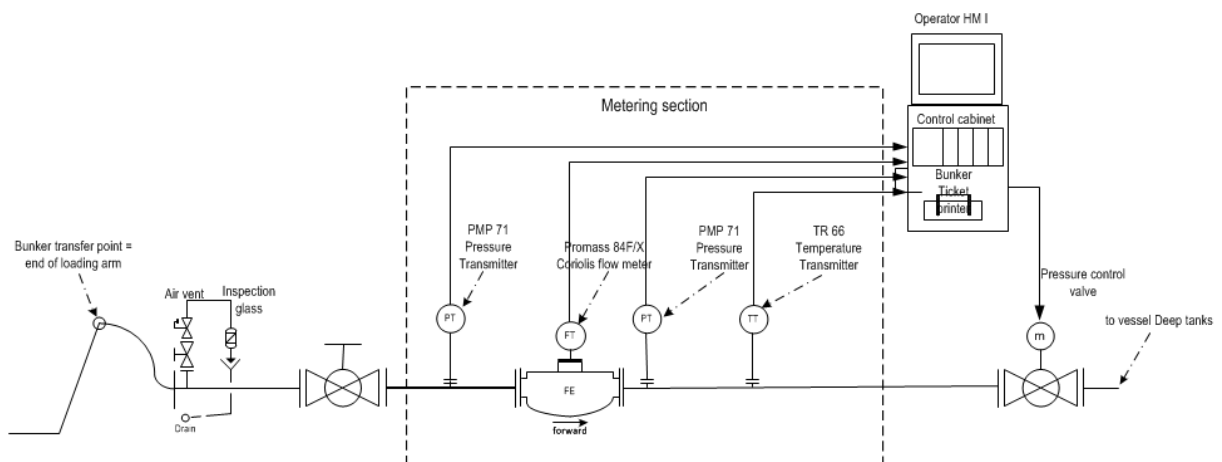
Schematics of the System

The below P&IDs are giving an overview of the system arrangement for HFO as well as for MGO.

HFO:



MGO:



Hardware Breakdown

The process sensors provide all information which is needed for computing the correct metering result. As explained earlier more than just a flow meter signal is required for this. The bunker flow meter system of Endress+Hauser comprises of the hardware components described below.

Flow Meter

The main process sensor is the Coriolis mass flow meter. Coriolis meters today are the most accurate custody transfer flow meters. At the same time they offer best possible properties for dealing with the harsh process conditions of bunkering.



Coriolis mass flow meter type **Promass 84F, typical size DN100/4" to DN250/10"**
Promass 84X, size DN350/14"

It is common practice in the oil and gas industry to calibrate flow meters with oil, since traditional measurement methods are greatly dependent upon liquid properties. These costly and time consuming calibrations can be completely omitted with Coriolis mass flow meters from Endress+Hauser.

Testing on the accredited calibration rigs of the Société du Pipeline Sud Européen (SPSE) in Fos-sur-Mer (FR) and at the National Engineering Laboratories (NEL) in Glasgow (UK) definitively demonstrated that our water-calibrated Promass F and Promass X Coriolis flow meters also measure hydrocarbons of various densities and viscosities with the same high accuracy.

Therefore, costly performance verification in the field is not required any more. This fact has also been confirmed and certified by NMI Certin (National Metrology Institute) in the Netherlands in accordance with MI-005. As a result, the Promass F and Promass X have easily fulfilled the strict requirements of the accuracy class 0.3 of OIML R117.

Pressure Transmitter

The two pressure transmitters are used to provide a secondary measuring mode during unstable process conditions caused by aerated fuel oil.



Pressure sensor type Cerabar S PMP171

Temperature Transmitter

An external temperature transmitter is used to provide custody transfer certified temperature information.



Temperature sensor type Omnigrad S TR66

Line Packing Valve

A control valve for installations on a vessel allows quickest possible line packing and ensures good metering conditions for as long as possible. This creates best possible process conditions for the flow meter and provides optimal metering results. The valve is fully controlled by the Bunker Metering Computer during the entire bunkering process. The exact type and specs are to be determined for the individual application.



Control valve type Butterfly valve with position feedback

With electrical actuator offering sufficient torque.

Heating and Insulation

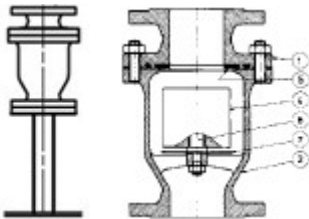
Steam or self-limiting parallel heating cables and insulation for the HFO metering section, including air release valves, sight glass, flow meter, pressure transmitter and line packing valve ensure optimal conditions for operation. The exact type and specs are to be determined for the individual application. The electrical heating will be complete with temperature controller and mounting material.



Self-limiting parallel heating cable

Air Release Valves

An air release valve at the bunker manifold optimizes the measuring conditions through air elimination during line packing. The exact type and specs are to be determined for the individual application.



Sight Glass

The proper function of the air release valves installed at the bunker manifold for HFO and MGO can be inspected by means of a sight glass. The exact type and specs are to be determined for the individual application.

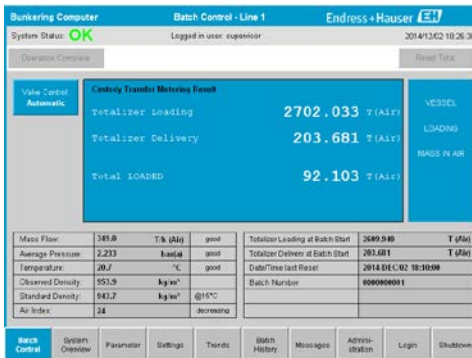


Description of the Bunker Metering System

Bunker Metering Computer

The Bunker Metering Computer BMC is the “brain” of the system. It takes signals from the process sensors, evaluates these signals and converts them into the custody transfer relevant quantity information. The BMC can handle two metering lines at the same time. The HMI displays the custody transfer relevant and other information.

It allows setting up and controlling the system. Historical data and the audit trail are stored on this unit.



The operator terminal offers process data storage, ticket printing and metering profile display. Metering profiles can be accessed as well by a read-only USB port. Bunkering data are available via remote through a Modbus TCP interface.

The bunker computer is available in three different housing variants.



Wall mounting housing
600 x 1000 x 260 mm



Desktop standing housing 600 x 400 x 262 and wall mounting control unit 400 x 500 x 210 mm



Wall mounting housing
600 x 400 x 210 mm and wall mounting control unit
400 x 500 x 210 mm

Description of the Bunker Metering System

Table 1 shows a summary of all relevant hardware components used for the Bunker Flow Meter System of Endress+Hauser.

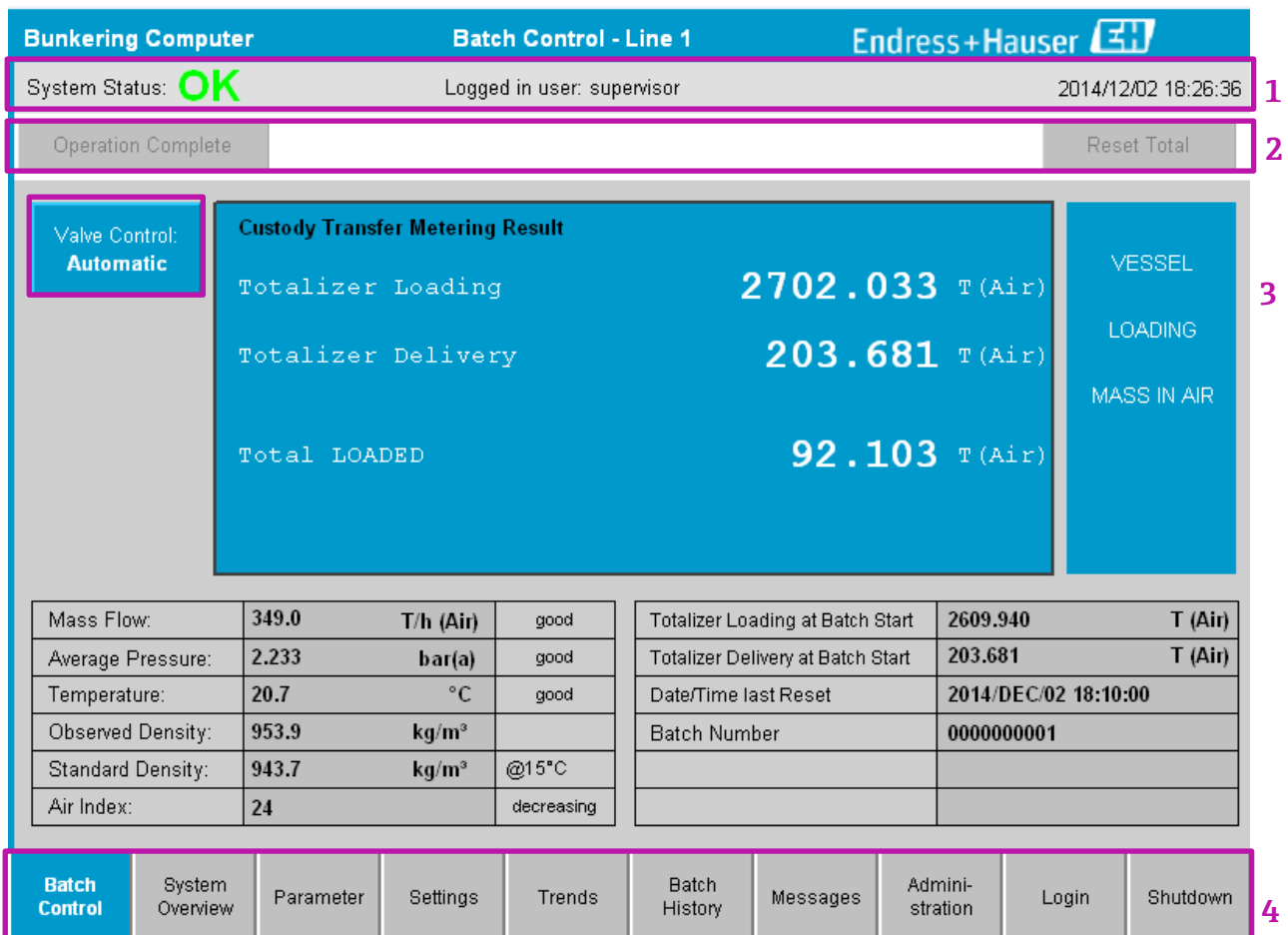
Device type	Model type	Quantity
Bunker Metering Computer	SBC600	1
Coriolis mass flow meter for HFO meter run	Promass 84F/X	1
Coriolis mass flow meter for MGO meter run	Promass 84F	1
Pressure transmitter for HFO meter run	PMP71	2
Pressure transmitter for MGO meter run	PMP71	2
Temperature transmitter for HFO meter run	TR66	1
Temperature transmitter for MGO meter run	TR66	1


Table 1.

Bunker Control Display Screen

The Bunker Metering Computer application is automatically started as soon as power is applied to the system. The user is automatically logged in as “Operator” after start up. The access mode can be changed under **Login** view to “Supervisor” for additional access rights like alarm settings for process parameters. The bunker control display screen consists of several views for optimized operation.

Batch Control View



Bunkering Computer **Batch Control - Line 1** Endress+Hauser 

System Status: **OK** Logged in user: supervisor 2014/12/02 18:26:36

Operation Complete Reset Total

Valve Control: **Automatic**

Custody Transfer Metering Result

Totalizer Loading	2702.033	T (Air)
Totalizer Delivery	203.681	T (Air)
Total LOADED	92.103	T (Air)

VESEL
LOADING
MASS IN AIR

Mass Flow:	349.0	T/h (Air)	good
Average Pressure:	2.233	bar(a)	good
Temperature:	20.7	°C	good
Observed Density:	953.9	kg/m³	
Standard Density:	943.7	kg/m³	@15°C
Air Index:	24		decreasing

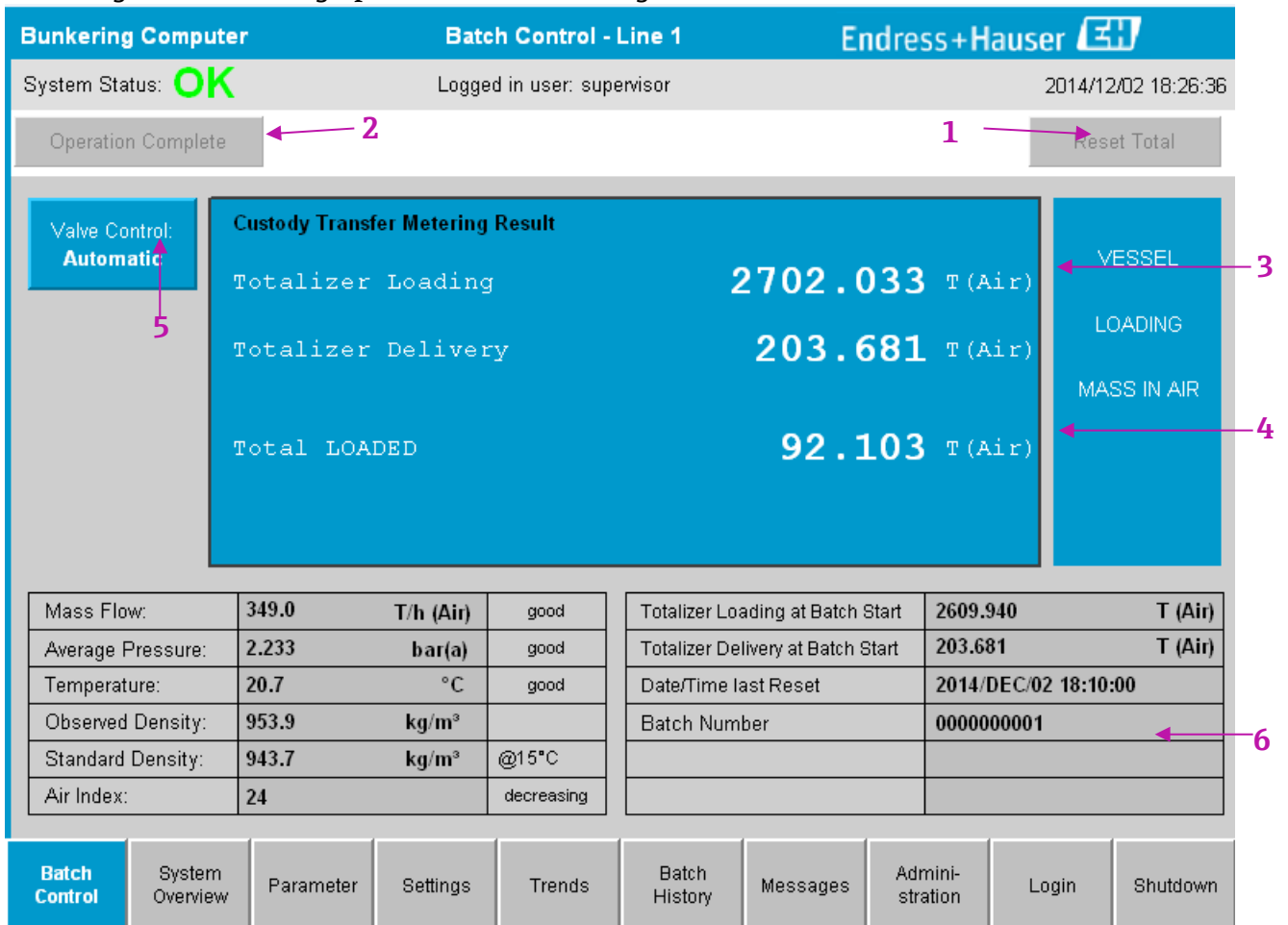
Totalizer Loading at Batch Start	2609.940	T (Air)
Totalizer Delivery at Batch Start	203.681	T (Air)
Date/Time last Reset	2014/DEC/02 18:10:00	
Batch Number	0000000001	


Batch Control System Overview Parameter Settings Trends Batch History Messages Administration Login Shutdown

- 1. System Status Bar:** Includes system status, current logged in user and current date and time.
- 2. Functions Bar:** Includes functions button or in-display navigation.
- 3. View Body:** Shows custody transfer information such as totalizers.
- 4. Navigation Bar:** Main navigation between views. The currently selected view is indicated by a blue button background color.
- 5. Control Valve Access:** Access button to control valve view.

Description of the Bunker Metering System

Handling of a bunkering operation is done using the **Batch Control** view.



Bunkering Computer **Batch Control - Line 1** Endress+Hauser 

System Status: **OK** Logged in user: supervisor 2014/12/02 18:26:36

Operation Complete Reset Total

Valve Control:
Automatic

Custody Transfer Metering Result

Totalizer Loading **2702.033** T (Air)

Totalizer Delivery **203.681** T (Air)

Total LOADED **92.103** T (Air)

VESSEL

LOADING

MASS IN AIR

Mass Flow:	349.0	T/h (Air)	good	Totalizer Loading at Batch Start	2609.940	T (Air)
Average Pressure:	2.233	bar(a)	good	Totalizer Delivery at Batch Start	203.681	T (Air)
Temperature:	20.7	°C	good	Date/Time last Reset	2014/DEC/02 18:10:00	
Observed Density:	953.9	kg/m ³		Batch Number	000000001	
Standard Density:	943.7	kg/m ³	@15°C			
Air Index:	24		decreasing			

Batch Control
System Overview
Parameter
Settings
Trends
Batch History
Messages
Administration
Login
Shutdown


1. Button Reset Total
2. Button Operation Complete
3. Non-Resettable Totalizer loading
4. Resettable Totalizer loaded
5. Valve control button with status indication

Parameter section: Overview of bunkering operation related parameter

Description of the Bunker Metering System

System Overview

The **System Overview** is used to provide an overview of the field instruments.

Bunkering Computer
System Overview - Line 1
Endress+Hauser 

System Status: OK
Logged in user: supervisor
2014/12/02 18:26:53

Line 1

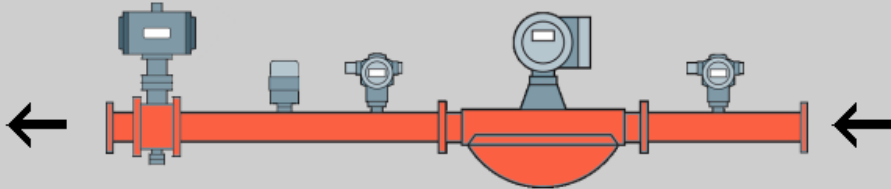
Act	0.0	%
Set	0.0	%

	20.7	°C
--	------	----

	1.899	bar(a)
--	-------	--------

	246	A/m
	0.0	kg/m ³
	349.3	T/h

	2.568	bar(a)
--	-------	--------



Valve Control
Temperature T1
Pressure P2
Mass Flow F1
Pressure P1

Fwavg Temperature:	20.7	°C	
Fwavg Pressure:	2.234	bar(a)	
Fwavg Obs. Density:	0.0	kg/m ³	
Fwavg Std. Density:	0.0	kg/m ³	@15°C
Density Conf. Level	0	%	
Air Index:	24		increasing

Total LOADED	93.730	T (Air)

Batch Control
System Overview
Parameter
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- If a sensor is in fault condition, the corresponding value field will flash red
- A click on the Valve Control value field will open the control valve view.
- The pipe will change its color to orange, as soon as flow is detected.
- If the BMC is equipped with a 2nd Bunker Metering Line for e.g. MGO, the 2nd line will be displayed below Line 1.

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Description of the Bunker Metering System

Parameter View (user “Supervisor” only)

The **Parameter** view displays additional data which are not displayed on the Batch Control view. To access the **Parameter** view the login needs to be changed to supervisor.



The screenshot displays the 'Parameter - Line 1' view. At the top, it shows 'System Status: OK' and 'Logged in user: supervisor' with a timestamp of '2014/12/02 18:27:12'. Below this is a 'Functions Bar' with buttons for 'Flow Meter Data', 'Flow Computer Data', 'VFR/Air Index', and 'API Density Calc.'. The main area contains a table of parameters:

Mass Flowrate	353.7	T/h	good
Raw Mass Flowrate	345.0	T/h	good
Flowing Density	953.6	kg/m ³	good
Operating Frequency	714.3	Hz	good
Exciter Current	50.3	mA	good
Tube Damping	246	A/m	good
ZERO Value (stored)	0		good
Calibration Factor	1.00000		good
Serial Number Sensor	????????????		good
Promass Status	109		good
Promass Temperature	23.6	°C	good


At the bottom, there is another 'Functions Bar' with buttons for 'Batch Control', 'System Overview', 'Parameter' (highlighted), 'Settings', 'Trends', 'Batch History', 'Messages', 'Administration', 'Login', and 'Shutdown'.

- Different parameter tables can be displayed with the buttons inside the Functions Bar.
- The current parameter value condition is displayed on the most right column.

Description of the Bunker Metering System

Settings View (user "Supervisor" only)

The **Settings** view is used to change alarm settings for the process parameters. To access the **Settings** view the login needs to be changed to supervisor.

Bunkering Computer
Settings - Line 1
Endress+Hauser 

System Status: OK
Logged in user: supervisor
2014/12/02 18:27:32

Custom Relay Output Config.

Alarm Limits	Low Limit	High Limit		Enable/Disable Alarms	
				Low	High
Mass Flowrate F1	0	1500	T/h	OFF	OFF
Temperature T1	20	70	°C	OFF	OFF
Pressure P1	0.0	10.0	bar(a)	OFF	OFF
Pressure P2	0.0	10.0	bar(a)	OFF	OFF
Air Index Warning		1500	-		OFF
Standard Density	0.0	1100.0	kg/m ³	OFF	OFF
Observed Density	0.0	1100.0	kg/m ³	OFF	OFF

Volume Display

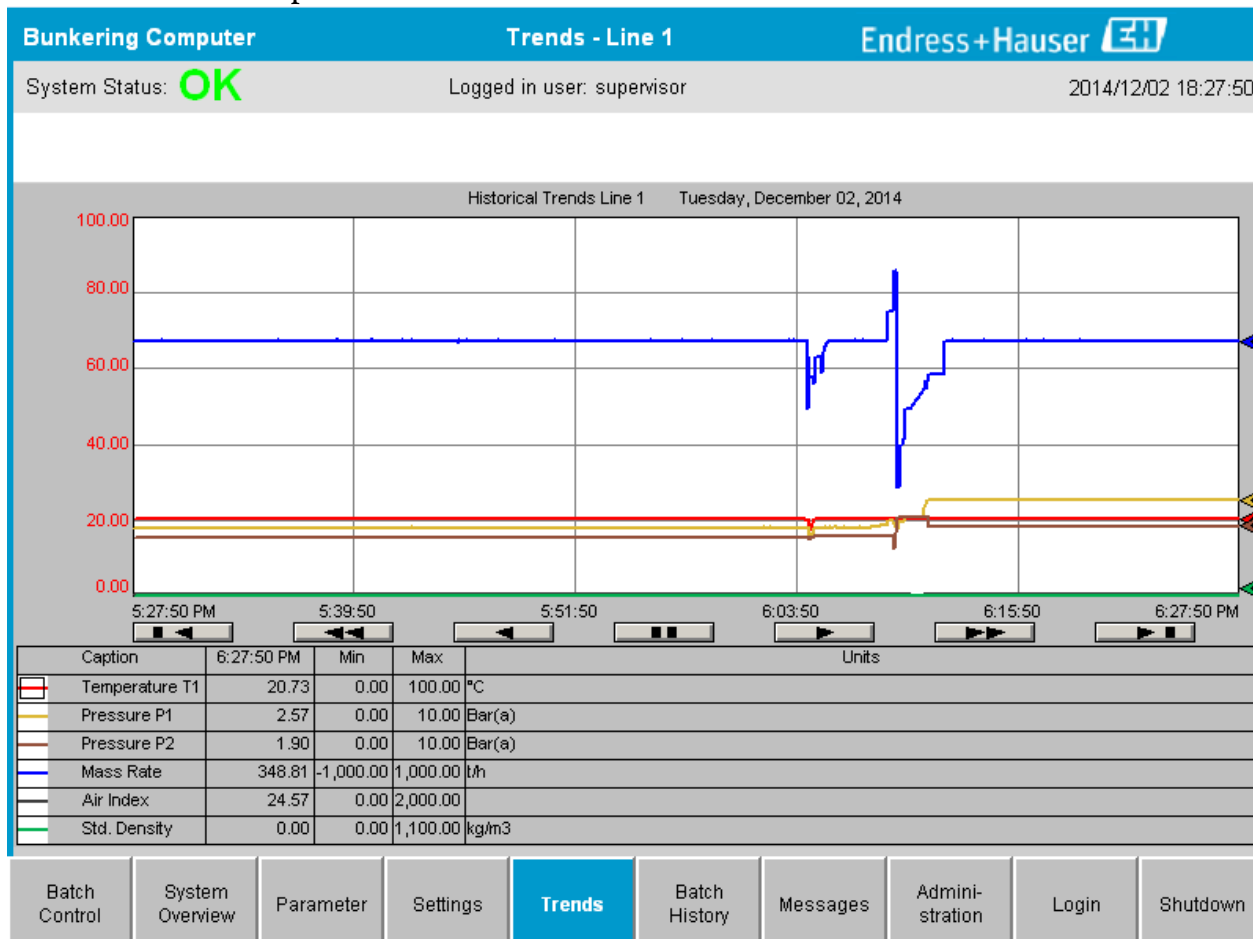
Show Volume Yes No

Batch Control
System Overview
Parameter
Settings
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Description of the Bunker Metering System

Trends View


The **Trends** view displays the progress of the bunkering operation. It allows the operator to “follow” the bunkering process in real time. “Irregularities” are made transparent and allow intervention on the spot.



The following values are shown: Temperature, Pressure, Mass rate and Air Index and Std. density.

Batch History View

The **Batch History** view shows the data of last 50 bunkering operations. By selecting a specific batch the metering result and the most important process parameter for this batch are displayed. A respective duplicate bunker metering ticket can be printed if desired.

Bunkering Computer
Batch History - Line 1
Endress+Hauser 

System Status: OK Logged in user: supervisor 2014/12/02 18:28:05

Standard Metering Profile
Extended Metering Profile

Batch Number	Date/Time @ Batch Start	Date/Time @ Batch End	Operation Mode	Total DELIVERED	
000000000	2014/NOV/17 18:59:48	2014/DEC/02 18:10:00	Loading	2406.259	T
000000000					T
000000000					T
000000000					T
000000000					T
000000000					T
000000000					T
000000000					T
000000000					T
000000000					T
000000000					T
000000000					T

▲

▲

▲

▼


▼

Click on desired row for batch details

Batch Control
System Overview
Parameter
Settings
Trends
Batch History
Messages
Administration
Login
Shutdown

- A click on data row opens the corresponding **Batch History Details** view.
- Up/down navigation is possible with the arrow buttons on the right side of the batch history table.
- **Metering Profiles** can be opened with the buttons on the **Functions Bar**.

Description of the Bunker Metering System

Bunkering Computer		Batch History Details		Endress+Hauser 	
System Status: OK		Logged in user: operator		2014/12/03 10:50:45	
Print Ticket Copy		Printer ready			
Batch Number:		0000000002 / Line 1			
Date/Time at Batch Start	2014/DEC/03 09:56:06	Totalizer Loading at Batch Start	2890.839	T (Air)	
Date/Time at Batch End	2014/DEC/03 10:36:08	Totalizer Loading at Batch End	2896.214	T (Air)	
Fwavg. Temperature	56.3 °C	+/-			
Fwavg. Pressure	1.903 bar(a)	Totalizer Delivery at Batch Start	203.681	T (Air)	
Average Flowrate during this Batch	350.5 T/h	Totalizer Delivery at Batch End	203.681	T (Air)	
Max. Flowrate during this Batch	356.7 T/h	=			
Air Index	24.6	Total Loaded	5.374	T (Air)	
Fwavg. Density Observed	0.0 kg/m ³				
Fwavg. Density Standard	0.0 kg/m ³				
Density Conf. Level	0 %				
Result for +/- 0.5% Requirement	PASS				
Power Loss during this Batch	NO				
ERROR during this Batch	NO				

- Additional operation data are displayed on the **Batch History Details** view.
- A Bunker Metering Ticket for the selected batch can be printed with the button on the **Functions Bar**.

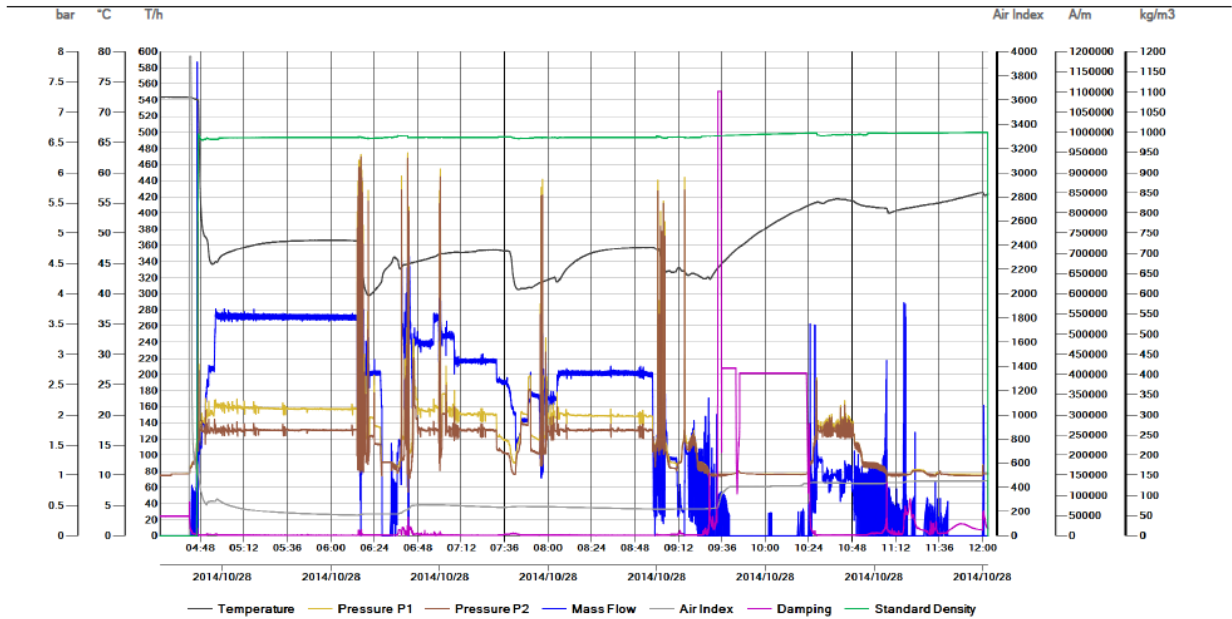
Description of the Bunker Metering System

Metering Profile

The metering profile is a finger print of the bunkering process where all relevant parameters are recorded. The metering profile provides transparency especially in “doubtful” situations where barge and vessel operators are of different opinion.

Bunker Metering Profile Expert

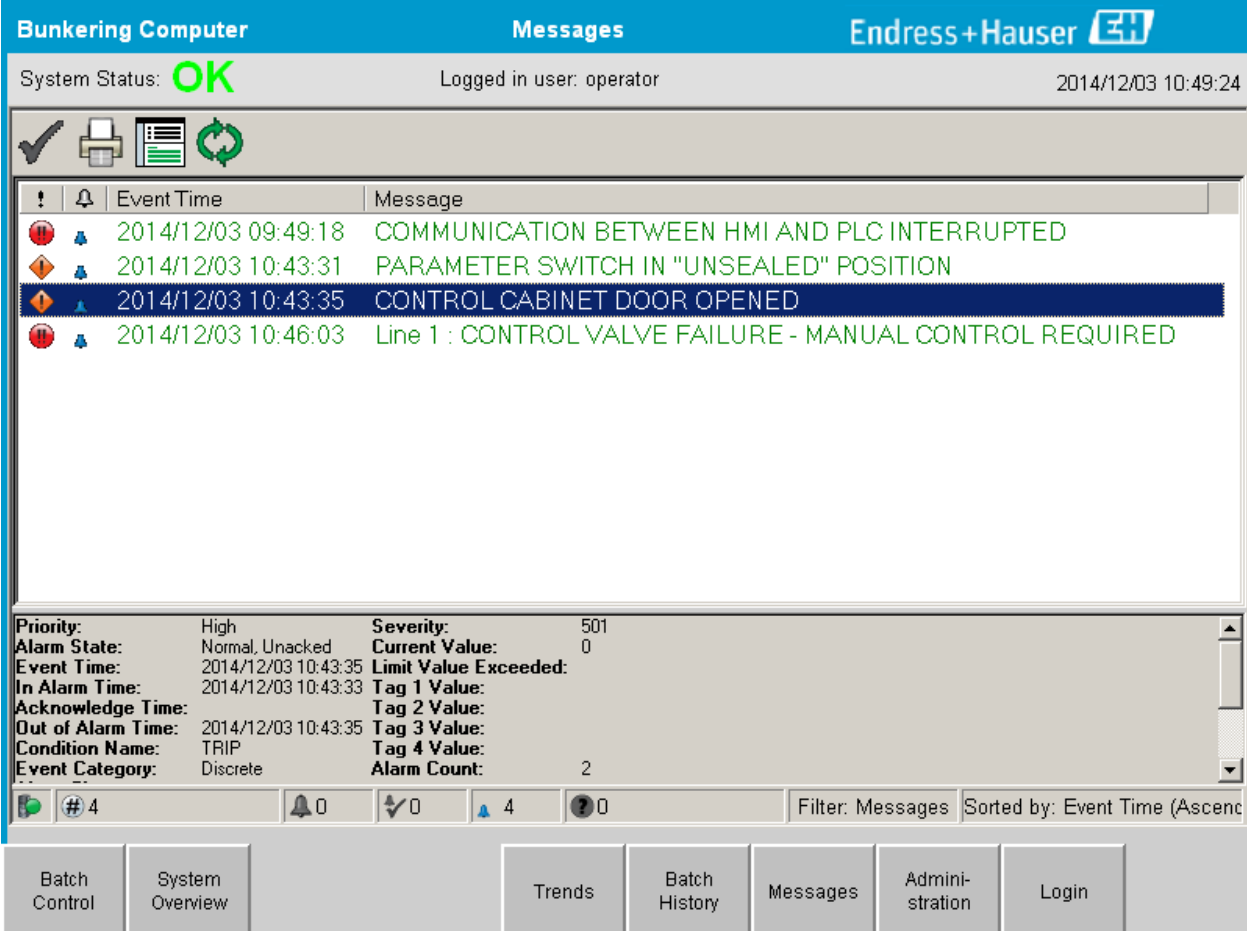
Mass Loading At Bunker Start:	0.0 T	System ID:	30231638360	Vessel ID:	9526904	Batching Mode:	Mass Vacuum
Mass Loading At Bunker End:	1007.028 T	Mass Total:	1007.028 T		MAERSK LUZ	Operation Mode:	Loading
Mass Delivery At Bunker Start:	0.0 T	Line Number:	1			Bunker Start Time:	2014/OCT/28 04:25:25
Mass Delivery At Bunker End:	0.0 T	Bunker Ticket No.:	1			Bunker End Time:	2014/OCT/28 12:02:58



Description of the Bunker Metering System

Messages View

The **Messages** view shows all currently active messages (below you see an example of messages during set-up of the system).



The screenshot displays the 'Messages' view in the Bunkering Computer interface. The top header shows 'Bunkering Computer', 'Messages', and the Endress+Hauser logo. Below the header, the system status is 'OK', the user is 'operator', and the time is '2014/12/03 10:49:24'. A toolbar contains icons for a checkmark, printer, list, and refresh. The main area is a table of messages:

!	🔔	Event Time	Message
🔴	🔔	2014/12/03 09:49:18	COMMUNICATION BETWEEN HMI AND PLC INTERRUPTED
🟡	🔔	2014/12/03 10:43:31	PARAMETER SWITCH IN "UNSEALED" POSITION
🟡	🔔	2014/12/03 10:43:35	CONTROL CABINET DOOR OPENED
🔴	🔔	2014/12/03 10:46:03	Line 1 : CONTROL VALVE FAILURE - MANUAL CONTROL REQUIRED

Below the table is a detailed summary for the selected message:

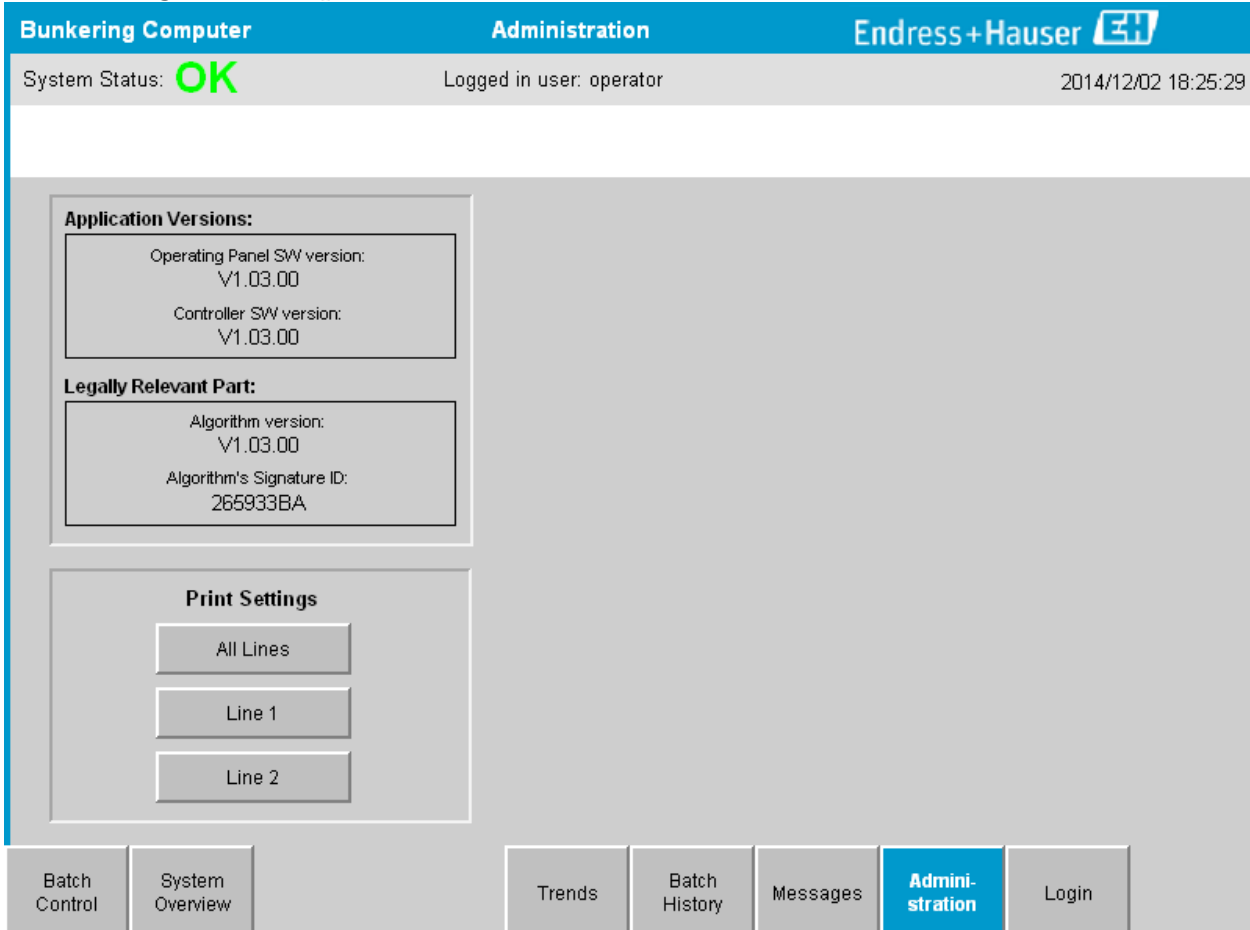
Priority:	High	Severity:	501
Alarm State:	Normal, Unacked	Current Value:	0
Event Time:	2014/12/03 10:43:35	Limit Value Exceeded:	
In Alarm Time:	2014/12/03 10:43:33	Tag 1 Value:	
Acknowledge Time:		Tag 2 Value:	
Out of Alarm Time:	2014/12/03 10:43:35	Tag 3 Value:	
Condition Name:	TRIP	Tag 4 Value:	
Event Category:	Discrete	Alarm Count:	2

At the bottom, there is a status bar with '# 4', a bell icon with '0', a checkmark icon with '0', a blue triangle icon with '4', and a question mark icon with '0'. It also shows 'Filter: Messages' and 'Sorted by: Event Time (Ascend)'. A navigation bar at the very bottom contains buttons for 'Batch Control', 'System Overview', 'Trends', 'Batch History', 'Messages', 'Administration', and 'Login'.

Description of the Bunker Metering System

Administration View

The **Administration** view allows printing the relevant process settings for documentary reason using the ticket printer.



The screenshot shows the Administration View interface. At the top, there is a blue header bar with the text "Bunkering Computer", "Administration", and the Endress+Hauser logo. Below the header, the system status is displayed as "System Status: OK" in green, with "Logged in user: operator" and the date/time "2014/12/02 18:25:29".

The main content area is divided into three sections:

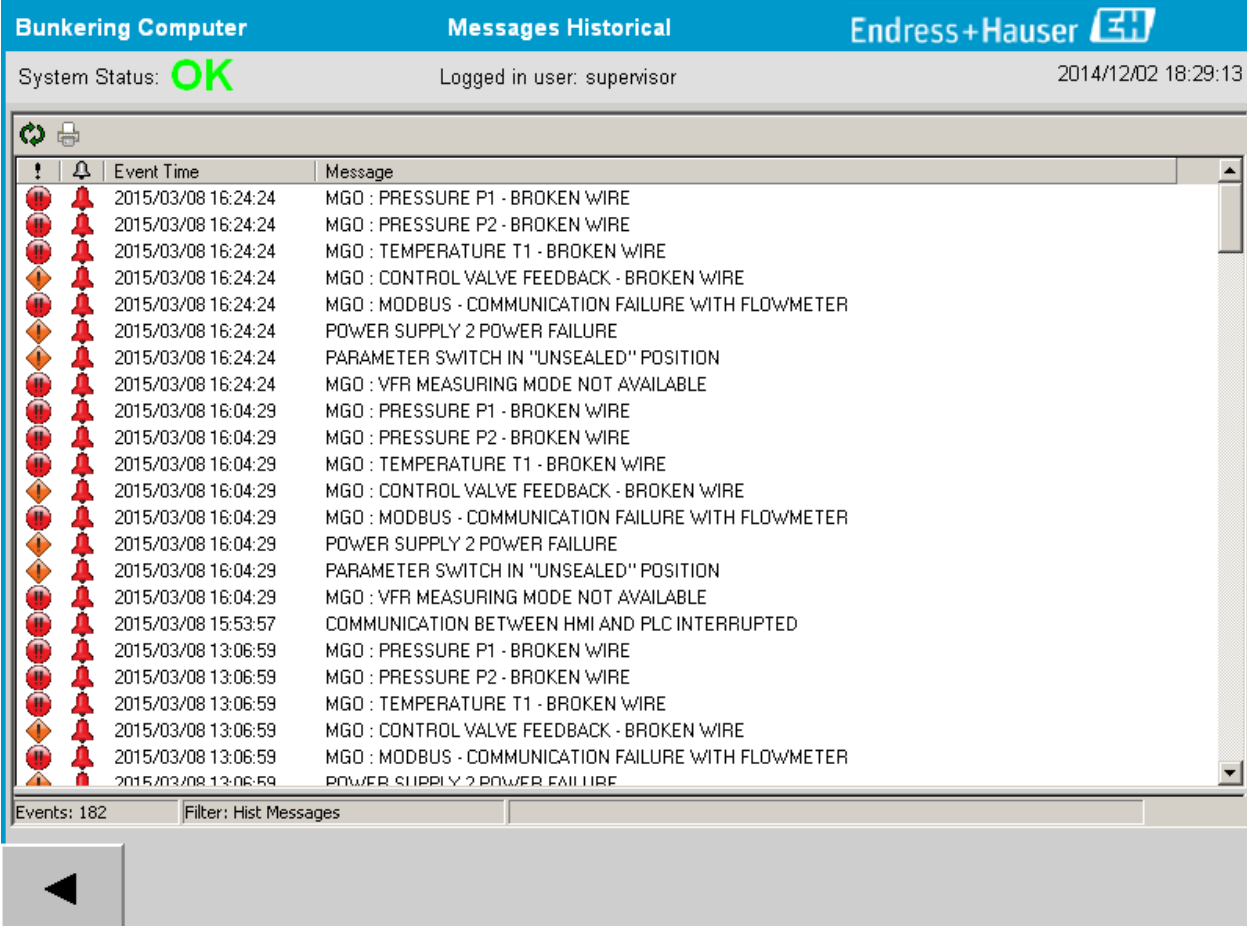
- Application Versions:** A box containing "Operating Panel SW version: V1.03.00" and "Controller SW version: V1.03.00".
- Legally Relevant Part:** A box containing "Algorithm version: V1.03.00" and "Algorithm's Signature ID: 265933BA".
- Print Settings:** A box containing three buttons: "All Lines", "Line 1", and "Line 2".


At the bottom, there is a navigation bar with buttons for "Batch Control", "System Overview", "Trends", "Batch History", "Messages", "Administration" (highlighted in blue), and "Login".

Description of the Bunker Metering System

Messages Historical (user “Supervisor” only)

A list of historical messages can be opened from the **Administration view** by clicking on the button **Messages Historical**. It shows all messages, which are not active anymore (past messages). To access the **Messages Historical** view the login needs to be changed to supervisor.



Bunkering Computer Messages Historical Endress+Hauser 

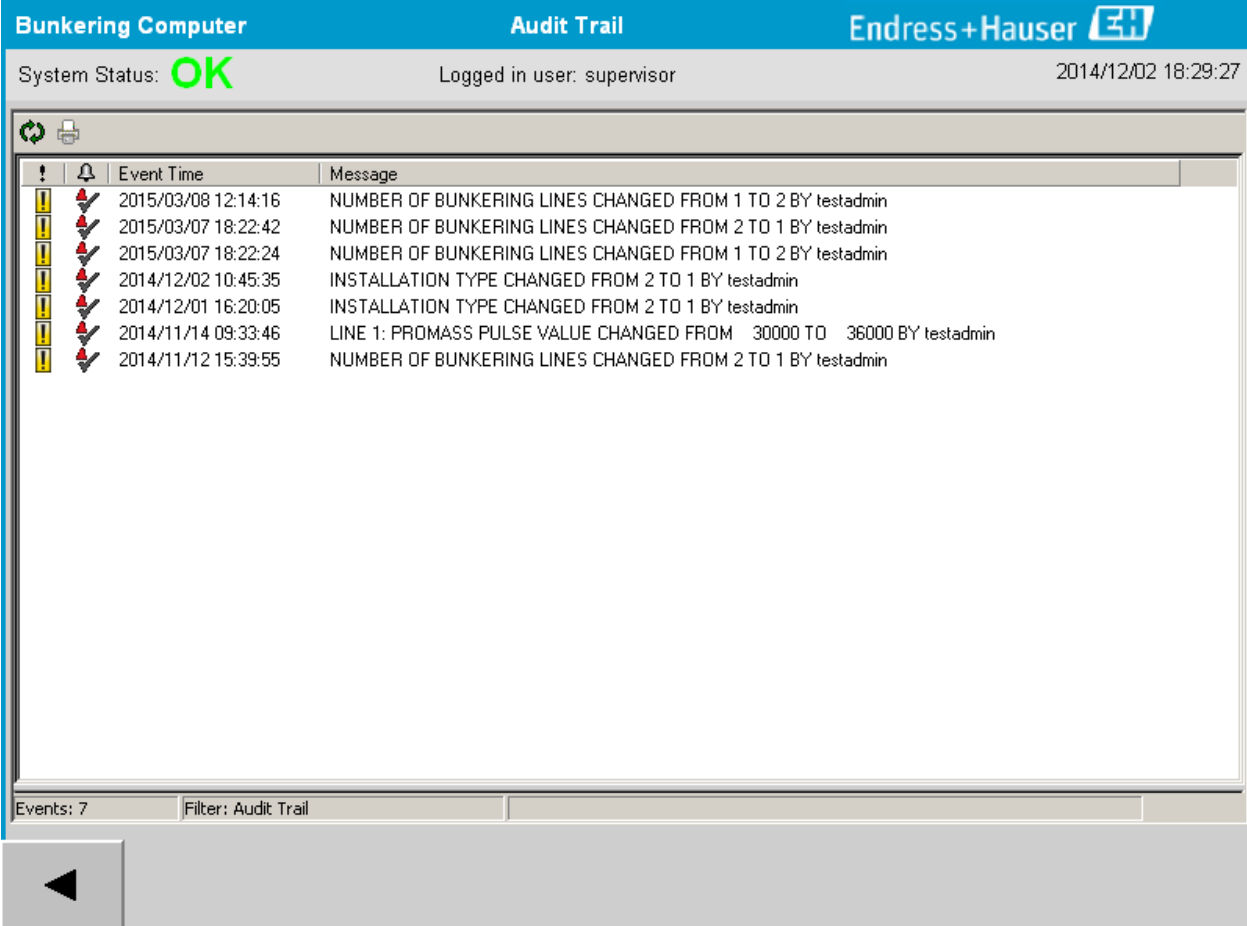
System Status: **OK** Logged in user: supervisor 2014/12/02 18:29:13

!	🔔	Event Time	Message
🔴	🔔	2015/03/08 16:24:24	MGO : PRESSURE P1 - BROKEN WIRE
🔴	🔔	2015/03/08 16:24:24	MGO : PRESSURE P2 - BROKEN WIRE
🔴	🔔	2015/03/08 16:24:24	MGO : TEMPERATURE T1 - BROKEN WIRE
🟡	🔔	2015/03/08 16:24:24	MGO : CONTROL VALVE FEEDBACK - BROKEN WIRE
🟡	🔔	2015/03/08 16:24:24	MGO : MODBUS - COMMUNICATION FAILURE WITH FLOWMETER
🟡	🔔	2015/03/08 16:24:24	POWER SUPPLY 2 POWER FAILURE
🟡	🔔	2015/03/08 16:24:24	PARAMETER SWITCH IN "UNSEALED" POSITION
🔴	🔔	2015/03/08 16:24:24	MGO : VFR MEASURING MODE NOT AVAILABLE
🔴	🔔	2015/03/08 16:04:29	MGO : PRESSURE P1 - BROKEN WIRE
🔴	🔔	2015/03/08 16:04:29	MGO : PRESSURE P2 - BROKEN WIRE
🔴	🔔	2015/03/08 16:04:29	MGO : TEMPERATURE T1 - BROKEN WIRE
🟡	🔔	2015/03/08 16:04:29	MGO : CONTROL VALVE FEEDBACK - BROKEN WIRE
🟡	🔔	2015/03/08 16:04:29	MGO : MODBUS - COMMUNICATION FAILURE WITH FLOWMETER
🟡	🔔	2015/03/08 16:04:29	POWER SUPPLY 2 POWER FAILURE
🟡	🔔	2015/03/08 16:04:29	PARAMETER SWITCH IN "UNSEALED" POSITION
🔴	🔔	2015/03/08 16:04:29	MGO : VFR MEASURING MODE NOT AVAILABLE
🔴	🔔	2015/03/08 15:53:57	COMMUNICATION BETWEEN HMI AND PLC INTERRUPTED
🔴	🔔	2015/03/08 13:06:59	MGO : PRESSURE P1 - BROKEN WIRE
🔴	🔔	2015/03/08 13:06:59	MGO : PRESSURE P2 - BROKEN WIRE
🔴	🔔	2015/03/08 13:06:59	MGO : TEMPERATURE T1 - BROKEN WIRE
🟡	🔔	2015/03/08 13:06:59	MGO : CONTROL VALVE FEEDBACK - BROKEN WIRE
🟡	🔔	2015/03/08 13:06:59	MGO : MODBUS - COMMUNICATION FAILURE WITH FLOWMETER
🟡	🔔	2015/03/08 13:06:59	POWER SUPPLY 2 POWER FAILURE

Events: 182 Filter: Hist Messages

Audit Trail (user “Supervisor” only)

The list of audit trail can be opened from the **Administration** view by clicking on the button **Audit Trail**. It shows all changes made to the system and by which user. To access the **Audit Trail** view the login needs to be changed to supervisor.



The screenshot displays the 'Audit Trail' window within the 'Bunkering Computer' application. The window title is 'Bunkering Computer Audit Trail' and includes the Endress+Hauser logo. The system status is 'OK' and the user is logged in as 'supervisor'. The timestamp is '2014/12/02 18:29:27'. The main area contains a table of events:

!	🔔	Event Time	Message
🟡	🔴	2015/03/08 12:14:16	NUMBER OF BUNKERING LINES CHANGED FROM 1 TO 2 BY testadmin
🟡	🔴	2015/03/07 18:22:42	NUMBER OF BUNKERING LINES CHANGED FROM 2 TO 1 BY testadmin
🟡	🔴	2015/03/07 18:22:24	NUMBER OF BUNKERING LINES CHANGED FROM 1 TO 2 BY testadmin
🟡	🔴	2014/12/02 10:45:35	INSTALLATION TYPE CHANGED FROM 2 TO 1 BY testadmin
🟡	🔴	2014/12/01 16:20:05	INSTALLATION TYPE CHANGED FROM 2 TO 1 BY testadmin
🟡	🔴	2014/11/14 09:33:46	LINE 1: PROMASS PULSE VALUE CHANGED FROM 30000 TO 36000 BY testadmin
🟡	🔴	2014/11/12 15:39:55	NUMBER OF BUNKERING LINES CHANGED FROM 2 TO 1 BY testadmin

At the bottom of the window, it shows 'Events: 7' and 'Filter: Audit Trail'. A navigation arrow is visible on the left side of the bottom bar.

Each time a parameter value is changed (if it is part of the audit trail), the old and the new value are displayed, together with a date/time stamp and the user who carried out the parameter change.

Operation

Basic System Functions

The bunker metering computer BMC is the “brain” of the system. It takes signals from the process sensors, evaluates these and converts them into the custody transfer relevant information. The received quantity of product is calculated from the non-resettable totalizers. After a bunkering operation, the values are read from the operation interface HMI and transferred to other documents used for documenting the transfer of product.

The print-out of the ticket printer, the bunker metering ticket BMT, serves as a document which contains the quantity information plus additional information about the time when the bunkering operation took place.

The BMT must be signed by the Chief Officer of the receiving vessel and the Cargo Master of the bunker barge and is attached to the BDN. However, the BMT is for documentary reasons only and is not necessarily part of the custody transfer relevant system.

If switched on, the system always remains in metering mode. I.e. bunkering operations can start at any time and the related data will be registered automatically. Data of up to 50 bunkering operations can be stored and accessed at any time.

In order to obtain a clearer metering profile, it is suggested to press the totalizer reset button before each start of an operation.

The system includes a robust failure handling strategy. The secondary system keeps up the system functionality even if the flow meter has failed. However, increased metering deviations will occur during such situations.

While immediately signaling failures, the system provides a metering result for as long as possible, following a strategy of “providing a result is better than providing no result – even if it is not fully meeting the specifications.” The quicker the crew reacts on indicated problems, the more representative the metering result will be.

Dealing with Aerated Fuel Oil

In standard (single phase) custody transfer applications the flow meter is the sole source of quantity information. Additional process sensors are only used for converting this information into standardized technical units in a flow computer. Such a system is always based on single phase product conditions.

In bunkering, however, the product by nature of the process contains significant amounts of air at certain times. This is normally the case during line packing, change-over of tanks, tank stripping and line clearing. These aerated phases can be long and can introduce large metering errors if not compensated for. Such correction of the metering result is required for maintaining the over-all accuracy of the received quantity.

The Endress+Hauser system in addition uses a secondary measuring mode to determine the flow rate and quantity during phases when the flow meter delivers doubtful signals. This considers the flow meter's operating conditions as well as process pressure and temperature information. The final metering result is therefore a composition of the flow meter reading and the reading of the secondary measuring mode. This approach and its details are patented and part of Endress+Hauser intellectual property.

Since the secondary measuring mode is normally less accurate than the flow meter reading, good metering conditions have to be maintained for as long as possible by following the barge/vessel operating procedures.

General Advantages of using a Bunker Metering System

Gains in Efficiency

Currently, manual tank sounding as well as flow metering are often used in parallel. Due to the different nature of the two methods there will always be differences and it is strongly recommended to only use one of the systems at the same time for determining the delivered/received quantity.

If the certified metering system is used, no tank sounding is needed. The efforts for sounding at beginning and end of a bunkering operation can be saved. It is estimated that this can make up to 3 hours per operation.

Better Process Transparency

Flow metering systems provide much more information than just the transferred quantity. The metering profiles allow matching the quantity information with the process conditions during the delivery/reception of product.

Doubtful situations can be identified and analyzed. This can be of specific help in situations where a barge or a terminal disagrees with the metered quantity and even letters of protest are issued.

Improved Measuring Accuracy

As mentioned, Coriolis meters today are the most accurate custody transfer flow meters and they offer best possible properties for dealing with bunkering process conditions. Coriolis meter based bunker metering systems provide mass based metering results. Conversion from level measurement via volume calculations (strapping tables) to mass calculations (API conversions) are not needed and inherent human induced errors can be avoided. Metering results do not depend on the sounding method (sounding or ullage), reading parallax and strapping table interpolation. Also, metering systems do not react to rough sea conditions which cause the product to unpredictably move in the tanks making good sounding virtually impossible.

Specific Advantages of the Endress+Hauser Bunker Flow Meter System

The Endress+Hauser bunker flow meter system offers some very distinctive advantages like easy set-up and operation, like audit trail or multi metering line usage.

The E+H system is designed in a way that the operation of the system is completely done from the control room. Only components which need to be installed in the pipeline are out in the field, i.e. on deck. This is not only an advantage for a quite complex component like the bunker metering computer, the operating interface or the data storage device but also for the operators themselves.

Easy to use System

Using a color touch screen allows displaying and accessing process information and system functionality in a very clear way. Different topics are organized in different views offering excellent overview and navigating. Different user levels offer the option of structuring access to different functions of the system.

Historical Data Storage

The Endress+Hauser system offers storage of up to 50 set of bunkering operations. Totalizer values, date and time, error conditions as well as the most important flow weighted process data are kept in the operating interface. If the memory is full, the first set of data gets overwritten (fifo).

Duplicate bunker metering tickets of these events can be printed at any time as long as it is available in the memory.

Audit Trail

Custody transfer relevant changes in system settings are recognized and stored. The Audit trail is a feature which is available from the operating interface.

Two Metering Lines

One bunker metering computer can simultaneously handle two metering lines. This can either mean to operate two independent metering lines or to aggregate the readings of two parallel metering lines into one single metering station result.

Line Packing Valve

The use of a fully automated line packing valve provides better metering conditions in average and consequently improved metering results.

Safety Aspects

Work Safety

The system is designed in a way that all manipulations during operation and control can be done from the operation interface which is normally located in the safe environment. The system is designed in a way that no manipulations during operation and control can be done from the operation interface.

Electrical Safety

All components are CE marked and fulfill the respective requirements by design. The latest documents can be downloaded under the links indicated above from the Endress+Hauser homepage.

Process Alarms

The system allows setting limit values to process parameters such as pressure and temperature. Overstepping the set limits will trigger alarm messages on the display and binary outputs which can be used for activating further signal indicators (lights, horns).

Functional Safety

Endress+Hauser Components

All Endress+Hauser system components are developed and qualified in accordance with the corporate product development standard. This includes, but is not limited to mechanical and electrical design, performance testing and environmental testing (e.g. climate, vibration, EMC).

The software is developed following a V-model based, standardized process.

Most of the components are qualified regarding their functional safety (hardware and software) and meet SIL level 2 requirements.

Third Party Components

Third party components and manufacturers are carefully selected and qualified. They must meet international and also the Endress+Hauser standards. The key component for the bunker metering computer is manufactured by the company Rockwell Automation where Endress+Hauser have a long term close cooperation active.

System Application (Software)

The application software is written by Endress+Hauser using the designated tools. Good software engineering practices as described in an Endress+Hauser standard for application software writing are applied.

Integrity Aspects

System integrity includes all measures that make sure that the metering value (quantity) cannot be altered - neither intentionally nor unintentionally. This is applied to all custody transfer relevant system and component functions.

These measures specifically cover access to settings, signal processing parameters and storage of metering results.

System

The custody transfer relevant instruments are certified to the MID (Measurement Instrument Directive) where OIML standards are used for qualification.

Hardware

The custody transfer relevant system components are qualified in accordance with OIML R-117. This involves temperature, vibration and EMC testing.

Software

The application software is qualified in accordance with the WELMEC 7.2 software guide.

System Access

Hardware

Access to the hardware is secured by means of mechanical seals. This prevents opening lids and covers for accessing meter settings and cable terminals.

For instruments with display HMI access to custody transfer relevant data is prevented by means of a software code or a hardware switch. The door of the cabinet containing the bunker metering computer is additionally safeguarded by a switch. Checking if all seals are still intact is part of the operating procedure for bunkering operations.

Operation

The system can only be operated via the operating interface HMI. Different roles allow accessing different information.

Roles: Operator	access to all information needed for bunkering operations
Supervisor	like "Operator" plus additional process and system information
Manufacturer	like "Supervisor" plus additional system information and settings

All modification of the custody transfer relevant data is logged in the audit trail.

Data Safety

Data safety is ensured by configuring the system interface, which potentially could be used for hacking into the system, read only.

MID Certification for Bunker Flow Meter System

Evaluation Certificate on Component Level

All essential system components of the bunker flow meter system of Endress+Hauser are holding a valid evaluation certificate issued by the notified body NMI Certin B.V. with the notified body number of 0122. Below the list of the current evaluation certification numbers by components:

- Coriolis flow meter sensor: TC7149
- Coriolis flow meter transmitter: TC7151
- Bunker flow computer: TC8396
- Temperature transmitter: TC8399 and TC8683
- Pressure transmitter: TC7675

Evaluation Certificate for Coriolis flow meter

E+H has proved that the Coriolis mass flow meter type Promass 84 performs in the allowed error limits of the OIML R117 class 0.3 when being calibrated on water in the factory. This has been confirmed under the subject water cal = liquid cal in the evaluation certificate TC7149. This allows the user to reduce the initial verification in the field to a zero point verification of the flow meter instead of a flow performance check with the application liquid against a given reference.

System EC type Examination Certificate for Bunkering

The bunker flow meter system of Endress+Hauser is approved specifically for custody transfer metering of aerated fuel oil for installation on barges and vessels. The compliance with the MID Mi-005 is confirmed by the EC type – examination certificate number T10591 issued by NMI Certin B.V. under the notified body number 0122. In addition the system is approved for commercial use by the Maritime and Port Authority (MPA) of Singapore.

Bunker Flow Meter System Initial Verification

The initial verification of the bunker metering system includes visual inspection of the system, flow meter zero point and zero flow testing and sealing. The aim of the initial verification is to confirm the conformity according to the 2004/22/EC Directive. An initial onsite performance check against a given reference is not required for the bunker metering system of Endress+Hauser.

Retaining the MID Certificate over the lifetime of a Vessel

Endress+Hauser are following the recommendation of NMI Certin B.V. as a notified body to retain the MID certificate of a vessel over its lifetime. The verification includes: visual inspection of the system, flow meter zero point and zero flow testing as well as a density check to ensure the integrity of the Coriolis sensor part. A recalibration of the individual components is not required.

Services for installation of a Bunker Flow Meter System

Site Survey

A site survey is the inspection of the barge or vessel where the metering system should be installed. Information about the piping layout and possible location for the meter are gathered. An E+H technician will come on board and define, together with the customer, the best place for installation. The E+H technician will also check the dimensioning of the system on base of the situation on board.

Installation Supervision

To avoid problems and time delay during commissioning, an installation supervision could be performed after the installation of the system. An E+H technician will come on board and check the mechanical and electrical installation and will point out to existing problems. This will be only a visual inspection of general installation. This won't be a review of single electrical or mechanical connections. For technical correct installation the customer is responsible.

Commissioning

During the commissioning, the whole system will be started up and checked for function. If the system is running, a zero point verification will be done. Therefore bunker medium is needed so that this had to be done during a bunker session.

MID approval

To get the MID approval acc. Module D for the installed system, an initial verification of the bunker metering system includes visual inspection of the system is needed. After the inspection the instruments and computer will be sealing. The approval will be realized by an E+H technician, according NMI module D. For the verification bunker medium is needed so that this should be done during a bunker session. Alternative this could also be done with water.