



GLOBALFLOW INC

Transloading Load Measurement System

Design and Theory of Operation

Document Revisions

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Chapter 1 – Introduction

The Transloading Load Measurement System referred to in this document as “The System” was designed and built by GlobalFlow Inc. for Torq Transloading Inc. The purpose of this system is to electronically measure, compensate and report the total flow of crude oil from a standard bulk liquid truck trailer to a standard bulk liquid railcar with a custody transfer level of accuracy and precision. The system is portable, securely mounted to a flat deck tandem axle trailer. The mechanical process and instrumentation is located in a vented and propane heated enclosure. The trailer has been modified to allow for low speed bi-directional towing to provide safe and efficient mobility. The system consists of four main components: the mechanical process, the measurement and user input, the flow calculation, and the result output.

Chapter 2 – The Mechanical Process

The Transloading Measurement System Process was designed in accordance with the ERCB Directive 17 and contains all the necessary components to achieve reliable and accurate liquid measurement. The system is fabricated from 3” Sch. 40 steel pipe with welded and flanged connections. Please refer to the Mechanical P&ID.

The truck trailer is connected to a gate valve (TV-1) at the inlet via flexible steel braided hose and dry disconnect couplings. The inlet is encased in a ERCB compliant spill box with a sample port and suction drain. The process flows through the valve to the stilling chamber, a section of 8” pipe, which encourages air/gas separation without restricting flow. The air/gas flows upward through an air eliminator (AV-1000), bypassing the metering section and recombines with the liquid stream just before the outlet. Liquid flows out of the retention chamber into the metering section consisting of the Foxboro 3” Coriolis Mass Flow Meter (FE-1000 & FQIT-1000), RTD transmitter (TT-1000) in a 2.5” thermowell (TW-1000), 2.5” verification thermowell (TW-1001) and Drexelbrook Water Cut Analyzer (LC-1000). The process continues through an electrically actuated 3” full port ESD ball valve (LCV-1000). This valve is closed on configurable high and low pressure shutdown set points. The low pressure shutdown is enabled once the pressure exceeds a configurable set point. After the ESD valve, the gas and liquid recombine, flow by a pressure transmitter (PT-1000) to the outlet, and into the rail car via flexible steel braided hose and dry disconnect couplings.

Chapter 3 – The Measurement and Operator Input

3.1 Measurement Input

Process measurements are performed by the following instruments; Coriolis Mass Flow, RTD Transmitter, Dielectric Water Cut Analyzer, and Pressure Transmitter. These instruments transmit live readings to the Flow Computer.

3.1.1 Coriolis Mass Flow Meter

The Coriolis Mass Flow Meter is a Foxboro Dual Path 3", Model CFS20-30, with Digital Transmitter, Model CFT51. This meter is accurate to $\pm 0.1\%$ mass flow rate and ± 0.0005 g/cc density, and is rated for 18 to 1800kg/min. The flow meter provides instantaneous mass flow rate and density to the flow computer via pulse and 4-20mA signal respectively. The pulse output signal is configured for 100 pulses per kg.

3.1.2 Water Cut Analyzer

The Water Cut Analyzer is a Drexelbrook CM6. The instrument is installed in a vertical section of 3" pipe and transmits an instantaneous 0 to 5% water cut reading to the flow computer via 4-20mA signal. The strapping table is configured to 0 to 5% Light Oil. The Operator Interface allows the user to adjust the offset of the signal by increments of 0.1% to compensate for changing oil densities and compositions.

3.1.3 RTD Transmitter

The RTD transmitter consists of a 100 Ω Platinum 385 \pm 0.1%, 3 wire, RTD with a WIKA T12.10 RTD Transmitter in a 2.5" insertion thermowell. The transmitter provides an instantaneous temperature reading to the flow computer via 4-20mA signal ranged from -20° to 100°C.

3.1.4 Pressure Transmitter

The Pressure transmitter is an AST 46HA. This instrument is accurate to $<\pm 0.1\%$ best fit straight line, and ranged from 0 to 50 PSI. The instantaneous pressure is transmitted to the flow computer via 4-20mA signal.

3.2 Operator Input

The System has a 5.7" Color Touchscreen HMI to provide operator input and live measurement data. To initialize a load measurement cycle the operator must enter the following information into the HMI.

- Rail Car ID Number
- Rail Car Current Mass (kg)
- Rail Car Current Volume (m³)
- Driver ID
- Driver Name
- Trucking Company ID
- Trucking Company Name
- Waybill Number
- Manual Water Cut (%)
- Water Density (kg/m³)
- Well ID
- Well Location
- Oil Company
- Oil Base Density (kg/m³)

Chapter 4 – The Flow Calculation

4.1 The Flow Computer

The System's flow computer is a ROC 800L v1.03 by Emerson Process Management. All of the measurement and Operator inputs are fed into this computer to ultimately calculate the total standard temperature and pressure compensated net oil and water volume for the load. The ROC 800L corrects the flow rate according to the following standards:

- Density - ASTM-D-1250-04; API MPMS Chapter 11.1, 2004; API Table 53A
- Temperature - ASTM-D-1250-04; API MPMS Chapter 11.1, 2004; API Table 54A
- Pressure - API MPMS Chapter 11.1 (2004), 11.2.1, 11.2.2, 11.2.1(M), and 11.2.2(M)

4.2 Flow Computer Configuration

The ROC 800L is running the Emerson Liquid Allocation Program and is configured to compute two flow calculations. The first uses the measured water cut reading from the Drexelbrook Analyzer, the second uses a manually entered BS&W value obtained by spinning a sample. The general flow computer configuration is as follows.

4.2.1 Units of Measure

- Mass – kg
- Mass Flow Rate – kg/minute
- Volume – Liters in the calculations, displayed/output as m³
- Volume Flow Rate – Liters/minute in calculations, displayed/output as m³/minute
- Temperature – Degrees Celsius
- Pressure – PSI
- Density – kg/m³

4.2.2 Fluid Properties

As per the API Standard the fluid is defined as Crude Oil and uses the 2004 ASTM / API Tables.

4.2.3 Density

The instantaneous density is acquired via 4-20mA signal from the Coriolis meter. The correction factors are determined using the RTD and Pressure transmitters via 4-20mA signal.

4.2.4 Flow Meter

The instantaneous mass flow is acquired via pulse signal @ 100 pulses per kg. The correction factors are determined using the RTD and Pressure transmitters via 4-20mA signal. The instantaneous water cut (S&W) is acquired via 4-20mA signal. A Low Flow Cutoff of 100 kg/min is used to eliminate erroneous flow accumulation when the meter is empty or not flowing.

4.2.5 Batching

The batching functionality of the flow computer is used to definitively start and stop the load measurement cycle. This eliminates roll-over and ensures all totalizers are zeroed before loading begins and stopped when loading is finished. The batch is started and stopped by the operator via the HMI immediately before and after the loading operation.

4.3 Equations

The flow computer runs the calculations once a second. P_i = The accumulated pulse count during the second. The following is a list of the equations used by the flow computer:

FACTORS	DESCRIPTION
KF	K-Factor, pulse rate of Coriolis Meter, 100 pulses/kg
MF	Meter factor, determined when meter is proven, ≈ 1
CTL	Correction for the effect of temperature on Liquid
CPL	Correction for the effect of pressure on Liquid

MASS	DESCRIPTION	FORMULA
MFR	Mass Flow Rate, kg/min	$P_i \times KF \times MF \times \frac{60s}{min}$
IM	Total Indicated Mass, kg	$\sum_{i=1}^n (P_i \times KF \times MF)$

DENSITY	DESCRIPTION	FORMULA
DEN _{obs,e}	Observed Density, Emulsion, kg/m ³	Live input (Coriolis Meter)
DEN _{b,w}	Base Density, Water, kg/m ³	Manually Entered (HMI)
DEN _{b,o}	Base Density, Oil, kg/m ³	$\frac{IM - \frac{SWV}{DEN_{b,w}}}{NSV}$

VOLUME	DESCRIPTION	FORMULA
VFR	Volume Flow Rate, m ³ /minute	$\frac{P_i \times KF \times MF}{DEN_{obs,e}} \times \frac{60s}{min}$
IV	Total Indicated Volume, m ³	$\sum_{i=1}^n \left(\frac{P_i \times KF \times MF}{DEN_{obs,e}} \right)$
GSVFR	Gross Standard Volume Flow Rate, m ³ /minute	$VFR \times CTL \times CPL$
GSV	Total Gross Standard Volume, m ³	$\sum_{i=1}^n \left(\frac{P_i \times KF \times MF \times CTL \times CPL}{DEN_{obs,e}} \right)$
NSV _{Meas}	Total Net Standard Volume-Measured, m ³	$\sum_{i=1}^n \left(\frac{P_i \times KF \times MF \times CTL \times CPL \times (1 - \%S\&W_{Meas})}{DEN_{obs,e}} \right)$
SWV _{Meas}	Total Sediment and Water Standard Volume-Measured, m ³	$\sum_{i=1}^n \left(\frac{P_i \times KF \times MF \times CTL \times CPL \times \%S\&W_{Meas}}{DEN_{obs,e}} \right)$
NSV _{Man}	Total Net Standard Volume-Manual, m ³	$\sum_{i=1}^n \left(\frac{P_i \times KF \times MF \times CTL \times CPL \times (1 - \%S\&W_{Man})}{DEN_{obs,e}} \right)$
SWV _{Man}	Total Sediment and Water Standard Volume-Manual, m ³	$\sum_{i=1}^n \left(\frac{P_i \times KF \times MF \times CTL \times CPL \times \%S\&W_{Man}}{DEN_{obs,e}} \right)$

S&W	DESCRIPTION	FORMULA
%S&W _{Meas}	Sediment and Water, %	Live input (Water Cut Analyzer)
%S&W _{Man}	Sediment and Water – Manual, %	Manually Entered (HMI)
WC	Total Water Cut, %	$\frac{SWV_{Meas}}{GSV}$

Chapter 5 – The Output

The System utilizes a thermal ticket (receipt) printer to provide a physical output of the final totals. Two different tickets are produced, the ‘Truck Ticket’ and the ‘Car Ticket’. The Truck Ticket is printed after each truck load and shows the totals for that truck. The Car Ticket is printed once the rail car is full and shows the totals for the rail car. Generally it takes three trucks to fill a car. The following is a description of each line of the printed tickets.

5.1 Truck Ticket

- **DATE:** Date the ticket was printed
- **TIME:** Time the ticket was printed
- **TERMINAL:** Unique name or identifier of this particular meter
- **TRUCK ID:** Unique ID number of the truck
- **DRIVER:** First/Last name of the driver
- **COMPANY ID:** Unique ID number for the trucking company
- **COMPANY:** Name of the trucking company
- **WAYBILL #:** Trucking company’s waybill number from their paperwork
- **LOAD #:** Incremental number to reference the load operation. Increments by 1.
- **LOAD TIME:** Duration of the load operation in minutes.
- **CAR ID:** Alpha-Numeric ID number of the rail car.
- **INIT VOL:** Initial volume of liquid in the rail car. Can be manually entered or carried over from the last load
- **FINAL VOL:** Final volume of liquid in the rail car after the loading operation has completed. This is uncorrected, indicated volume (IV) plus the initial volume at observed temperature and pressure.
- **INIT MASS:** Initial mass of liquid in the rail car. Can be manually entered or carried over from the last load
- **FINAL MASS:** Final mass of liquid in the rail car after the loading operation has completed.
- **WELL ID:** Unique ID number of the well
- **COMPANY:** Name of the oil company
- **WELL:** Location of the well, LSD or UWI
- **BASE DENS:** Base density of the oil.
- **AVG DENS:** Average Base Density of the emulsion
- **AVG TEMP:** Average temperature of the emulsion during the load operation
- **UNCOR VOL:** Total uncorrected indicated volume (IV) of the emulsion
- **COR VOL:** Total corrected gross standard volume (GSV) of the emulsion. Corrected to 15°C
- **GROSS MASS:** Total mass of the emulsion.
- **MEASURED CUT, NET OIL:** Net standard volume (NSV) of the oil using the measured water cut reading, corrected to 15°C

- **MEASURED CUT, NET WATER:** Net standard sediment and water volume (SWV) using the measured water cut reading, corrected to 15°C
- **MEASURED CUT, CUT:** The measured water cut of the entire load. (WC)
- **MEASURED CUT, OIL DENS:** Base density of the oil, using the measured water cut reading, corrected to 15°C
- **MANUAL CUT, NET OIL:** Net standard volume (NSV) of the oil using the manually entered water cut reading, corrected to 15°C
- **MANUAL CUT, NET WATER:** Net standard sediment and water volume (SWV) using the manually entered water cut reading, corrected to 15°C
- **MANUAL CUT, CUT:** The manually entered water cut reading.
- **MANUAL CUT, OIL DENS:** Base density of the oil, using the manually entered water cut reading, corrected to 15°C

5.2 Car Ticket

- **DATE:** Date the ticket was printed
- **TIME:** Time the ticket was printed
- **TERMINAL:** Unique name or identifier of this particular meter
- **CAR ID:** Alpha-Numeric ID number of the rail car.
- **INIT VOL:** Initial volume of liquid in the rail car. Manually entered
- **FINAL VOL:** Final volume of liquid in the rail car after all loading operations have completed. This is uncorrected, indicated volume (IV) plus the initial volume at observed temperature and pressure.
- **INIT MASS:** Initial mass of liquid in the rail car. Manually entered
- **FINAL MASS:** Final mass of liquid in the rail car after all loading operations have completed.
- **UNCOR VOL:** Total uncorrected indicated volume (IV) of the emulsion
- **COR VOL:** Total corrected gross standard volume (GSV) of the emulsion. Corrected to 15°C
- **GROSS MASS:** Total mass of the emulsion.
- **MEASURED CUT, NET OIL:** Net standard volume (NSV) of the oil using the measured water cut reading, corrected to 15°C
- **MEASURED CUT, NET WATER:** Net standard sediment and water volume (SWV) using the measured water cut reading, corrected to 15°C
- **MEASURED CUT, CUT:** The measured water cut of the entire load. (WC)
- **MEASURED CUT, OIL DENS:** Base density of the oil, using the measured water cut reading, corrected to 15°C
- **MANUAL CUT, NET OIL:** Net standard volume (NSV) of the oil using the manually entered water cut readings, corrected to 15°C
- **MANUAL CUT, NET WATER:** Net standard sediment and water volume (SWV) using the manually entered water cut readings, corrected to 15°C
- **MANUAL CUT, CUT:** Calculated from the manually entered water cut readings.
- **MANUAL CUT, OIL DENS:** Base density of the oil, using the manually entered water cut readings, corrected to 15°C