

csstel



AN-862200

Fuel Monitoring with ComView

Document No.: AN-862200, Rev 1.00
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Introduction

ComView offers a suite of user applications. Fuel app is one of the add-on applications that helps users simplify their tasks in fuel consumption management.

Fuel app lets users measure fuel level in a tank, get notified on alarm conditions based on fuel level thresholds and rate of change, and analyze fuel consumption trends with data visualizations.

Fuel app supports up to 3 fuel tanks. A level sensor is installed in each tank to measure fuel level. The sensor output connects to either an analog input (if it is of voltage or 4-20mA current loop type) or an RS-485 port (if it is of Modbus type).

Fuel app supports various tank types with user-definable dimensions. These include:

- Rectangular tank
- Cylindrical tank in vertical orientation
- Cylindrical tank in horizontal orientation
- Oval tank in vertical orientation
- Oval tank in horizontal orientation
- Capsule tank in vertical orientation
- Capsule tank in horizontal orientation

Fuel app operates on CSV-formatted data records made available by Analogs or RS-485 app depending on the level sensor output type. It reads raw fuel level measurements from these data records, applies a 5-point Moving-Average filtering to these measurements for noise reduction, and calculates instantaneous fuel volumes based on tank type and dimensions. Filtered volumes are then used to calculate rates of change of volumes. These values are then monitored for user-defined alarm conditions on high/low volume thresholds and high/low fuel inflow (into tank) and outflow (out of tank) rates. This capability enables the monitoring of potential fuel thefts.

Fuel app generates CSV-formatted records for its calculated values and stores them in a raw data file, one for each tank. These files can be automatically pushed to a remote server for storage and for further user-specific data processing.

This application note is intended to provide an overview of Fuel app and how to configure it for measuring and monitoring fuel level.

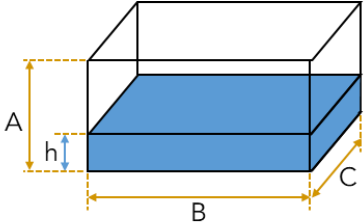
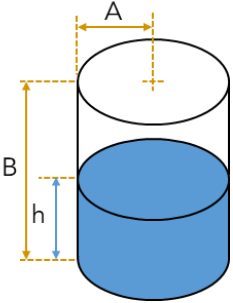
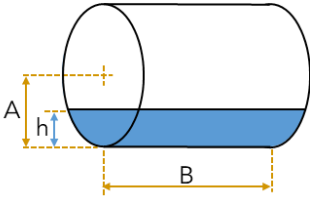
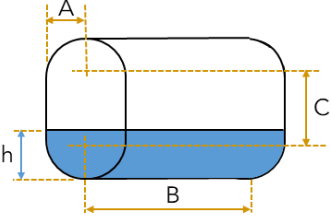
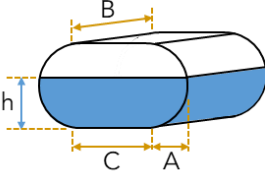
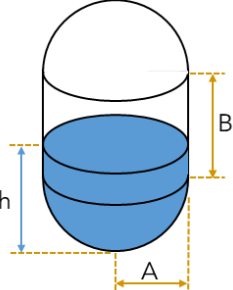
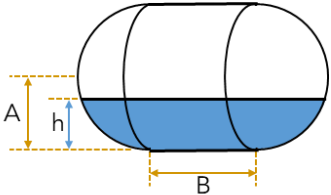
This application note does not provide detailed description of how to use ComView, its connectivity and configuration, and other supporting information, as these are beyond the scope of this document. Refer to other resources for more details.

References:

- [1]. ComView - User Guide

Fuel Tank Types

Fuel app supports the following tank types with user-definable dimensions referenced as 'A', 'B', and 'C' as required in tank setup section of Fuel app configuration.

<p>Rectangular</p> 	
<p>Cylindrical - Vertical</p> 	<p>Cylindrical – Horizontal</p> 
<p>Oval – Vertical</p> 	<p>Oval – Horizontal</p> 
<p>Capsule – Vertical</p> 	<p>Capsule – Horizontal</p> 

Fuel Tank Setup

Fuel Tank Setup section allows users to select a tank from the 'Select tank number' dropdown list. Operation of the selected tank [0..2] can be defined in the entries thereafter as shown below:

The screenshot shows the 'FUEL TANK SETUP' configuration page in the ComView interface. The page includes the following fields and controls:

- Select tank number:** A dropdown menu currently set to '0'.
- Tank Enable:** Radio buttons for 'No' and 'Yes' (selected).
- Tank Name:** A text input field containing 'Tank 0'.
- Tank Shape & Orientation:** A dropdown menu currently set to 'Rectangular'.
- Tank Dimensions (cm):** Three text input fields for length, width, and height, with values 40, 100, and 50 respectively.
- Volume Thresholds - Low/High (L):** Three text input fields with values 20, 180, and 2.
- Volume High Rate of Change Threshold (L/min):** Two text input fields with values 10 and 1.
- Volume Low Rate of Change Threshold (L/min):** Two text input fields with values 2 and 0.2.
- Fuel Density (Kg/L):** A text input field with value 0.85.
- Level Sensor Output Type:** Radio buttons for 'Analog' (selected) and 'RS-485'.
- Analog Type Connection:** A dropdown menu currently set to 'Analog 0'.
- Set Output on Alarm:** A dropdown menu set to 'None', followed by 'To:' (On), 'For:' (00:09), and two more dropdown menus for hours and minutes.
- Raw Data File Size:** A text input field with value 2048,5,5.
- Data Source Filename:** A text input field with placeholder '(path to data file)'.

At the bottom of the form, there are 'Refresh' and 'Apply' buttons, and a small icon representing a document or settings.

Tank Enable:

Description: To enable or disable Fuel application for tank [0..2]

Usage: Select [Yes,No]

Tank Name:

Description: To define name for tank [0..2] for identification purposes

Usage: Enter a string up to 24 characters

Tank Shape & Orientation:

Description: To define shape and orientation of tank [0..2]

Usage: Select from dropdown list:

- None: Fuel application function disabled for this tank
- Rectangular: rectangular tank
- Cylindrical (Vertical): cylindrical tank in vertical orientation
- Cylindrical (Horizontal): cylindrical tank in horizontal orientation
- Oval (Vertical): oval tank in vertical orientation
- Oval (Horizontal): oval tank in horizontal orientation

- Capsule (Vertical): capsule tank in vertical orientation
- Capsule (Horizontal): capsule tank in horizontal orientation

Tank Dimensions (cm):

Description: To define physical dimensions of tank [0..2]

Usage: Enter value in 'cm' for 'A', 'B', and 'C' dimension input fields. Enter '0' for dimension not required.

Volume Thresholds – Low/High (L):

Description: To define alarm conditions on volume for tank [0..2]

Usage: Enter value for 'Low', 'High', 'Tolerance' input fields:

- Low: Low volume alarm threshold, decimal number in 'L' (liters)
- High: High volume alarm threshold, decimal number in 'L' (liters)
- Tolerance: Tolerance, decimal number in 'L' (liters)

Volume High Rate of Change Threshold (L/min):

Description: To define alarm conditions on high rate of change of volume for tank [0..2]

Usage: Enter value for 'High' and 'Tolerance' input fields:

- High: High-rate alarm threshold, decimal number in 'L/min' (liters per minute)
- Tolerance: Tolerance, decimal number in 'L/min' (liters per minute)

Note: High rate of change of volume is intended to detect unusual high outflow events

Volume Low Rate of Change Threshold (L/min):

Description: To define alarm conditions on low rate of change of volume for tank [0..2]

Usage: Enter value for 'Low' and 'Tolerance' input fields:

- Low: Low-rate alarm threshold, decimal number in 'L/min' (liters per minute)
- Tolerance: Tolerance, decimal number in 'L/min' (liters per minute)

Note: Low rate of change of volume is intended to detect unusual low outflow events

Fuel Density (Kg/L):

Description: To define liquid density for tank [0..2]

Usage: Enter value in decimal number in 'kg/L'

Level Sensor Output Type:

Description: To define level sensor output connectivity to analog or RS-485 port for tank [0..2]

Usage: Select 'Analog' or 'RS-485':

- If Analog is selected, then select analog port number from 'Analog Type Connection' dropdown list
- If RS-485 is selected, then select values from 'RS-485 Type Connection' dropdown lists for port number, device number, and variable number

Set Output on Alarm:

Description: To define output control on alarm detection for tank [0..2]

Usage: Select values from dropdown lists for output number, output state, and its activated time duration

Raw Data File Size:

Description: To define raw data file size in kilo bytes (kB), the percentage (%) to remove data in FIFO manner when file overflows its limit, and the time interval in minutes (min) to check the file size.

Usage: Enter values in 'kB,%,min' format

Data Source Filename:

Description: To define pathname of source data file for tank [0..2] for Fuel application to process

Usage: Enter a valid full pathname to source data file in the device. This input field should be empty in normal operation.

Note: If file pathname is present, the application will not process real-time data but use this data file instead. This function is intended for testing purposes only or to process historical data.

From the above, users can define and monitor alarm conditions on fuel volume, fuel volume low rate of change, and fuel volume high rate of change with Low and High thresholds and automatic activation of output on alarm.

Fuel Consumption Data

Fuel app helps users simplify fuel consumption management by performing the front-end data processing that deals with raw level measurements and filtering, detailed mathematical calculations of instantaneous volume for different tank shapes and sizes, and normalizing pre-processed data into CSV-formatted records with timestamps to ease further data processing.

For user convenience, fuel consumption data files can be scheduled to upload automatically to a remote server for storage and for further user-specific data processing.

In operation, Fuel app performs the following steps:

- Reads raw level measurements from Analogs or RS-485 app
- Converts raw level measurements to density-specific fuel level measurements ('l')
- Performs 5-point Moving Average filtering on 'l' to get filtered level measurements ('h')
- Calculates instantaneous volume ('Vh') based on 'h' using equations specific to tank shape and dimensions
- Calculates rate of change of volume ('Vht') based on 'Vh'
- Applies 5-point Moving Average filtering on 'Vht' to get filtered rate of change of volume ('Vft')
- Constructs CSV-formatted record and stores it in raw data file, one file per tank

Fuel app CSV-formatted record has the following format:

```
YYYYMMDD, HHMMSS, SensorNo, h, UoM0, Vh, UoM1, Vht, UoM2, Vft, UoM3
```

YYYYMMDD: Date stamp
 HHMMSS: Time stamp
 SensorNo: Level sensor for tank number [0,1,2]
 h: Calculated value of level (height) using 5-point Moving-Average filter
 UoM0: Unit of measurement of level 'h' in cm
 Vh: Calculated value of fuel volume based on 'h' and tank shape and dimensions
 UoM1: Unit of measurement of 'Vh' in L (liter)
 Vht: Calculated value of fuel volume rate of change based on 'Vh'
 UoM2: Unit of measurement of 'Vht' in L/min (liter/minute)
 Vft: Calculated value of fuel volume rate of change using 5-point Moving-Average filter on 'Vht'
 UoM3: Unit of measurement of 'Vft' in L/min (liter/minute)

Example:

```
20221009, 142545, 0, 18.522, cm, 92.611, L, -69.064, L/min, -19.081, L/min
```

With pre-processed fuel consumption data in CSV-formatted records, data files can be readily processed further according to user-specific requirements for trend analysis and reporting using common software such as Microsoft Excel and Google Sheets.

Fuel Monitoring on Volume

Fuel app helps users monitor fuel level in a tank to plan for fuel refill on low volume or to measure refill on high volume. Users can define low and high-volume thresholds along with tolerance to meet their fuel volume monitoring requirements.

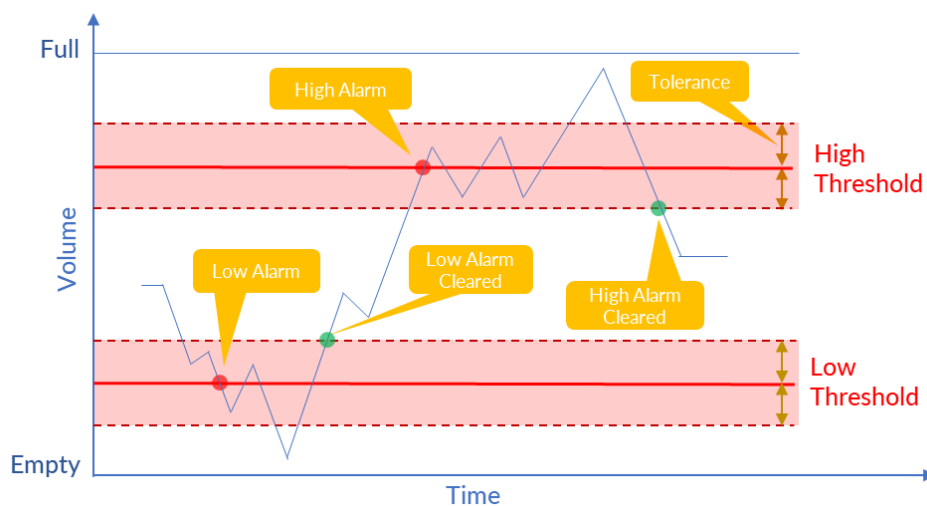
On detecting an alarm condition, Fuel app generates an alarm record, logs it in an alarm file, automatically notifies users of the condition, and optionally take corrective action by activating outputs (i.e., controlling onsite audible/visual devices).

Fuel app monitors volume alarm conditions based on user-defined value for input field labeled as 'Volume Thresholds – Low/High (L)' on its web page, such as:

Volume Thresholds - Low/High (L):

The app detects an alarm condition based on volume level that 'falls below' the Low-volume threshold and volume level that 'rises above' the High-volume threshold.

Tolerance value is used to prevent repetitive alarm conditions of the same type from generating new alarms and alarm notifications, i.e., alarms of the same type must be cleared first prior to the new one being generated, as shown below:



From the above,

Low volume alarm:

$$\text{Volume ('Vh')} \leq \text{Low}$$

Low volume alarm cleared:

$$\text{Volume ('Vh')} > (\text{Low} + \text{Tolerance})$$

High volume alarm:

Volume ('Vh') \geq High

High volume alarm cleared:

Volume ('Vh') < (High – Tolerance)

Using the volume threshold setting above (20,180,2), Fuel app will detect fuel low and fuel high alarms for volumes as captured in the alarm records below.

```
20220728,220355,Analog, Tank 0,19.1812,L,Fuel low  
20220728,220510,Analog, Tank 0,26.6541,L,Fuel low alarm cleared  
20220728,220650,Analog, Tank 0,181.8176,L,Fuel high  
20220728,221125,Analog, Tank 0,178.0000,L,Fuel high alarm cleared
```

On alarm detection, ComView will also notify users of alarm using the alarm delivery methods that users define.

Fuel Monitoring on Volume Rate of Change

Fuel app helps users monitor inflow and outflow rates of change of volume in a tank to detect unusual activities, such as potential fuel thefts, fuel leaks, and other events. Users can define low and high-rate thresholds along with tolerance to meet their fuel monitoring requirements.

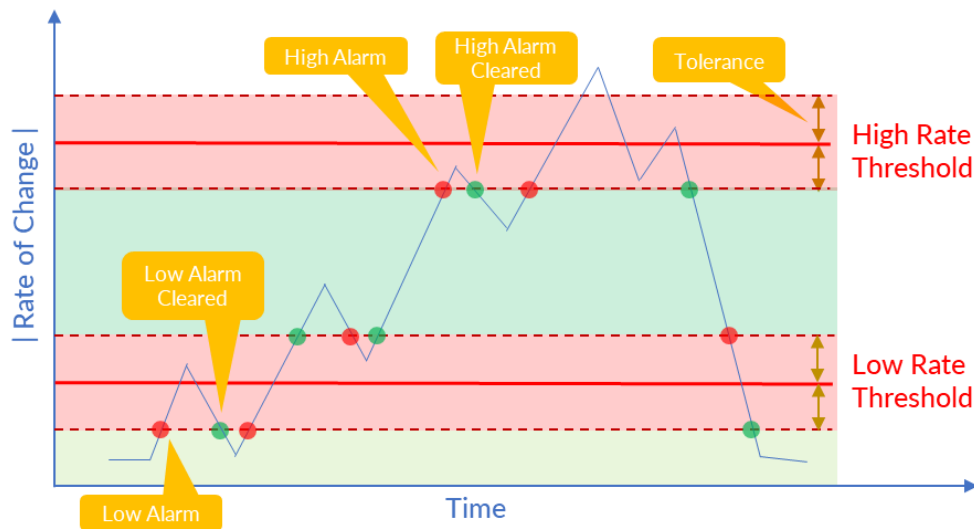
On detecting an alarm condition, Fuel app generates an alarm record, logs it in an alarm file, automatically notifies users of the condition, and optionally take corrective action by activating outputs (i.e., controlling onsite audible/visual devices).

Fuel app monitors volume rate of change alarm conditions based on user-defined values for input fields labeled as 'Volume High Rate of Change Threshold (L/min)' and 'Volume Low Rate of Change Threshold (L/min)' on its web page, such as:

Volume High Rate of Change Threshold (L/min):	<input type="text" value="10"/>	<input type="text" value="1"/>
Volume Low Rate of Change Threshold (L/min):	<input type="text" value="2"/>	<input type="text" value="0.2"/>

The app detects an alarm condition based on volume rate of change that 'falls below' the Low-rate threshold and volume rate of change that 'rises above' the High-rate threshold.

Tolerance value is used to prevent repetitive alarm conditions of the same type from generating new alarms and alarm notifications, i.e., alarms of the same type must be cleared first prior to the new one being generated, as shown below:



From the above,

Low-rate alarm:

$$(Low - Tolerance) \leq |Rate| \leq (Low + Tolerance)$$

Low-rate alarm cleared:

$$|Rate| < (Low - Tolerance) \text{ or } |Rate| > (Low + Tolerance)$$

High-rate alarm:

$$|\text{Rate}| \geq (\text{High} - \text{Tolerance})$$

High-rate alarm cleared:

$$|\text{Rate}| < (\text{High} - \text{Tolerance})$$

Outflow is when Rate < 0 (i.e., negative value). Inflow is when Rate > 0 (i.e., positive value). Using High-rate threshold of '10,1' and Low-rate threshold of '2,0.2' as above, Fuel app will detect fuel low and high inflow/outflow rate alarms for rates as captured in the alarm records below:

```
20220728,220130,Analog,Tank 0,-1.8918,L/min,Fuel low outflow rate
20220728,220210,Analog,Tank 0,-2.4254,L/min,Fuel low-rate alarm cleared
20220728,220325,Analog,Tank 0,-10.9101,L/min,Fuel high outflow rate
20220728,220415,Analog,Tank 0,-7.3271,L/min,Fuel high-rate alarm cleared
20220728,220425,Analog,Tank 0,-1.8268,L/min,Fuel low outflow rate
20220728,220430,Analog,Tank 0,0.0904,L/min,Fuel low-rate alarm cleared
20220728,220440,Analog,Tank 0,2.0922,L/min,Fuel low inflow rate
20220728,220505,Analog,Tank 0,8.0725,L/min,Fuel low-rate alarm cleared
20220728,220510,Analog,Tank 0,20.1176,L/min,Fuel high inflow rate
20220728,220730,Analog,Tank 0,8.0753,L/min,Fuel high-rate alarm cleared
20220728,220830,Analog,Tank 0,-1.8353,L/min,Fuel low outflow rate
20220728,220835,Analog,Tank 0,-2.6654,L/min,Fuel low-rate alarm cleared
20220728,220925,Analog,Tank 0,-9.2951,L/min,Fuel high outflow rate
20220728,221015,Analog,Tank 0,-7.9793,L/min,Fuel high-rate alarm cleared
20220728,221025,Analog,Tank 0,-2.0922,L/min,Fuel low outflow rate
20220728,221030,Analog,Tank 0,-0.0452,L/min,Fuel low-rate alarm cleared
20220728,221040,Analog,Tank 0,2.0922,L/min,Fuel low inflow rate
20220728,221105,Analog,Tank 0,1.4428,L/min,Fuel low-rate alarm cleared
20220728,221135,Analog,Tank 0,-10.4725,L/min,Fuel high outflow rate
20220728,221215,Analog,Tank 0,-7.4626,L/min,Fuel high-rate alarm cleared
```

On alarm detection, ComView will also notify users of alarm using the alarm delivery methods that users define.

Fuel Reports

Fuel Reports section allows users to select a tank to view its fuel data summary. This includes total number of data points, first and last data point timestamps, and the last 5 data records for references.

Users can enter labels for fuel level, volume, and rate of change of volume data series. To plot, enter chart title and define chart data range – All data points, First Data Points, and Last Data Points. When Last Data Points is selected, users can click on 'Refresh' button to view chart updates in real-time for 1 minute duration. Re-click the button to continue viewing. Users can also zoom in the chart to view finer details of data series.

Fuel reports are shown below with sample data:

➤

FUEL REPORTS

Available Fuel Tanks:

Total data points = 164 ▲

First data point timestamp = 20220728,220000

Last data point timestamp = 20220728,221255

Last 5 data points:

20220728,221235,0,33.9092,cm,169.5459,L,-1.0871,L/min,-1.4372,l

20220728,221240,0,33.8908,cm,169.4541,L,-1.1012,L/min,-1.0475,l ▼

Select Fuel Tank No.: 0 1 2

Fuel Level (h) Label:

Fuel Volume (Vh) Label:

Fuel Volume Rate of Change (Vht) Label:

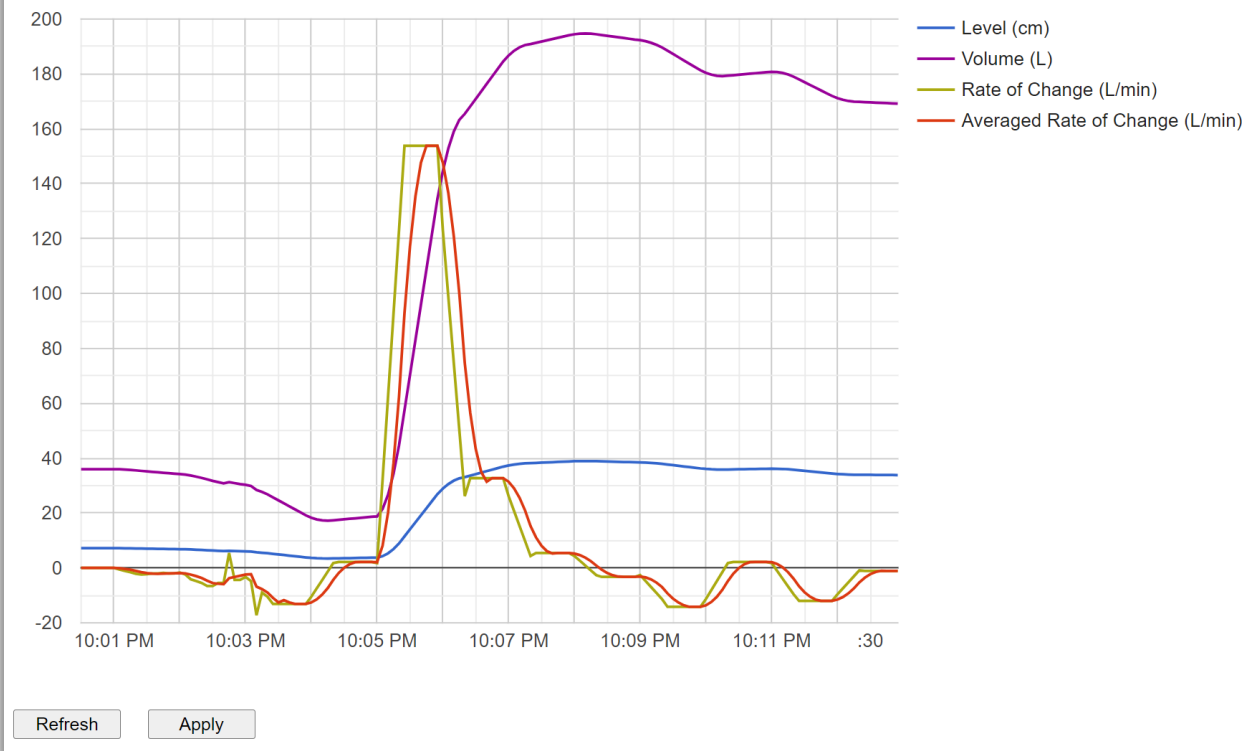
Fuel Volume Rate of Change (Vft) Label:

Chart Data Range:

All / Or ▼

Chart Title:

Fuel Chart



From the above chart,

Level (cm):

Level data series in 'cm', 5-point Moving Average filtered data

Volume (L):

Volume data series in 'L'

Rate of Change (L/min):

Rate of change data series in 'L/min':

- Inflow rate when it is above '0' horizontal axis
- Outflow rate when it is below '0' horizontal axis

Averaged Rate of Change (L/min):

Rate of change data series in 'L/min', 5-point Moving Average filtered data:

- Inflow rate when it is above '0' horizontal axis
- Outflow rate when it is below '0' horizontal axis

With data visualization, users can quickly identify areas of interests such as unusual outflow and inflow rates or get better views of fuel consumption trends.

Summary

This application note illustrates how ComView Fuel app helps users simplify the tasks of fuel monitoring by performing the complex frontend calculations and data processing. The results let users measure and monitor fuel level and its rates of inflow and outflow to detect unusual activities, such as fuel thefts. The application note also shows the additional benefits that users can realize from Fuel app with its CSV-formatted data records for further upstream data processing and instant real-time data visualizations of fuel level and its rates of change.

About CSSTEL

CSSTEL is a privately held developer and manufacturer of ComView hardware and software solutions for secure, remote infrastructure site management since 1997 with installations in over 30 countries around the world.

We offer ComView solutions that are scalable and customizable to monitor and manage virtually the entire spectrum of remote site infrastructure and site conditions.

We help telecom service providers, carriers, financial institutions, healthcare providers, government agencies, utilities, and other public and private sector organizations maintain constant visibility and control over their remote site infrastructure.



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Revision History

Revision	Date	Description
1.00	2023-01-08	Initial release

*** End of document ***