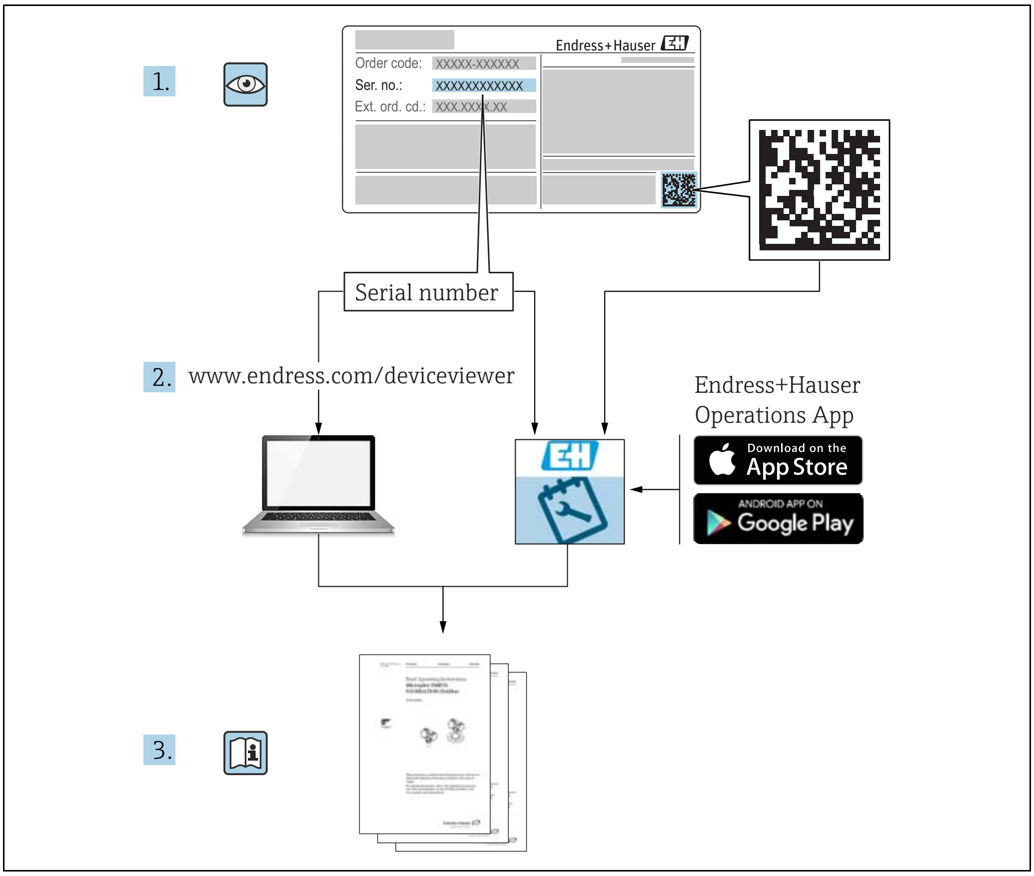
BA00426G/00/EN/19.23-00
71600412
2023-02-15

Valid as of software version:
02.03.01

Operating Instructions
Tankvision
Tank Scanner NXA820, Data Concentrator NXA821, Host Link NXA822

System Description

Endress+Hauser
People for Process Automation



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Make sure the document is stored in a safe place such that it is always available when working on or with the device.
To avoid danger to individuals or the facility, read the "Basic safety instructions" section carefully, as well as all other safety instructions in the document that are specific to working procedures.
The manufacturer reserves the right to modify technical data without prior notice. Your Endress+Hauser distributor will supply you with current information and updates to these Instructions.

Change history

Document version	Valid for SW version	Changes to the previous version
BA00426G/15.17	02.00.00	Introduced Temperature and Density Profile
BA00426G/16.17	02.01.00	Introduced Floating Roof Weight Correction, Redundancy functionality with NXA820 Interface Only, CH alarm for Volume or Mass
BA00426G/17.18	02.02.00	Introduced Switch by Gauge redundancy mode for NXA820 Interface Only
BA00426G/18.20	02.03.00	Introduced tank comment fields and improved the change alarm functions
BA00426G/20.23-00	02.03.01	Bug fix version

Table of Contents

1 About this document

1.1 Document function

This manual is giving detailed information on the system capabilities and architecture. It supports project and sales engineers in designing the system architecture during acquisition and execution phase. Furthermore during operation time of the system all servicing personnel in need of detailed knowledge about the system capabilities.

ℹ This manual is not suitable for the Interface only version of NXA820.

1.2 Symbols

1.2.1 Safety symbols

Symbol	Meaning
⚠ DANGER A0011189-EN	**DANGER!** This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.
⚠ WARNING A0011190-EN	**WARNING!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.
⚠ CAUTION A0011191-EN	**CAUTION!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.
NOTICE A0011192-EN	**NOTICE!** This symbol contains information on procedures and other facts which do not result in personal injury.

1.2.2 Electrical symbols

Symbol	Meaning
⎓ A0011197	**Direct current** A terminal to which DC voltage is applied or through which direct current flows.
~ A0011198	**Alternating current** A terminal to which alternating voltage is applied or through which alternating current flows.
⏚ A0011200	**Ground connection** A grounded terminal which, as far as the operator is concerned, is grounded via a grounding system.
⊜ A0011199	**Protective ground connection** A terminal which must be connected to ground prior to establishing any other connections.

1.2.3 Symbols for certain types of information

Symbol	Meaning
A0011193	**Tip** Indicates additional information.
A0011195	**Reference to page** Refers to the corresponding page number.
1. , 2. , 3. ...	Series of steps
✔ A0018373	Result of a sequence of actions

1.2.4 Symbols in graphics

Symbol	Meaning
1, 2, 3 ...	Item numbers
1. , 2. , 3. ...	Series of steps
A, **B**, **C** ...	Views
EX A0011187	**Hazardous area** Indicates a hazardous area.
EX A0011188	**Indicates a non-hazardous location** Safe area (non-hazardous area)

1.3 Documentation

The following documentation types are available in the Downloads area of the Endress+Hauser website: www.endress.com/downloads

For an overview of the scope of the associated Technical Documentation, refer to the following:

- *W@M Device Viewer*: www.endress.com/deviceviewer - Enter the serial number from the nameplate
- *Endress+Hauser Operations App*: Enter the serial number from the nameplate or scan the matrix code on the nameplate

1.4 Registered trademarks

Microsoft®, Windows® and Internet Explorer®
Registered trademarks of the Microsoft Corporation

Modbus™
Modbus is a registered trademark of Schneider Electric USA, Inc.

Java®
Registered trademark of Oracle® Corporation

2 Basic safety instructions

2.1 Requirements for the personnel

The personnel for installation, commissioning, diagnostics and maintenance must fulfil the following requirements:

- Trained, qualified specialists: must have a relevant qualification for this specific function and task
- Are authorized by the plant owner or operator
- Are familiar with federal or national regulations
- Before starting work, read and understand the instructions in the manual and supplementary documentation as well as the certificates (depending on the application)
- Follow instructions and comply with basic conditions

The operating personnel must fulfil the following requirements:

- Are instructed and authorized according to the requirements of the task by the facility's owner-operator
- Following the instructions in these Operating Instructions

2.2 Intended use

2.2.1 Application

Tankvision is a dedicated tank inventory management system.
Components:

- Tankvision Tank Scanner NXA820
  scans parameters from tank gauges and performs tank calculations
- Tankvision Data Concentrator NXA821
  summarizes data from various Tank Scanners NXA820
- Tankvision Host Link NXA822
  provides data to host systems (such as PLC or DCS) via Modbus

The above mentioned components are operated via a standard web browser. It does not require any proprietary software. Tankvision is based on a distributed architecture on a Local Area Network (LAN). Due to its modular structure it can be adjusted to any application. It is ideally suited for small tank farms with only a couple of tanks, but also for large refineries with hundreds of tanks.

2.3 Workplace safety

For work on and with the device:

- Wear the required personal protective equipment according to federal/national regulations.
- Switch off the supply voltage before connecting the device.

2.4 Operational safety

Risk of injury!

- Operate the device only if it is in proper technical condition, free from errors and faults.
- The operator is responsible for interference-free operation of the device.

Modifications to the device
Unauthorized modifications to the device are not permitted and can lead to unforeseeable dangers!

- If modifications are nevertheless required, consult with the manufacturer.

Repair
To ensure continued operational safety and reliability:

- Carry out repairs on the device only if they are expressly permitted.
- Observe federal/national regulations pertaining to repair of an electrical device.
- Use only original spare parts and accessories.

2.5 Product safety

This measuring device is designed in accordance with good engineering practice to meet state-of-the-art safety requirements, has been tested, and left the factory in a condition in which it is safe to operate. It meets general safety standards and legal requirements. It also complies with the EC directives listed in the device-specific EC Declaration of Conformity. Endress+Hauser confirms this by affixing the CE mark to the device.
Furthermore, the device meets the legal requirements of the applicable UK regulations (Statutory Instruments). These are listed in the UKCA Declaration of Conformity along with the designated standards.
By selecting the order option for UKCA marking, Endress+Hauser confirms a successful evaluation and testing of the device by affixing the UKCA mark.

Contact address Endress+Hauser UK:

- Endress+Hauser Ltd.
  Floats Road
  Manchester M23 9NF
  United Kingdom
  www.uk.endress.com

2.6 IT security

We only provide a warranty if the device is installed and used as described in the Operating Instructions. The device is equipped with security mechanisms to protect it against any inadvertent changes to the device settings.

IT security measures in line with operators' security standards and designed to provide additional protection for the device and device data transfer must be implemented by the operators themselves.

Endress+Hauser can be contacted to provide support in performing this task.

3 Application

3.1 Inventory control

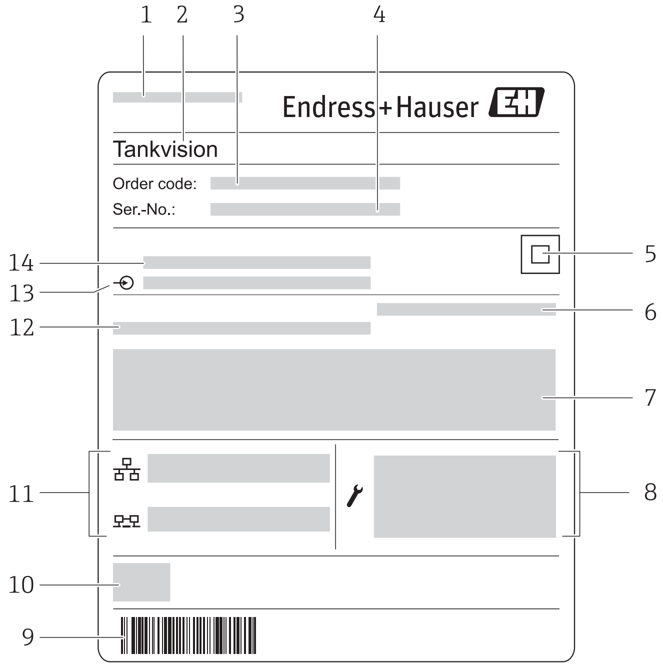
By using Tankvision to monitor the tank level and stored volume of valuable liquids remotely, owners or operators of tank farms or terminals for petroleum products and chemicals (liquids) can visualize the volumes or mass of the stored medium in real time. The data can be used to plan the inventory and distribution. The data can also be used to manage tank farm operations like pumping or transferring products.
Tankvision has its unique concept using network technology. Without using proprietary software, the users can visualize and manage their valuable liquids stored in the tanks by a web browser.
Tankvision is a flexible and cost effective solution due to its scalable architecture. The application coverage goes from small depots with only a few tanks up to refineries.

3.2 Application areas

- Tank farms in refineries
- Ship loading terminals
- Marketing and distribution terminals
- Pipeline terminals
- Logistic terminals for tanks storing products like crude oils, refined white and black products, chemicals, LPGs, fuels, biofuels, alcohols

4 Identifying the components

4.1 Nameplate



nameplate_2

1 *Address of manufacturer*
2 *Device name*
3 *Order code*
4 *Serial number (Ser. no.)*
5 *Data Matrix Code*
6 *Degree of protection*
7 *Certificate and approval relevant data*
8 *Technical data of the Service LAN port*
9 *Barcode*
10 *CE mark*
11 *MAC address of the System LAN port and Sync LAN port*
12 *Admissible ambient temperature*
13 *Type of fieldbus communication (only for Tank Scanner NXA820)*
14 *Supply voltage*

4.2 Tank Scanner NXA820

- The Tank Scanner NXA820 connects multiple tank gauges:
  from up to 15 tanks via one field-loop. The Tank Scanner NXA820 supports different field protocols (Modbus EIA485, Sakura V1, Whessoe WM550).
- The measured values are transmitted by the network and visualized on HTML pages.
- The Tank Scanner NXA820 can be used stand-alone for small tank farms, but also be integrated into a large system for use in refineries.
- The Tank Scanner NXA820 is equipped with a full set of tank inventory calculations. The calculations are based on various international standards such as API, ASTM, IP and many others. Measured values are used to calculate volume and mass.

4.2.1 Ordering information

Detailed ordering information is available from the following sources:
- In the Product Configuration on the Endress+Hauser website: www.endress.com → Select country → Instruments → Select device → Product page function: Configure this product
- From your Endress+Hauser Sales Center: www.endress.com/worldwide

Product Configurator - the tool for individual product configuration

- Up-to-the-minute configuration data
- Depending on the device: Direct input of measuring point-specific information such as measuring range or operating language
- Automatic verification of exclusion criteria
- Automatic creation of the order code and its breakdown in PDF or Excel output format
- Ability to order directly in the Endress+Hauser Online Shop

4.2.2 Product picture

L00-NXA8xxxx-10-08-06-xx-002

4.3 Data Concentrator NXA821

- The NXA821 Tankvision Data Concentrator is the enhanced solution for large tank farms and refineries. The Data Concentrator is required if:
  The plant contains more than one field loop (each of which has its own Tank Scanner NXA820) and tanks of more than one Tank Scanner NXA820 are to be grouped
- The Data Concentrator collects the data of several Tank Scanner units and enables reconciliation and totalization of the tank data of many or all tanks in structured groups.
- Alarms and events from all connected Tank Scanners NXA820 can be shown in a common screen. Any tank of the system can be assigned to any tank group, regardless of the Tank Scanner it is linked to. This ensures the highest possible flexibility for the plant or tank farm.
- An alarm pop-up shows alarms of all connected Tank Scanners NXA820 even if the web browser is closed.
- Direct serial printer connection for report printing (W+M certified acc. PTB)
- 90 tanks (more on request) can be allocated to each Data Concentrator NXA821. Each of these tanks must have been allocated to a Tank Scanner NXA820 beforehand.
- Tanks from up to 6 different Tank Scanners NXA820 (more on request) can be integrated in this way.

4.3.1 Ordering information

Detailed ordering information is available from the following sources:
- In the Product Configuration on the Endress+Hauser website: www.endress.com → Select country → Instruments → Select device → Product page function: Configure this product
- From your Endress+Hauser Sales Center: www.endress.com/worldwide

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- Ability to order directly in the Endress+Hauser Online Shop

4.3.2 Product picture

L00-NXA8xxxx-10-08-06-xx-003

4.4 Host Link NXA822

- The Host Link NXA822 collects data from all Tank Scanners NXA820 on a network and transfers them to the host system.
- The MODBUS option supports serial EIA-232(RS) and EIA-485(RS) or MODBUS TCP/IP. The NXA822 is configured as a MODBUS slave. Supported functions are:
  - Coil Status (#01)
  - Read Input Status(#02)
  - Holding Registers (#03)
  - Input Registers (#04)
  - Force Single Coil (#05)
  - Write Modbus Values (#06)
  - Force Multiple Coils (#15)
  - Preset Multiple Registers (#16)
- The MODBUS register map is described via XML files and can easily be adapted to individual MODBUS master requirements.
- Gauge commands for Servo Gauges
- 90 tanks (more on request) can be allocated to each Host Link NXA822. Each of these tanks must have been allocated to a Tank Scanner NXA820 beforehand.
- Tanks from up to 6 different Tank Scanners NXA820 (more on request) can be integrated in this way.
- Per system 2 NXA822 units can be installed.

4.4.1 Ordering information

Detailed ordering information is available from the following sources:
- In the Product Configuration on the Endress+Hauser website: www.endress.com → Select country → Instruments → Select device → Product page function: Configure this product
- From your Endress+Hauser Sales Center: www.endress.com/worldwide

Product Configurator - the tool for individual product configuration

- Up-to-the-minute configuration data
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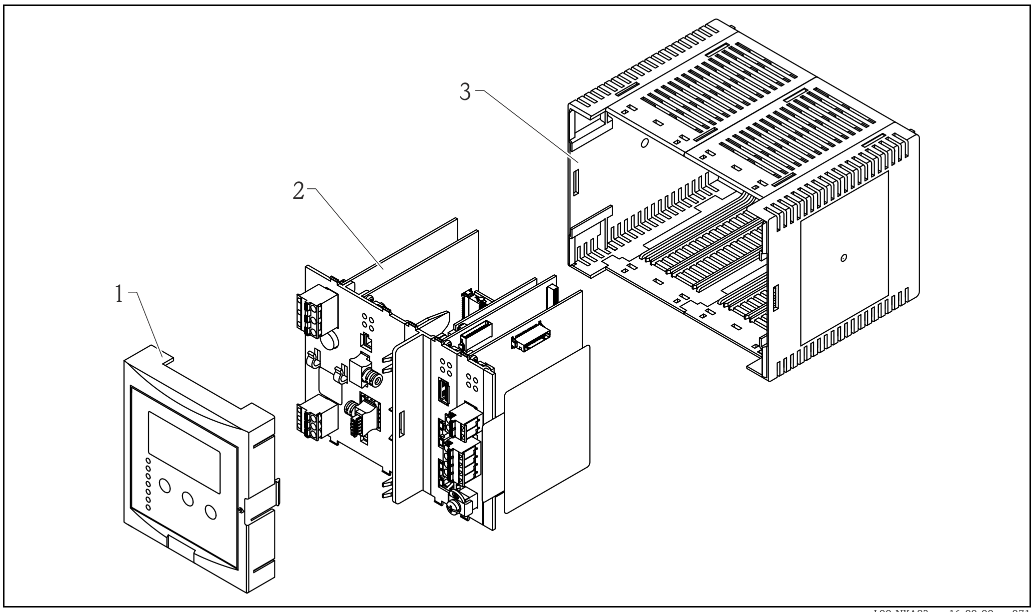
- Automatic creation of the order code and its breakdown in PDF or Excel output format
- Ability to order directly in the Endress+Hauser Online Shop

4.4.2 Product picture

L00-NXA8xxxx-10-08-06-xx-004

4.5 Explosion picture



L00-NXA82xxx-16-00-00-xx-071

1 Cover plate
2 Inner electronics
3 Housing

4.6 Tankvision OPC Server

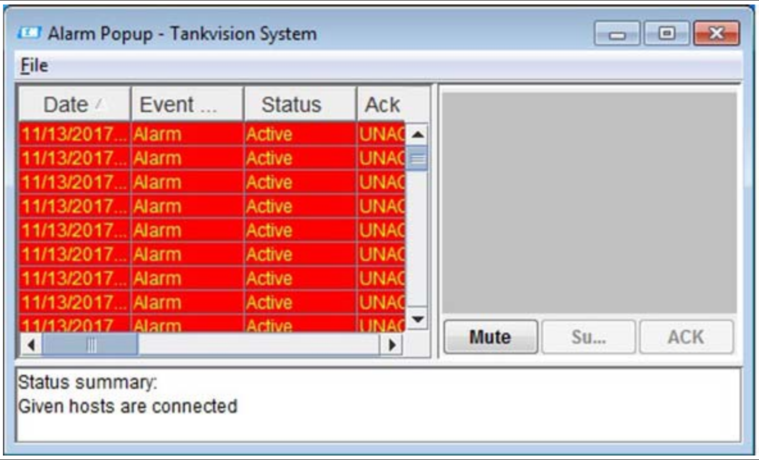
- The OPC Server is a Windows program installed on a PC connecting to NXA820 and allows access to measured and calculated tank parameters.
- The OPC Server connects to OPC clients on the same PC or other PCs via LAN.
- The OPC Server supports browsing tanks and tank parameters on NXA820.
- The OPC Server is included in each NXA820 and can be uploaded to the PC.
- The OPC Server is based on OPC DA V3.0

4.7 Tankvision Printer Agent

- The Printer Agent is a Windows program installed on a PC, connecting to NXA820/ NXA821. Supports up to 2 network connection per PC.
- The program is running in the background and enables (scheduled) printing reports on connected printers.
- Up to 3 printers (directly connected to the PC or network printers) can be assigned to the Printer Agent.
- If a printout can not be performed, a record is kept within the Printer Agent.
- The printer agent software is included in each NXA820 and can be uploaded to the PC (for more information, see document BA00339G).

4.8 Tankvision Alarm Agent

- The Alarm Pop-Up-Agent is a Windows program installed on a PC, connecting to NXA820/NXA821.
- The program is running in the background and scans for alarms generated in NXA820/ NXA821.
- If an alarm is present, a pop-up window opens displaying the alarm.
- The alarm can be acknowledged within this window.
- The window can only be closed if no alarm is active.
- The Alarm Agent can be uploaded from NXA820/821 to the PC.
- A single alarm Agent can support multiple NXA820/NXA821.



Alarm-Popup-Agent

For more information, see document BA00339G.

5 PC recommendations

5.1 PC connection for viewing data

Tankvision Tank Scanner NXA820, Tankvision Data Concentrator NXA821 and Tankvision Host Link NXA822 are providing a web server to view and enter data or perform configurations. Viewing the pages requires a web browser and JAVA runtime installed on a PC.
PC and the Tankvision components must be connected within the same Local Area Network (LAN) consisting out of Ethernet lines, switches and/or routers.

HUBs shall not be used. In secured systems e.g. for W&M purposes, routers cannot be used. If company policies allow a remote connection into the LAN also enables a remote connection to Tankvision components.

5.1.1 Recommendations PC configuration

With all on the market available web browser entering the Tankvision web server is possible. Nevertheless the pages are optimized for Microsoft Internet Explorer (supported version IE9, IE10 and IE11 – Compatibility Mode).
The user interface pages are optimized for a screen resolution of 1280x1024 (or higher).

5.2 Recommendations when using OPC Server, Printer Agent or Alarm Agent

- Windows XP 32 Bit Service Pack 3, Windows 7 32 Bit or 64 Bit, Windows 10 32 Bit or 64 Bit
- Java 8 or higher

5.3 Alternations from the recommendations

Alternations to the recommendations in the previous chapters might have influences on the proper behaviour of the system especially when communication ports are used by other programs (e.g. other OPC servers). In case of uncertainty consult Endress+Hauser.

Included Software and Operating System requirements	Windows 7 (32/64 bit)	Windows Server 2008
OPC Server	X	X
Alarm Agent	X	–
Printer Agent	X	–
Tankvision Installation and Recovery Tool	X	–

6 Connections to gauges and host systems

6.1 Field instruments and slave devices

Please take care that the signal and power cables always are separated to prevent noise and electrical interference between them.

6.1.1 Communication variants

Field instruments or other slave devices are connected to the Tankvision Tank Scanner NXA820. The unit is available in 3 communication versions.

- Modbus RTU RS485
  According to "Modbus over serial line specification and implementation guide V1.02" published by the Modbus-IDA organization (www.modbus.org) and based upon the EIA/TIA-485-A physical layer specification.

Characteristic impedance	135 to 165 Ω at measuring frequency of 3 to 20 MHz
Cable capacitance	≤ 30 pF/m
Core cross-section	≥ 0.34 mm² (AWG 22) multi-strand cable is preferred
Cable type	Single twisted pair + third conductor (for common) or Dual twisted pair (common uses second pair with wire joined together)
Cable resistance	≤ 110 Ω /km
Signal damping	Max. 9 dB over the entire length of the cable cross-section
Shielding	Copper braided shielding or combined foil and braided shielding

- Sakura V1
  V1 fieldbus is a voltage mode digital communication using up to ±30 VDC.

Cable capacitance	≤ 50 nF/m
Core cross-section	≥ 0.9 mm² (AWG 17) multi-strand cable is preferred
Cable type	Twisted pair
Cable resistance	≤ 30 Ω /km
Shielding	Copper braided shielding or combined foil and braided shielding
Insulation	≥ 60 V_{DC}

- Whessoe WM550
  The WM550 communication protocol works using a current loop principle.
  Connection
  Please take into consideration that the principle of current loop connection works as follows:
  The Tankvision (master) (-) signal point connects to slave 1 (+) signal point. Slave 1 (-) signal point connects to slave 2 (+) signal point until (the last) slave N (-) signal point connects back to the Tankvision (master) (+) signal point closing the current loop.

  Cable specification
  Please ensure to follow the following recommendations for field installation of the Tankvision with the WM550 protocol variant.
  - Cable with twisted and non-shielded pairs
  - Cable with at least 0.5 mm² (AWG 20) section
  - Maximum total cable resistance: 250 Ω
  - Cable with low capacitance

	Cross section (mm² (AWG))	Resistance (Ω/km)	Capacitance (nF/km)
Cable 1	0.5 (20)	39.2	60
Cable 2	0.75 (18)	24.6	65
Cable 3	1.3 (16)	14.2	75

6.1.2 Field devices

The following list gives an overview on possible field instruments which can be connected directly or via system components. Nevertheless the connection possibilities are not limited to these devices.

- Micropilot NMR8x
  Micropilot NMR81 is used for custody transfer and inventory control applications with NMi- and PTB-approvals and meets the requirements according to OIML R85 and API 3.1B. NMR81 is particularly suited for free space applications up to 70 m. The drip-off lens antenna with 79 GHz transmitting frequency produces a sharply focused beam angle of 3° and avoids obstacles even close to tank wall.
  Micropilot NMR81 is available with Modbus RS485 and Sakura V1 output.
  For more information see TI01252G/00/EN.
  Micropilot NMR84 is used for custody transfer and inventory control applications with NMi- and PTB-approvals. It meets the relevant requirements according to OIML R85 and API 3.1B. The NMR84 free space radar with drip-off planar antenna is specifically suited for stilling well applications. The superior drip-off antenna design with proven track record eliminates problems caused by condensation.
  Micropilot NMR84 is available with Modbus RS485 and Sakura V1 output.
  For more information see TI01253G/00/EN.

- Proservo NMS8x
  The intelligent tank gauge Proservo NMS80 is designed for high accuracy liquid level measurement in custody transfer and inventory control applications with NMi- and PTB-approvals. It meets the relevant requirements according to OIML R85 and API 3.1B. It fulfills the exact demands of tank inventory management and loss control and is optimized in regards of total cost saving and safe operation.
  Proservo NMS8x is available with Modbus RS485 and Sakura V1 output.
  For more information see TI01248G/00/EN, TI01249G/00/EN or TI01250G/00/EN.

- Tank Side Monitor NRF8x
  The Tank Side Monitor NRF81 is a sensor integration and monitoring unit for bulk storage tank gauging applications. It integrates various level, temperature and pressure tank sensor data into a control host system. Various selectable alarms and outputs.
  Tank Side Monitor NRF8x is available with Modbus RS485 and Sakura V1 output.
  For more information see TI01251G/00/EN.

- Proservo NMS5/7
  The Proservo NMS5/7 intelligent tank gauges are designed for high accuracy liquid level measurement in storage and process applications. Tank mounted intelligence makes the Proservo NMS5 ideal for single or multi-task installation, converting a wide of measurement functions including beside others:
  - Liquid level
  - Interface level
  - Spot density
  - Density profile

  Proservo NMS5/7 is beside others available with Modbus RTU RS485, Sakura V1, Whessoe WM550 output. For more information see TI00452G/08/EN.

- Tank Side Monitor NRF590

The Tank Side Monitor NRF590 is a sensor integration and monitoring unit for bulk storage tank gauging applications. It can be used with Micropilot radar or Proservo level gauges and can be combined with other HART compatible devices.
Connects up to 6 HART devices via intrinsic safe 2 wire, for example Prothermo for average temperature measurement and Cerabar/Deltabar for HTMS density applications. Various industry standard communication protocols, including
– Sakura V1
– EIA-485 Modbus
– Whessoe WM550
For more information see TI00402F/00/EN.

- Micropilot S FMR53x/FMR540
  The Micropilot S is used for highly accurate level measurement in storage tanks and can be applied in custody transfer applications. It meets the relevant requirements according to OIML R85 and API 3.1B.
  The Micropilot S is communicating via the industry standard protocoll HART (Standard 5) and can be connected to the Tankvision Tank Scanner via the Tank Side Monitor. For more information see TI00344F/00/EN and TI00412F/00/EN.

- Prothermo NMT539
  The Prothermo NMT539 is based on API (American Petroleum Institute) Manual of Petroleum Measurement Standard, Chapter 7, and enables high accuracy temperature measurement. At the same time, it is an intelligent average temperature sensor for tank gauging with an optional WB capacitance sensor at the bottom of the temperature probe. For average temperature measurement, it consists of precision multi-spot Pt100 elements. The NMT539 is a highly capable solution that provides both contant average temperature data and water interface data via local HART® communication. For accurate inventory measurement, it is best suited connected to Endress+Hauser's Proservo NMS, Micropilot NMR or Tank Side Monitor NRF with level tankg gauge (e.g. Micropilot). For more information see TI00042G/08/EN.

- Prothero NMT532
  The Prothermo NMT532 consists of an intelligent local HART® signal converter and average temperature sensor. For average temperature measurement, it consists of precision multi-spot Pt100 (max. 6) elements which have fixed interval (2 m (6.6 ft) or 3 m (9.8 ft)). The NMT532 is a highly capable solution for a variety of tank gauging applications and provides constant average temperature data via local HART® communication. For accurate inventory measurement, it is best suited connected to Endress+Hauser's Proservo NMS, Micropilot NMR or Tank Side Monitor NRF with level tank gauge (e.g. Micropilot). For more information see TI00049G/08/EN.

- Micropilot M FMR2xx
  The Micropilot M is used for continuous, non-contact level measurement of liquids, pastes, slurries and solids. The measurement is not affected by changing media, temperature changes.
  – The FMR230 is especially suited for measurement in buffer and process tanks.
  – The FMR231 has its strengths wherever high chemical compatibility is required.
  – The FMR240 with the small 40 mm (1½") horn antenna is ideally suited for small vessels. Additionally, it provides an accuracy of ±3 mm (0.12 in).
  – The FMR244 combines the advantages of the horn antenna with high chemical resistance.
    The 80 mm (3") horn antenna is used additionally in solids.
  – The FMR245 - highly resistance up to 200 °C (392 °F) and easy to clean.
  The Micropilot M is communicating via the industry standard protocol HART and can be connected to the Tankvision Tank Scanner via the Tank Side Monitor or an HART to Modbus converter e.g. by Moore Industries. For more information see TI000345F/00/EN.

- Levelflex M FMP4x

Level Measurement - Continuous level measurement of powdery to granular bulk solids e.g. plastic granulate and liquids.
– Measurement independent of density or bulk weight, conductivity, dielectric constant, temperature and dust e.g. during pneumatic filling.
– Measurement is also possible in the event of foam or if the surface is very turbulent.
Interface measurement
Continuous measurement of interfaces between two liquids with very different dielectric constants, such as in the case of oil and water for example.
The Levelflex M is communicating via the industry standard protocol HART and can be connected to the Tankvision Tank Scanner via the Tank Side Monitor or an HART to Modbus converter e.g. by Moore Industries. For more information see TI00358F/00/EN.

- Levelflex FMP5x
  - FMP51
    Premium device for level and interface measurement in liquids.
  - FMP52
    Premium device with coated probe for the use in aggressive liquids. Material of wetted parts FDA listed and USP Class VI compliant.
  - FMP54
    Premium device for high-temperature and high-pressure applications, mainly in liquids.

  Levelflex is communicating via the industry standard protocol HART and can be connected to the Tankvision Tank Scanner via the Tank Side Monitor or an HART to Modbus converter e.g. by Moore Industries. For more information see TI01001F/00/EN.

- Cerabar M
  The Cerabar M pressure transmitter is used for the following measuring tasks:
  - Absolute pressure and gauge pressure in gases, steams or liquids in all areas of process engineering and process measurement technology.
  - High reference accuracy: up to ±0.15%, as PLATINUM version: ±0.075%

  Cerabar M is communicating via the industry standard protocol HART and can be connected to the Tankvision Tank Scanner via the Tank Side Monitor or Proservo.
  For more information see TI000436P/00/EN.

- Cerabar S
  The Cerabar S pressure transmitter is used for the following measuring tasks:
  - Absolute pressure and gauge pressure in gases, steams or liquids in all areas of process engineering and process measurement technology.
  - High reference accuracy: up to ±0.075%, as PLATINUM version: ±0.05%

  Cerabar S is communicating via the industry standard protocol HART and can be connected to the Tankvision Tank Scanner via the Tank Side Monitor or Proservo.
  For more information see TI000383P/00/EN.

- Deltabar M
  The Deltabar M differential pressure transmitter is used for the following measuring tasks:
  - Flow measurement (volume or mass flow) in conjunction with primary elements in gases, vapors and liquids
  - Level, volume or mass measurement in liquids
  - Differential pressure monitoring, e.g. of filters and pumps
  - High reference accuracy: up to ±0.1%, as PLATINUM version: ±0.075%

  Deltabar M is communicating via the industry standard protocol HART and can be connected to the Tankvision Tank Scanner via the Tank Side Monitor or Proservo.
  For more information see TI000434P/00/EN.

- Deltabar S
  The Deltabar S differential pressure transmitter is used for the following measuring tasks:
  - Flow measurement (volume or mass flow) in conjunction with primary devices in gases, vapors and liquids
  - Level, volume or mass measurement in liquids
  - Differential pressure monitoring, e.g. of filters and pumps

– High reference accuracy: up to ±0.075%, as PLATINUM version: ±0.05%
Deltabar S is communicating via the industry standard protocol HART and can be connected to the Tankvision Tank Scanner via the Tank Side Monitor or an HART to Modbus converter e.g. by Moore Industries. For more information see TI000382P/00/EN.

- Liquicap M
  The Liquicap M FMI5x compact transmitter is used for the continuous level measurement of liquids.
  – Suitable for interface measurement
  Liquicap M is communicating via the industry standard protocol HART and can be connected to the Tankvision Tank Scanner via the Tank Side Monitor or an HART to Modbus converter e.g. by Moore Industries. For more information see TI00401F/00/EN.

- Whessoe ITGs
- Sakura Endress Float&Tape Transmitter TMD
- Sakura Endress TGM5000
- Sakura Endress TGM4000
- SWG70: Wireless HART gateway
- Modbus slave devices
  As Modbus is an open protocol there are various system components available which can be connected to Tankvision Tank Scanner. To do so the so called gauge definition file and the Modbus map file need to be adapted to the needs. This is a standard procedure and described in BA00339G/00/EN. Examples for such devices are HART to Modbus converters, PLCs or other protocol converters e.g. Gauge Emulator by MHT.

Remote service access via the Endress+Hauser device configuration tool FieldCare is supported for the following device combination:

- Tankvision Tank Scanner with Modbus or Sakura V1 communication
- Tank Side Monitor Modbus or Sakura V1 communication and SW version 02.04.00 or later
- HART devices connected to Tank Side Monitor intrinsic safe HART bus and supporting FDT/DTM
  or
- Tankvision Tank Scanner with Modbus or Sakura V1 communication
- Proservo NMS5/7 (Modbus or Sakura V1 communication) with
  – TCB-6 version 4.27E
  – Graphical display operation module
  – Modbus communication module COM-5, version 2.0 or
  – V1 communication module COM-1 (SRAM-mounted), version 5.01
  – HART devices connected to Proservo cannot be reached by FieldCare

6.2 Host Systems communication

To transfer and receive data to/from host system the communication variants OPC DA (version 3.0) and Modbus RS232, Modbus RS485 and Modbus TCP are available.

6.2.1 OPC DA server

See "Tankvision OPC Server", → 📄 15.
For available parameters see A.1 Parameter list.

6.2.2 Modbus slave via Host Link NXA822

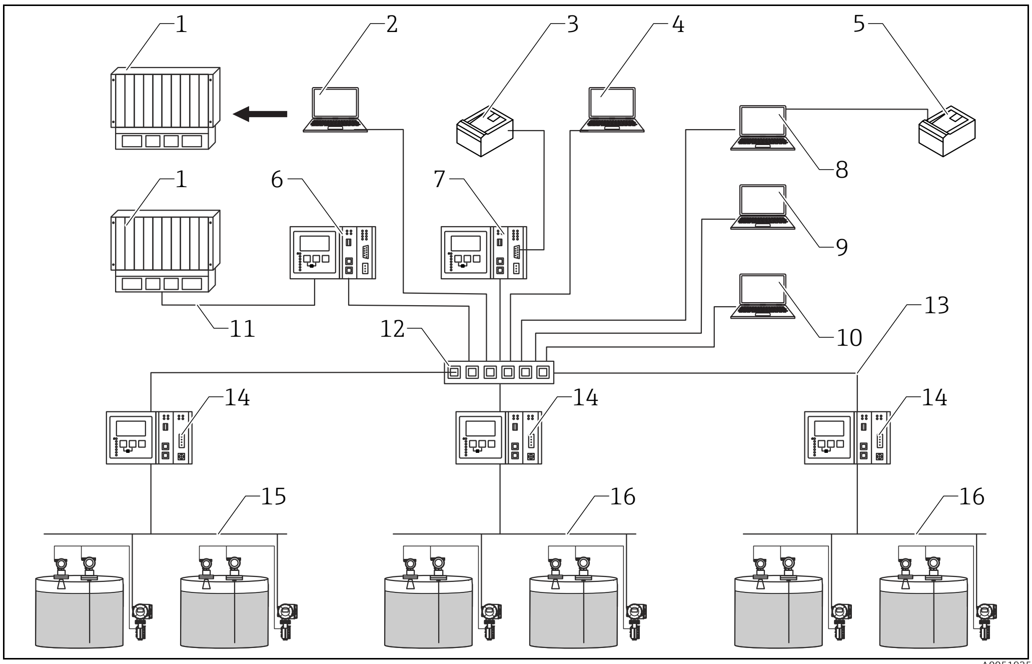
See "Host Link NXA822", → 📄 13.
For available parameters see A.1 Parameter list.

6.2.3 Connection to Tankvision Professional

To connect to Tankvision Professional a dedicated communication is available. In this case measured data are transferred as the calculations are performed in Tankvision Professional.

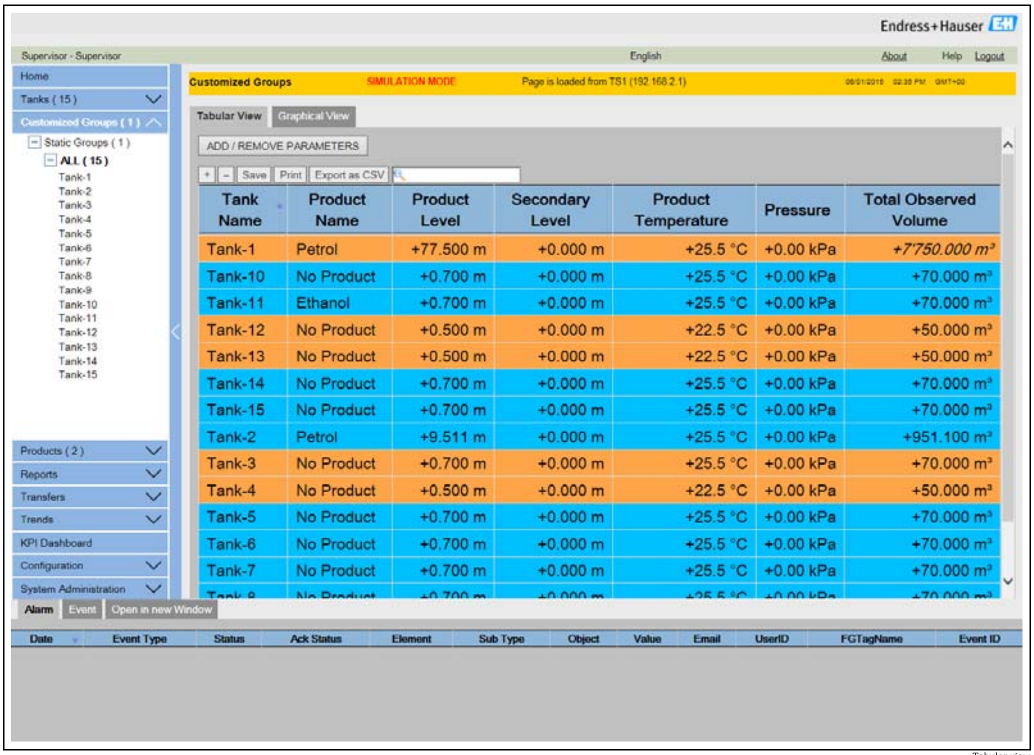
7 Examples

7.1 System architecture



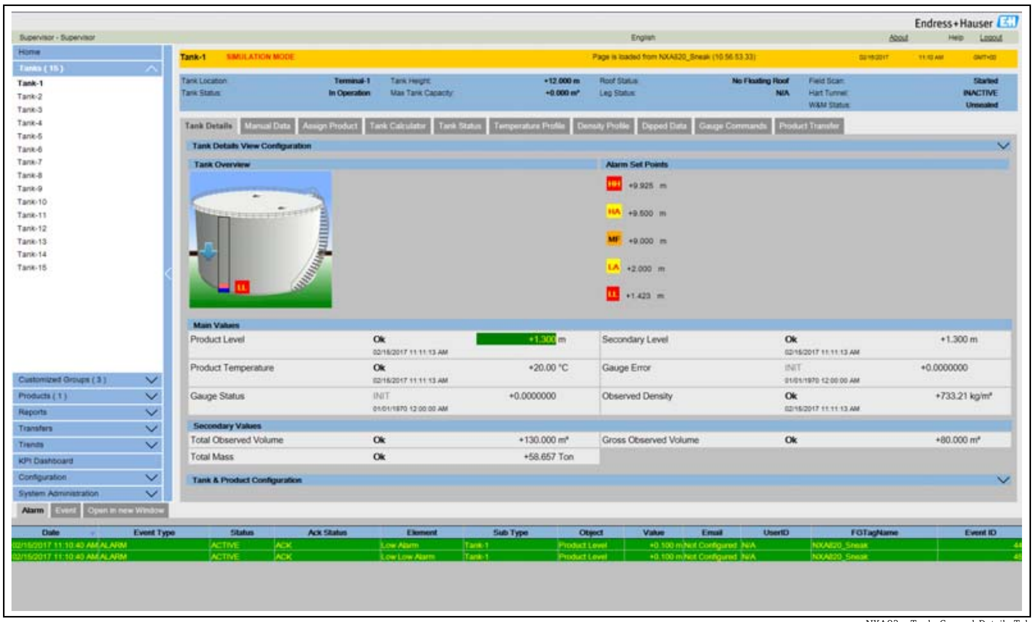
1 DCS
2 OPC Server
3 Several printers for W&M reports
5 Printer
6 Tankvision Host Link NXA822
7 Tankvision Data Concentrator NXA821
8 Operator 1, web browser workstation
9 Operator 2, web browser workstation
10 Operator 3, web browser workstation
11 Modbus RTU RS232/485 or Modbus TCP connection
12 Switch
13 Ethernet connection
14 Tankvision Tank Scanner NXA820
15 Fieldbus protocol (e.g. Modbus, V1, WM550)
16 Fieldbus protocol

7.2 Screen examples in Browser



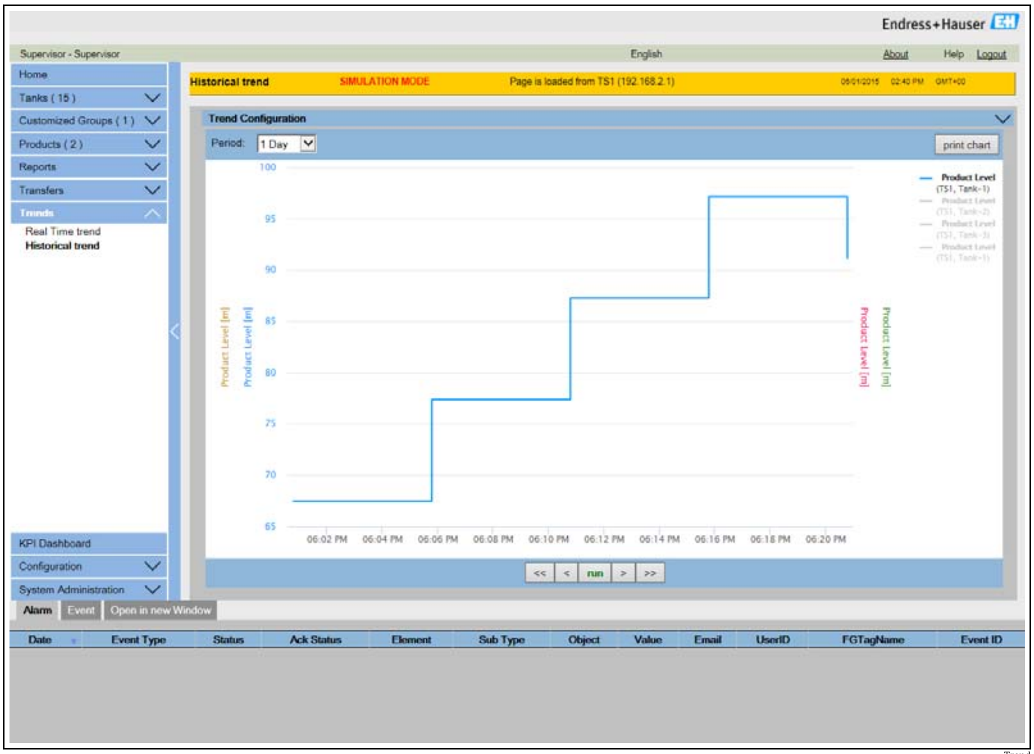
Tabular view

Tank tabular view



NXA82x_Tank_General-Details-Tab

Tank details



Trend

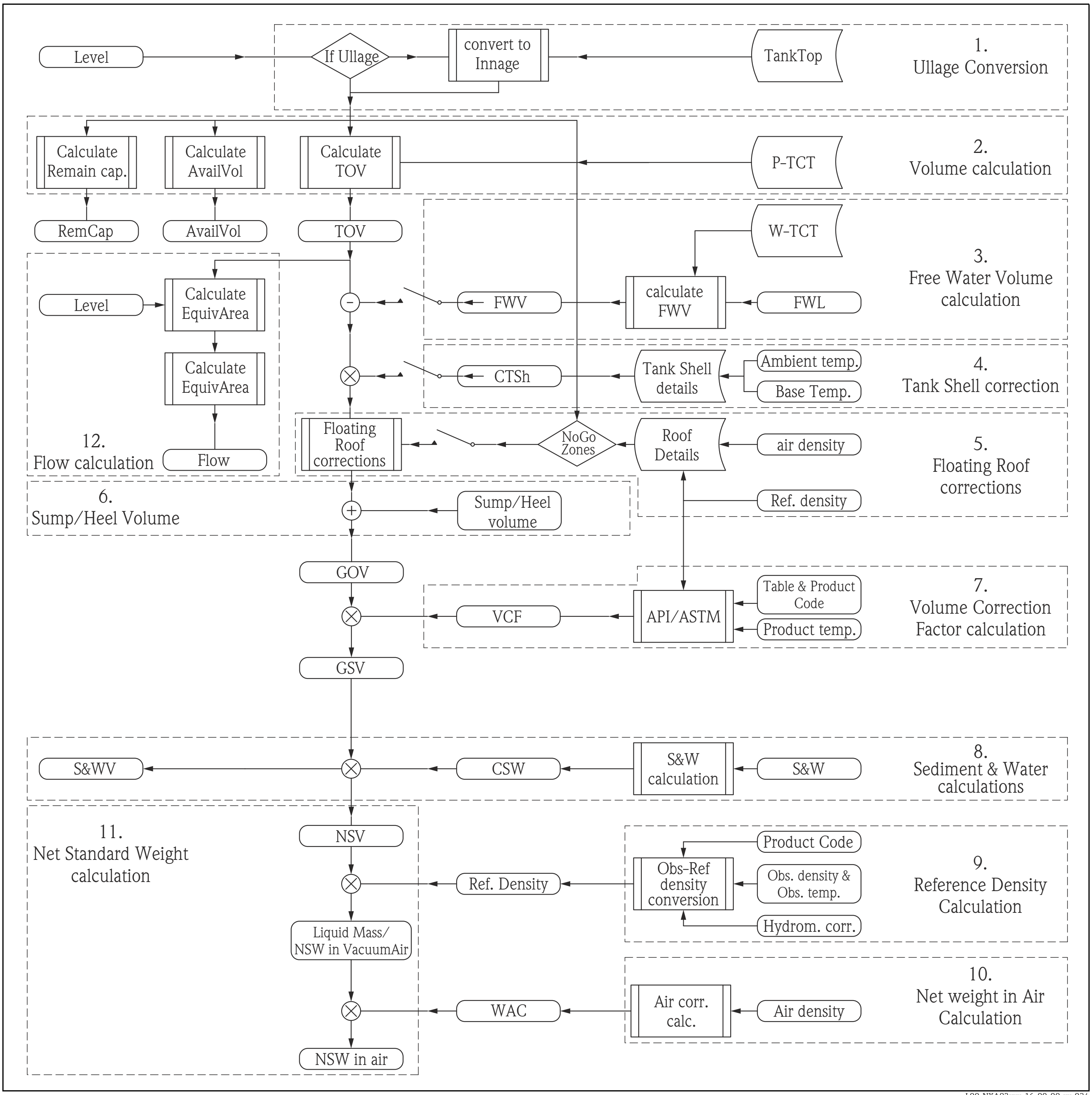
Trend view

8 Calculations

Tankvision Tank Scanner can perform various kinds of calculations which are described in the following chapters. The inventory calculations allow the conversion from measured data like level and temperature to standard data (e.g. Net standard volume or mass). There are various standards for these calculations available differing in the sequence of the calculation or the way compensation factors are determined (from tables or formula). Today calculations from API (see Text → 28) and GB/T (see Text → 28) are implemented in Tankvision Tank Scanner.

8.1 API Flow Charts

The chart shows the sequence calculations are done according to the API. The different steps are explained in the following chapters.



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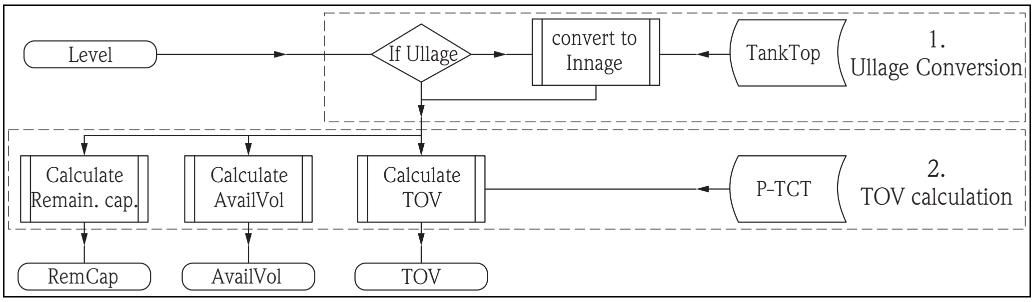
API (American Petroleum Institute)

The American Petroleum Institute, commonly referred to as API, is the largest U.S trade association for the oil and natural gas industry. It claims to represent about 400 corporations involved in production, refinement, distribution and many other aspects of the petroleum industry.
The association's chief functions on behalf of the industry include advocacy and negotiation with governmental, legal and regulatory agencies; research into economic, toxicological and environmental effects; establishment and certification of industry standards; and education outreach. API both funds and conducts research related to many aspects of the petroleum industry.

GB (Chinese national standards)

GB standards are the Chinese national standards issued by the Standardization Administration of China (SAC), the Chinese National Committee of the ISO and IEC. GB stand for Guobiao, Chinese for national standard. Mandatory standards are prefixed "GB". Recommended standards are prefixed "GB/T". A standard number follows "GB" or "GB/T".

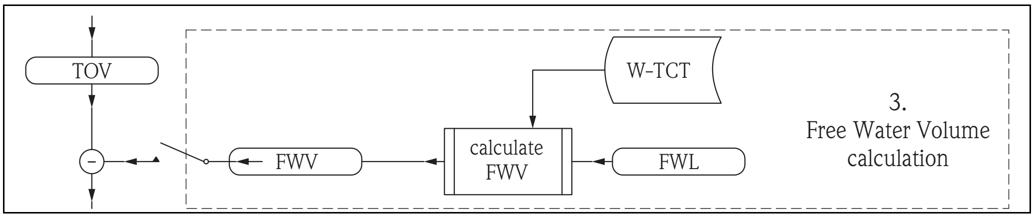
8.1.1 Total Observed Volume - TOV



The Total Observed Volume (TOV) is determined with the level information and the Tank Capacity Table (TCT). The TOV is the volume observed at the present (temperature) conditions.
The TCT is a tank specific table created by calibration holding the level to volume transfer information. To differentiate the TCT for the Product and for the Water the TCT gets marked with a P (P-TCT).
The level information needed for this step is in innage which is the normal way the level is transferred from the gauge. In case the gauge inputs ullage to the system a calculation into innage is necessary beforehand (Ullage substracted from Mounting position).

Two more information can be derived from TCT and level:
- Remaining Capacity (RemCap) shows how much more product could be pumped into the tank safely.
- Available Volume (AvailVol) indicates how much product can be pumped out of the tank to the lowest (defined) possible point e.g. the tank outlet.

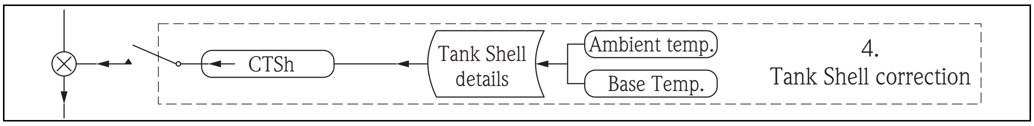
8.1.2 Free Water Volume - FWV



In some cases the tank can also contain water. It can derive from the delivered crude oil, the processing or by tank breathing. The (innage) water level information together with a Water Tank Capacity Table (W-TCT) result in the Free Water Volume. It is substracted from the TOV.

8.1.3 Tank Shell Correction - CTSh

- The Tank Shell expands and contracts with temperature changes (compared to TCT calibration temperature)
- Some countries require CTSh (Correction for Tank Shell temperature effects)
- For heated products the CTSh can be in excess of 0.3% TOV



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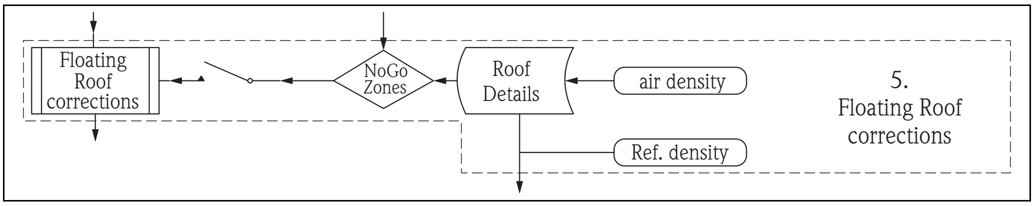
For more details see → 55, Chapter "CTSh".
The Tank Shell Correction is a factor which is multiplied with the TOV reduced by the FWV.

8.1.4 Floating Roof Correction - FRC



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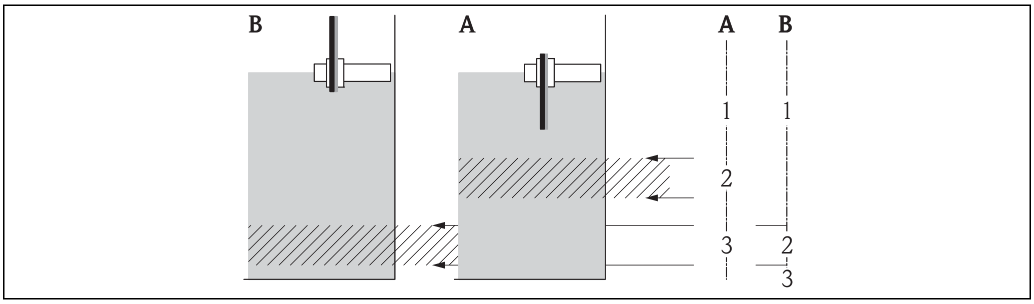
A tank can often have a floating roof. A floating roof is called so because it floats on the product stored in the tank. The roof moves up or down along with product level. Since the roof is floating on the tank, it displaces some amount of product depending on the weight of the roof and the density of the product. This displacement in product level results in a different apparent level, introducing an error into the volume calculations. The product volume therefore needs to be corrected.
A floating roof often has supporting legs. The roof can be rested on these legs when the level is too low or the tank is empty. This allows maintenance staff to enter below the roof for carrying on tank maintenance. Based on the product level, the floating roof can be landed on the legs or floating on the product. However, in a certain range of product level, the floating roof can be partially landed. This zone is called "critical zone". In the Tankvision system there can be two critical zones related to the position of the floating roof legs.



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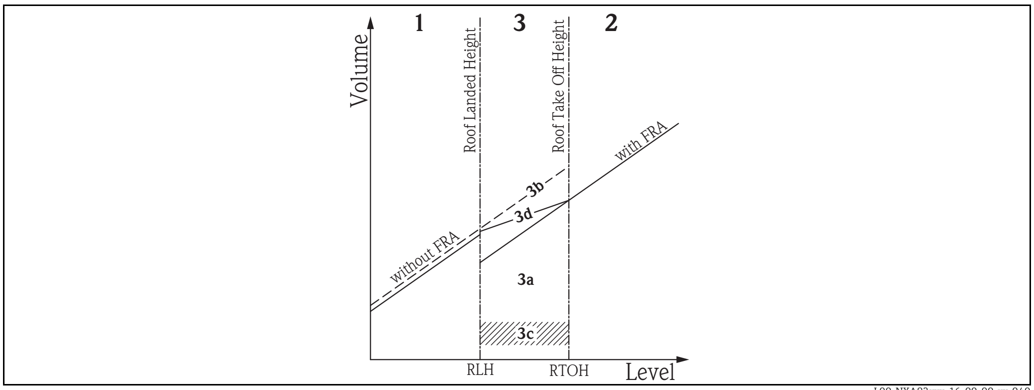

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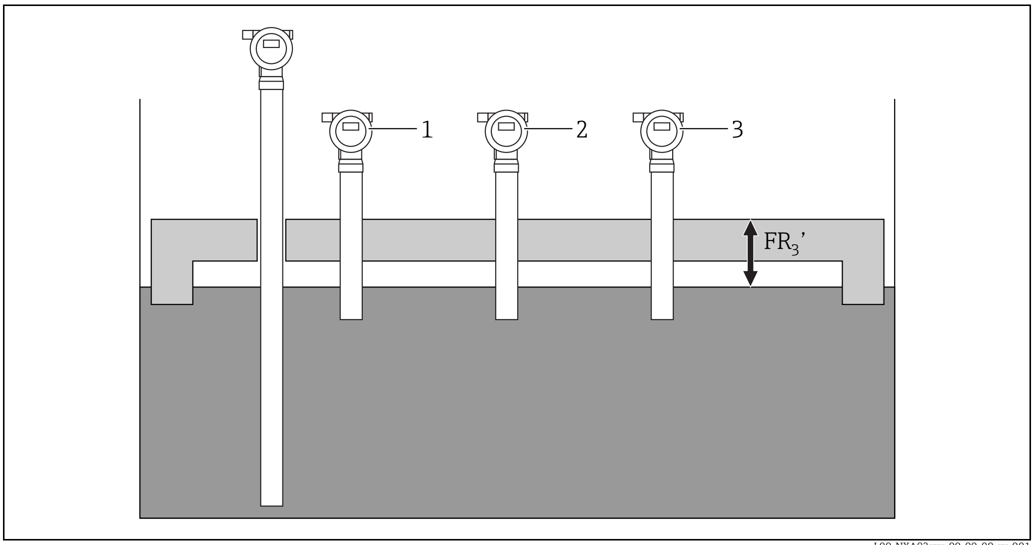
Inside critical zone:
3a Apply full FRA
3b Do not Apply FRA
3c Do not calculate FRA
3d Use partial FRA (interpolate)

Floating roofs can already be considered in the TCT.

8.1.5 Weight correction of the floating roof

The Floating roof position can be changed due to heavy snowfall, rain, sand or during unloading which triggers the roof to fluctuate that may cause variations in the stock inventory calculation. It's required to compensate Floating Roof immersion and also to compensate changing weight on floating roof.
The floating roof position can be monitored with 3 additional level sensors mounted on top of the floating roof. The level devices are connected to gauges which will be connected to Tankvision NXA820.



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1 FR Level 1
2 FR Level 2
3 FR Level 3

To measure the submersion or elevation of a floating roof it is required to monitor the level of the roof. If the gauges are on the floating roof, then the average of the distances FR1/2/3 compared to the average of the Reference FR1/2/3 provide:

$\Delta FR_1 = FR_1' - FR_1$

$\Delta FR_2 = FR_2' - FR_2$

$\Delta FR_3 = FR_3' - FR_3$

$$\Delta FR = \frac{\Delta FR_1 + \Delta FR_2 + \Delta FR_3}{3}$$

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If $\Delta FR < 0$ then we have an elevation
If $\Delta FR > 0$ then we have a submersion
Additional volume and mass of the floating roof calculated as:
$\Delta V = \Delta FR \times A_{FR}$
$\Delta m = \Delta FR \times A_{FR} \times \rho$
A_{FR} : The numerical value of the horizontal cross-sectional area floating roof
Δm : Additional Mass of the floating roof (Mass of snow, sand, rain or others)
ρ : Observer Density
ΔV : Addition Volume displaced in floating roof due to snow/rain/sand or others

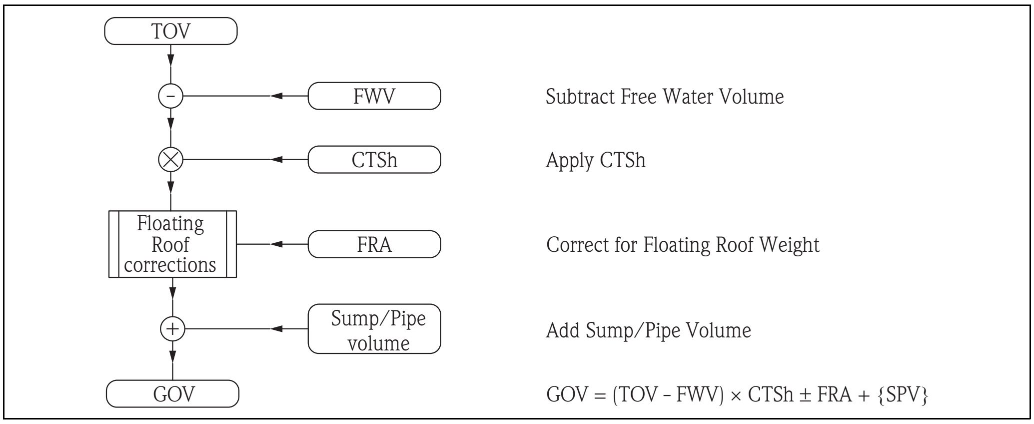
Total mass of the roof = Original mass of the Floating roof (m') + Additional Mass of the floating roof due to snow, rain etc. (Δm)
$m = m' + \Delta m$
$m = m' + \Delta FR * A_{FR} * \rho$

This equation can be used to calculate the GOV of the tank.
$GOV = TOV - (\Delta FR * A_{FR} + m / \rho)$

8.1.6 Sump/Heel/Pipe volume

Volume of the Sump and Pipes are added.

8.1.7 Gross Observed Volume - GOV



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8.1.8 Volume Correction Factor - VCF

The VCF corrects for the temperature expansion of the liquid. Especially hydrocarbons have a large expansion factor. The most common VCF corrections were developed by American Society for Testing and Materials (ASTM), USA and Institute of Petroleum, UK and updated regularly. There are more authorities issuing VCF corrections. Most of them are derived from the ASTM/IP tables.

VCF Implementation

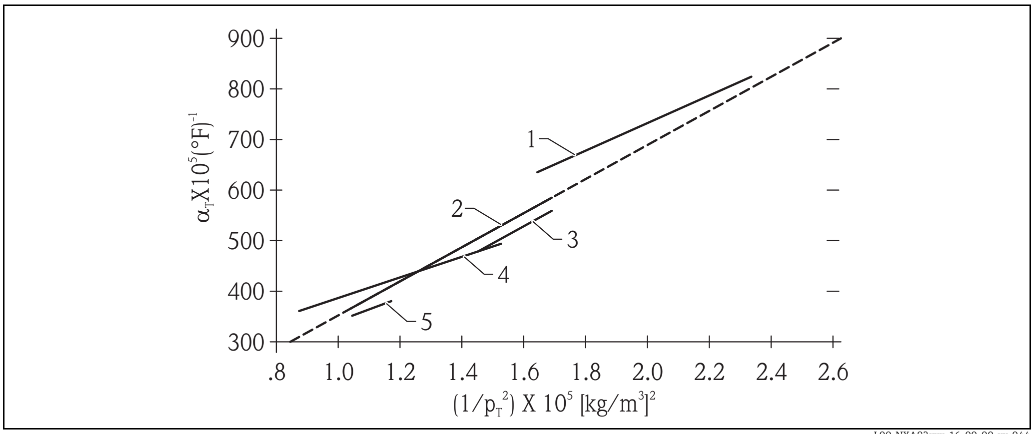
- Calculations are based on "representative samples" ("generalized products")

$$VCF = e^{[-\alpha_{60}\Delta t(1.0+0.8\alpha_{60}\Delta t)]}$$

- The "Tables" are based on specific calculation procedures

$$\alpha_{60} = \frac{K_0+K_1p^{*}+K_2p^{*2}}{p^{*2}} = \frac{K_0}{p^{*2}} + \frac{K_1}{p^{*}} + K_2$$

- Calculation is complex and rounding and truncating unique. There are many small but significant differences - exact requirements and needs depend on application, country and company.



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1 Gasolines
2 Crudes
3 Jets
4 Fuel oils
5 Lube oils

VCF Tables

- The formulas are too complex for direct use - hence the "Tables" were printed
- There are specific tables for:
  - Products (crudes, refined products, lube oils, alcohols, palm oil, chemicals, etc.)
  - Different measurement units (kg/m³ vs. °API, °C vs. °F, etc.)
  - Different "Reference" or standard temperature (60 °F, vs. 15 °C, 25 °C or 30 °C)
  - Each table has range limits
  - Tables for VCF and for density correction are available

Most known VCF "Tables"

The Tables are normally grouped in pairs:
- Tables 5 and 6 - ODC resp. VCF °API at 60 °F
- Tables 53 and 54 - ODC resp. VCF kg/m³ at 15 °C
- Tables 24 and 25 - ODC resp. VCF RD 60/60 °F at 60 °F
- Tables 50 and 60 - ODC resp. VCF kg/m³ at 20 °C

Most tables have so called Product Codes:
- A = for generalized crude’s
- B = for refined products
- C = for chemicals
- D = for lube oils
- E = liquefied gases

For chemicals normally a "polynomial equation" is used.

Typical table example: 54B (1980)

The range of application:

Density, kg/m³	Temperature, °C
653.0 to 778.5	-18.0 to 90.0
779.0 to 824.0	-18.0 to 125.0
824.5 to 1075.0	-18.0 to 150.0

$$VCF = EXP\,[-\alpha_{15}\Delta t(1.0+0.8\alpha_{15}\Delta t)]$$

where: $\Delta t = DEGC - 15.0$

$$\alpha_{15} = \frac{K_0}{p_{15}^2} + \frac{K_1}{p_{15}}$$

$$K_0 = 346.4228$$
$$K_1 = 0.4388$$

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Special corrections

VCF Chemical 1

$$VCF = \{D_{Ref} - A \times 10E3 \times (T_{Obs} - T_{Ref}) - B \times 10E3 \times (T_{obs} - T_{Ref})^2 - C \times 10E3 \times (T_{Obs} - T_{Ref})^3 - D \times 10E3 \times (T_{Obs} - T_{Ref})^4 - E \times 10E3 \times (T_{Obs} - T_{Ref})^5\} / D_{Ref}$$

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with:
- D_{Ref} = Reference density
- T_{Obs} = Actual or observed temperature
- T_{Ref} = Reference Temperature
- A-E = Configurable coefficients

TCF Method

$$TCF = K0 + K1 \times \Delta t + K2 \times \Delta t^2 + K3 \times \Delta t^3 + K4 \times \Delta t^4$$
$$\Delta t = t - T_{Ref}$$

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with:
- K_0, K_1, K_2, K_3, K_4 = Customer coefficients
- t = Actual product temperature
- T_{Ref} = Reference Temperature

For the VCF we can write:

$$TCF = 1 - TCF \times (T_{Obs} - T_{Ref})$$

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With the TCF method the p_{Ref} can be calculated with p_{Obs} / VCF (when manual p_{Obs} is provided) and an actual p_{Obs} can be calculated with p_{Ref} x VCF, when p_{Ref} is known and no actual p_{Obs} is available.

Palm oil

$$D_{Obs} = K_0 + K_1 \times T_{Obs} + K_2 \times (T_{Obs})^2 + K_3 \times (T_{Obs})^3 + K_4 \times (T_{Obs})^4$$
$$D_{ref} = K_0 + K_1 \times T_{ref} + K_2 \times (T_{ref})^2 + K_3 \times (T_{ref})^3 + K_4 \times (T_{ref})^4$$

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For the VCF we can easily derive: $VCF = D_{Obs}/D_{ref}$

$$VCF = \frac{K_0 + K_1 \times T_{Obs} + K_2 \times (T_{Obs})^2 + K_3 \times (T_{Obs})^3 + K_4 \times (T_{Obs})^4}{K_0 + K_1 \times T_{ref} + K_2 \times (T_{ref})^2 + K_3 \times (T_{ref})^3 + K_4 \times (T_{ref})^4}$$

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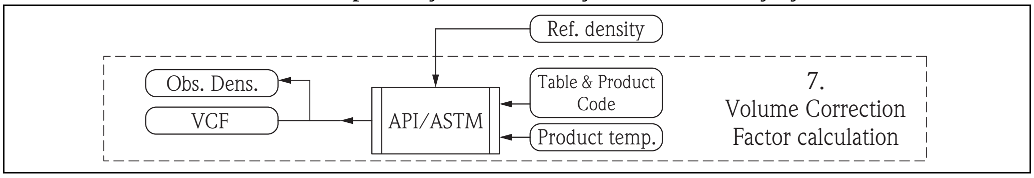
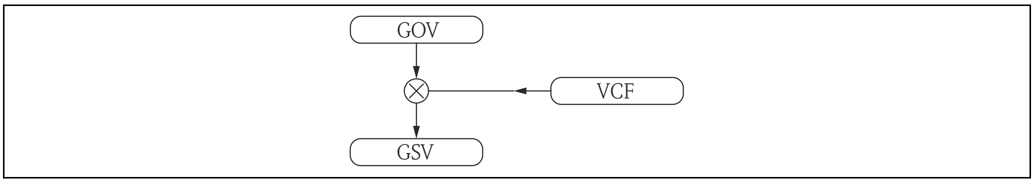
VCF Calculation

- The API/ASTM Tables are a "primary" need for any Tank Inventory system



The correct table for the product must be chosen. Together with the Product temperature and reference density the VCF can be calculated.
In addition to the VCF the observed density can be calculated.

8.1.9 Gross Standard Volume - GSV



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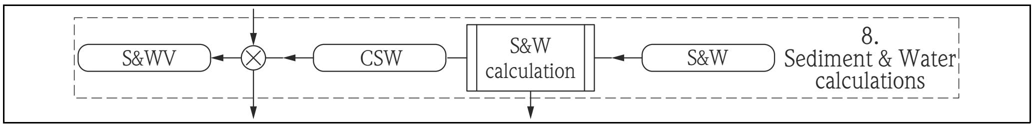
The Gross Standard Volume is calculated by applying the VCF to the GOV.

8.1.10 Sediment & Water - S&W



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- Some products have entrained (suspended) sediment and water (S&W)
  – i.e. crudes
- S&W is determined from sample by laboratory method ("Karl-Fisher"-method). The Sediment and Water percentage (S&W%) determined with the sample is transferred in the Sediment and Water Fraction (SWF). A correction factor for the product is determined.

As second result the Sediment and Water Volume can be calculated.

Sediment & Water calculation methods

There are 6 methods to calculate S&W

1. SWV = 0
2. SWV = TOV x SWF
3. SWV = (TOV - FWV) x SWF
4. SWV = {(TOV - FWV) x CTSh} x SWF
5. SWV = GOV x SWF
6. SWV = GSV x SWF ("standard" or "default" method)

Where the sediment and water fraction (SWF) is:

$$SWF = 1 - (100 - S\&W\%) / 100$$
$$= S\&W\%/100$$

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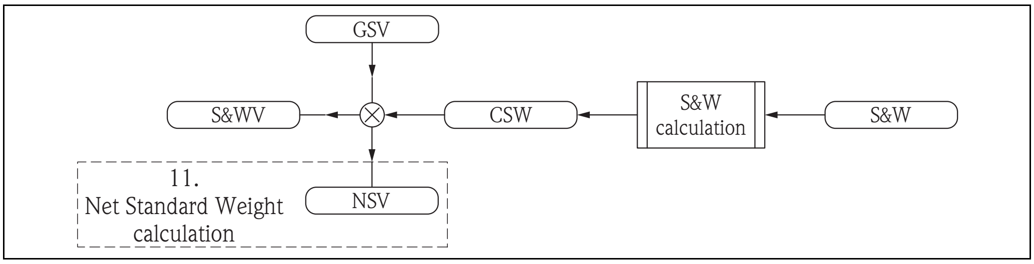
8.1.11 Net Standard Volume - NSV



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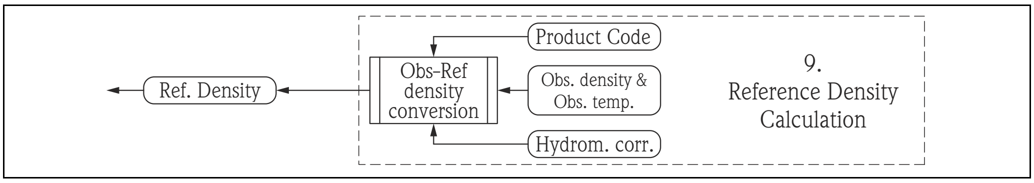
Subtracting the SWV from the GSV result in Net Standard Volume.

8.1.12 Density calculations



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We have to distinguish between: observed and reference density
- Observed density is the density of the product at actual (observed) temperature
- Reference density is the density the product would have if we heat/cool it until the reference temperature (usually 15 °C/60 °F)
- Reference density is used to calculate VCF, FR and mass
- If you know the RefDens you can easily geht the ObDens
  ObsDens = RefDens x VCF
- If you know the ObsDens you need (API/ATSM) tables and the sample temperature to get the RDC (reference density correction factor).
- You can also correct for the thermal expansion of the hydrometer glass (HYC)
  RefDens = RDC x ObsDens x HYC

Hydrometer Correction - HYC

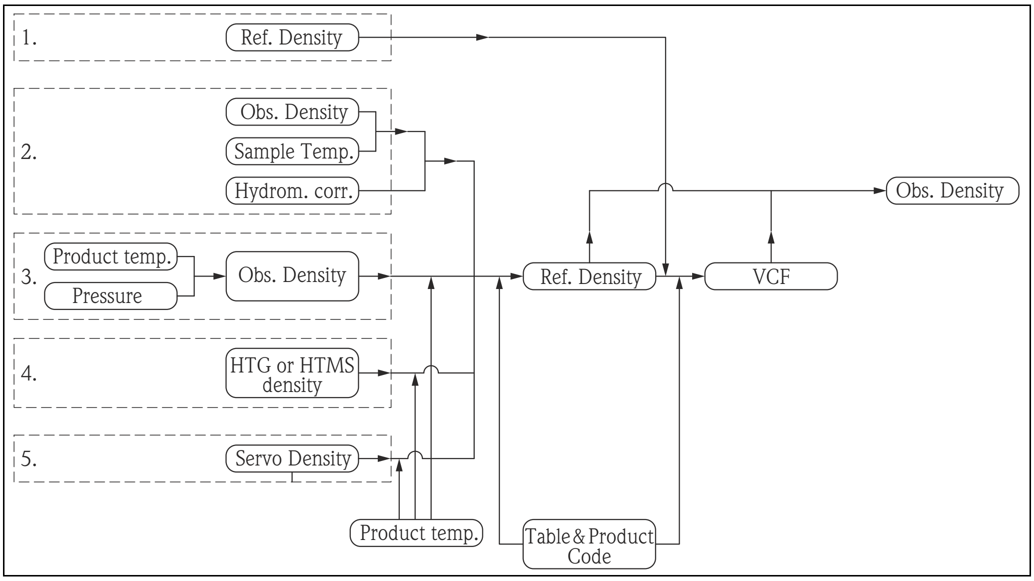
$$HYC = 1.0 - A_{HYC} \times (t - T_{Cal}) - B_{HYC} \times (t - T_{Cal})^2$$

L00-NXA82xxx-16-00-00-xx-054

with:
- HYC = Hydrometer correction
- A_{HYC}, B_{HYC} = Thermal expansion coeff. for glass
- t = Temperature of sample
- T_{Cal} = Calibration temperature of glass hydrometer

T_{Cal}	A_{HYC}	B_{HYC}
15 °C	0.000 0230 0	0.000 000 020
60 °F	0.000 0127 8	0.000 000 062

Density handling in NXA820



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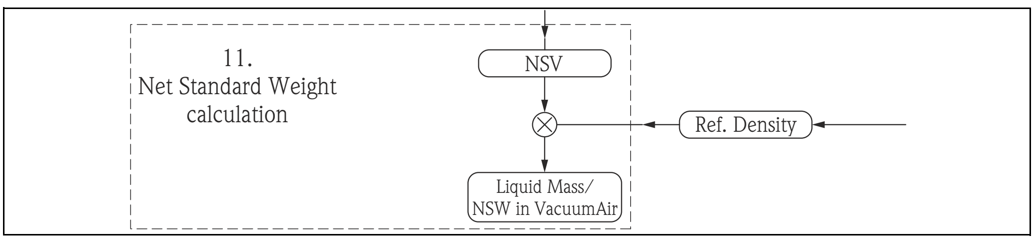
NXA820 offers various possibilities to enter and further process density information:

1. Manual entry of Reference density (from laboratory)
2. Manual entry of Observed density with the according sample temperature (from laboratory) is required corrected for the hydrometer. With the above information and the according Product information and ASTM/IP table (for density correction) the reference density can be calculated.
3. Product pressure, temperature, density table (PTD table): look up table for observed density with the use of measured product temperature and pressure. With the from the table derived Observed density, the product temperature and the according Product information and ASTM/IP table (for density correction) the reference density can be calculated.
4. Density from HTG or HTMS calculation (→ 🗎 47). With the from the calculations derived Observed density, the product temperature and the according Product information and ASTM/IP table (for density correction) the reference density can be calculated.
5. Density measured by Servo gauge. With the by the servo gauge measured Observed density, the product temperature and the according Product information and ASTM/IP table (for density correction) the reference density can be calculated.

Having the reference density and the according Product information and ASTM/IP table (for volume correction) the VCF can be determined.
Observed density can be calculated by multiplying reference density with VCF.

8.1.13 Mass/Net Weight in Vacuum



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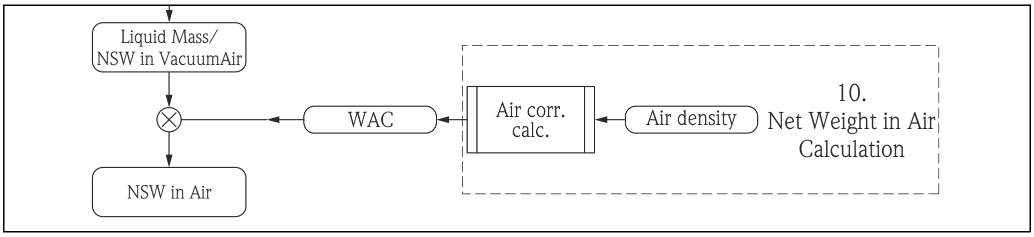
- Mass in temperature and product property independent
- Mass is needed for "Loss Reconciliation" required for every refinery and terminal
- Mass is calculated out of NSV and the reference density (or GOV and observed density)

8.1.14 Net Weight in Air - NWA



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- The flotation of a body is based on the principle discovered by Archimedes on century 3 BC "Every submerged body in a liquid experience a vertical upper force that is equal to the weight of the liquid displaced"
- Considering the liquid displaced is air
- The flotation is related to the liquid density where the body is floating because: Weight = Vol x Dens.

Calculation formula:

$$WAC = \frac{1 - \left(\frac{Dens_{Air}}{Dens_{Ref}}\right)}{1 - \left(\frac{Dens_{Vap}}{Dens_{Brass}}\right)}$$

$$NWA = WAC \times Mass$$

L00-NXA82xxx-16-00-00-xx-057

$Dens_{Air}$ Air density
$Dens_{Ref}$ Product reference density
$Dens_{Vap}$ vapor density
$Dens_{Brass}$ Brass density used to calibrate the weight scale

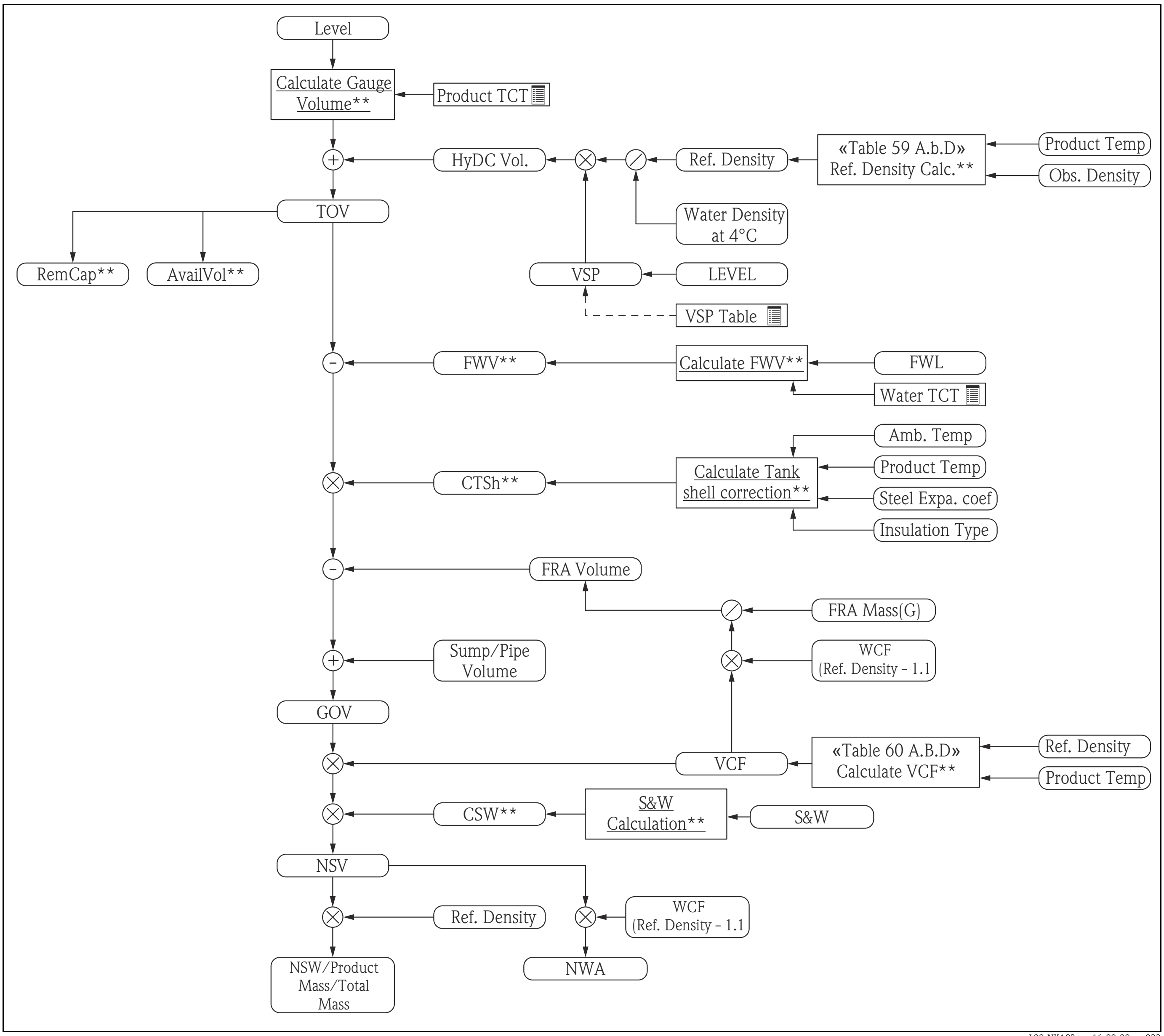
Net weight in Air methods

WAC Methods	Calculated	AirDen	VapDen	BrassDen
Weight in vacuum	No	0	0	0
OIML R85	Yes	1.2	1.2	8000
Table 56	Yes	1.22	1.22	8100
Table 57 (short tons)	Yes≈	1.2194	1.2194	8393.437
Table 57 (long tons)	Yes	1.224	1.224	8135.8
Simplified	Yes	1.1	0	1
Custom	Yes	1.225	1.225	8553

The Net Standard Weight in Air is in some countries called Mass.

8.2 GBT calculation flow chart

The GBT standard is the standard for China.
Main difference is the hydrostatic deformation of the tank not being part of the product TCT but in a separate table. The VCF and density calculations are based on the same ASTM/IP tables like the API calculations.



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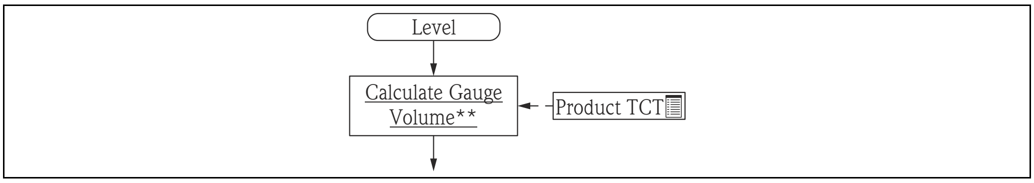
8.2.1 Calculated Gauge Volume



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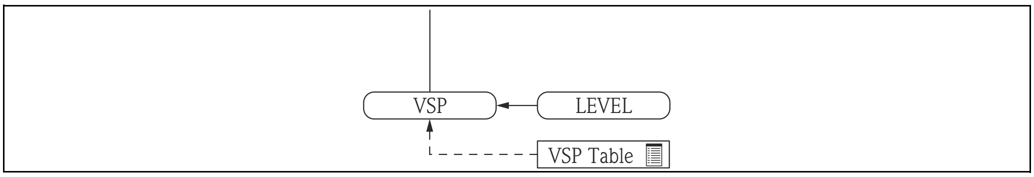
The Calculated Gauge Volume is determined with the level information and the Tank Capacity Table (TCT). The Calculated Gauge Volume is the volume observed at the present (temperature) conditions without considering the hydrostatic deformation of the tank.

The TCT is a tank specific table created by calibration holding the level to volume transfer information. To differentiate the TCT for the Product and for the Water the TCT gets marked with a P (P-TCT).

The level information needed for this step is in innage which is the normal way the level is transferred from the gauge. In case the gauge inputs ullage to the system a calculation into innage is necessary beforehand (Ullage subtracted from Mounting position).

8.2.2 Static Pressure Correction Volume - VSP



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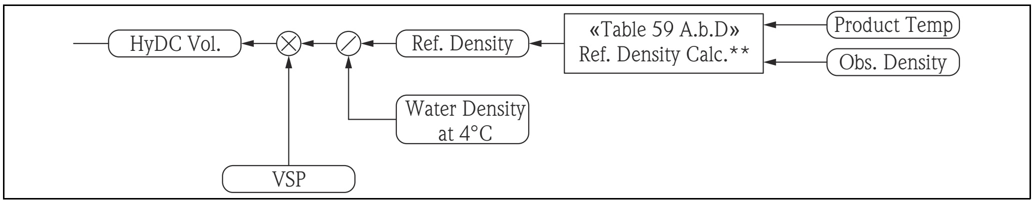
The VSP is determined with the level information and the static pressure correction table (VSP-table). The VSP is the volume the tank expands at the actual level if it would be filled with water (wet calibration).

8.2.3 Hydrostatic Deformation Correction Volume - HyDC Vol



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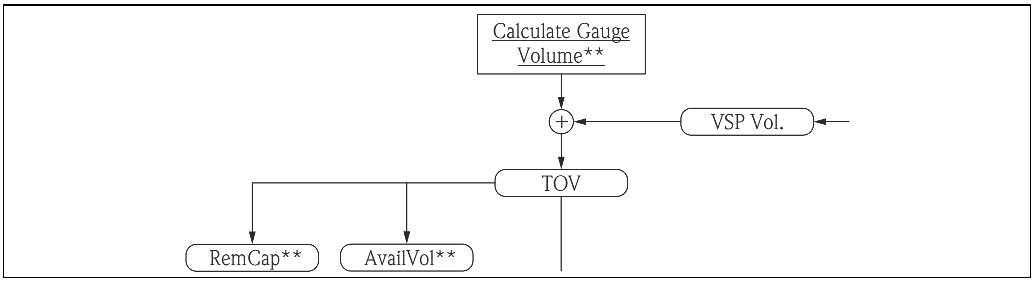
The Hydrostatic Deformation Correction Volume is the real from the product fill level created hydrostatic volume.
It is calculated by correcting the VSP with the ratio of the density of the product versus the water density.

$$HyDC = [Vsp \times \rho_r]$$
$$\rho_r = [\rho_{20} / \rho_{w4}]$$

ρ20 Reference Density at 20 °C (68 °F)
ρw4 Water Density at 4 °C (39 °F)

The reference density of the Product can be calculated (if not known) with the Observed Density, the Product/Sample Temperature and the Reference Density Table for the Product.

8.2.4 Total Observed Volume - TOV



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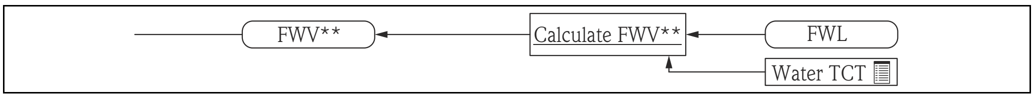
The Total Observed Volume is calculated from the Calculated Gauge Volume and the Hydrostatic Deformation Correction Volume.

Two more information can be derived from TCT and level:
- Remaining Capacity (RemCap) shows how much more product could be pumped into the tank safely
- Available Volume (AvailVol) indicates how much product could be pumped out of the tank to the lowest (defined) possible point e.g. the tank outlet.

8.2.5 Free Water Volume - FWV



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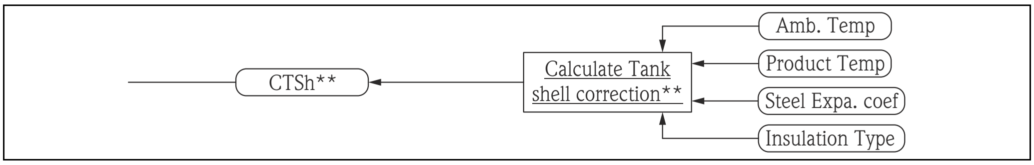
In some cases the tank can also contain water. It can derive from the delivered crude oil, the processing or by tank breating.
The (innage) water level information together with a Water Tank Capacity Table (W-TCT) result in the Free Water Volume. It is subtracted from the TOV.

8.2.6 Correction for the thermal Expansion of the tank shell - CTSh



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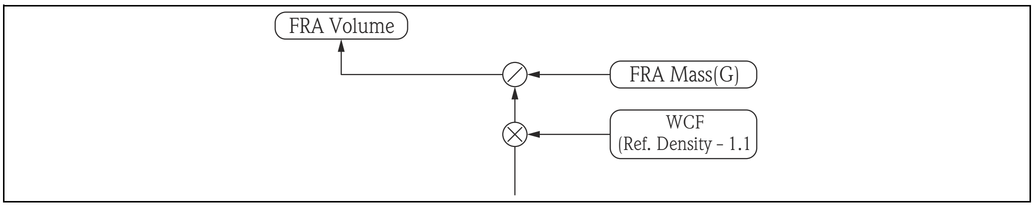
- The Tank Shell expands and contracts with temperature changes (compared to TCT calibration temperature)
- Some countries require CTSh (Correction for Tank Shell temperature effects)

For more details see → 55, Chapter "CTSh".

8.2.7 Floating roof adjustment - FRA



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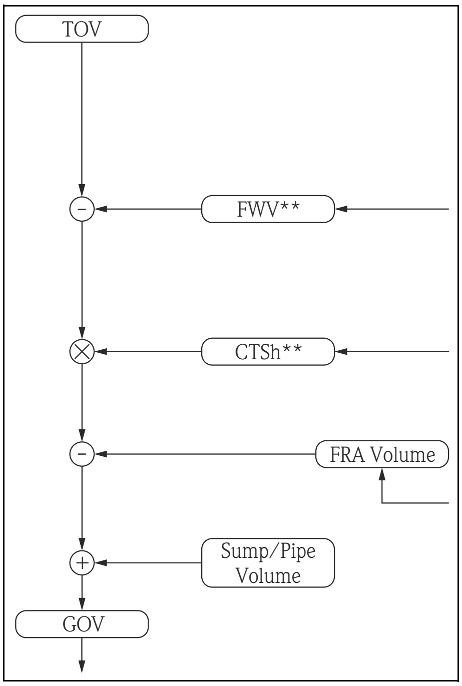
Additional displacement due to the air is considered, see Net Weight in Air calculation.

8.2.8 Sump/pipe volume

The Volume of the sump and pipes is added.

8.2.9 Gross Observed Volume - GOV

GOV is calculated like follows:
- Starting from the TOV
- Subtract FWV
- Multiply ba the thermal expansion correction factor
- Subtract the floating roof adjustment volume and
- Add the Sump/pipe volume



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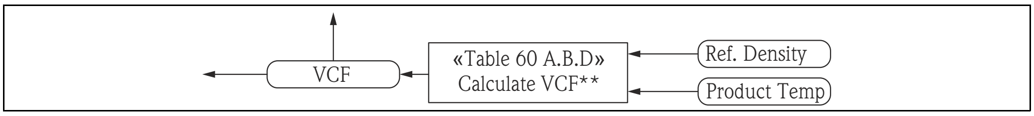
8.2.10 Volume Correction Factor - VCF



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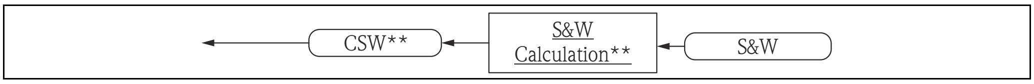
8.2.11 Sediment and Water



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- Some products have entrained (suspended) sediment and water (S&W) – i. e. crudes
- S&W is determined from sample by laboratory method ("Karl-Fisher"-method). The Sediment and Water percentage (S&W%) determined with the sample is transferred in the Sediment and Water Fraction (SWF). A correction factor for the product is determined.

As second result the Sediment and Water Volume can be calculated.

Sediment & Water calculation methods

There are 6 methods to calculate S&W

1. SWV = 0
2. SWV = TOV x SWF
3. SWV = (TOV - FWV) x SWF
4. SWV = {(TOV - FWV) x CTSh} x SWF
5. SWV = GOV x SWF
6. SWV = GSV x SWF ("standard" or "default" method)

Where the sediment and water fraction (SWF) is:

$$SWF = 1 - (100 - S\&W\%) / 100$$
$$= S\&W\%/100$$

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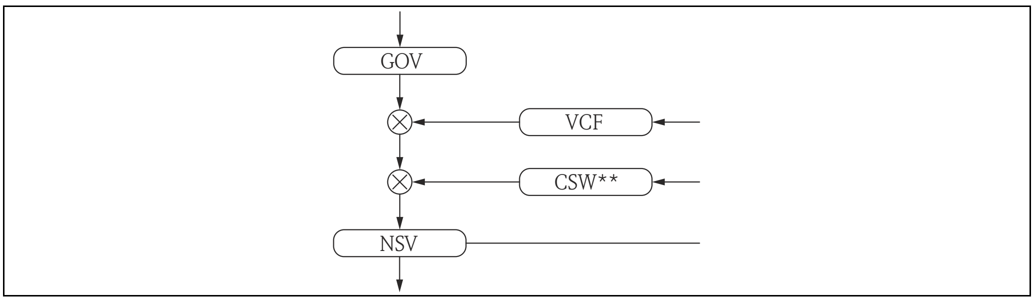
8.2.12 Net Standard Volume - NSV



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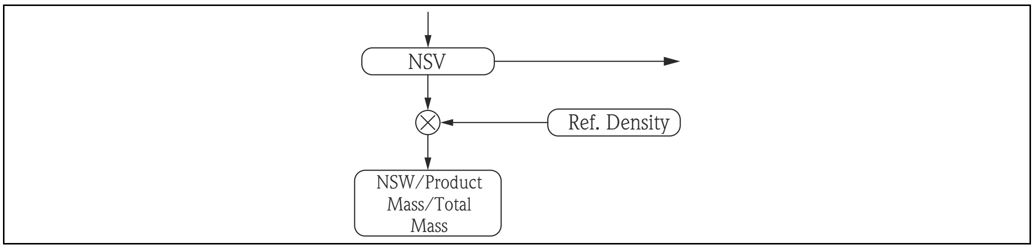
Net Standard Volume is calculated like follows:
- Starting from GOV
- Multiply by the Volume Correction Factor and
- Multiply by the S&W correction factor

8.2.13 Net Standard Weight - NSW / Product Mass



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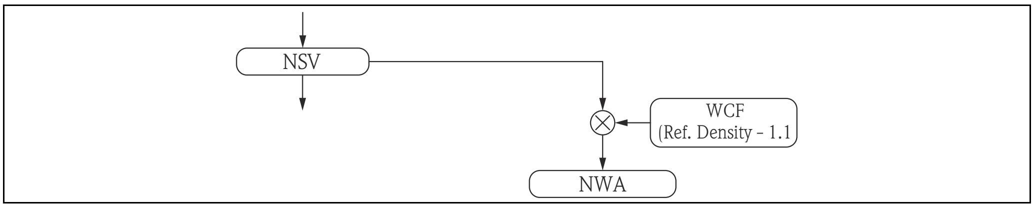
Mass is calculated by multiplying NSV with the Reference density.

8.2.14 Net Standard Weight in air - NWA



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The Net Standard Weight in Air is calculated by multiplying the NSV with the Reference Density reduced by the influence of the Air buoyancy (Reference density - 1.1).

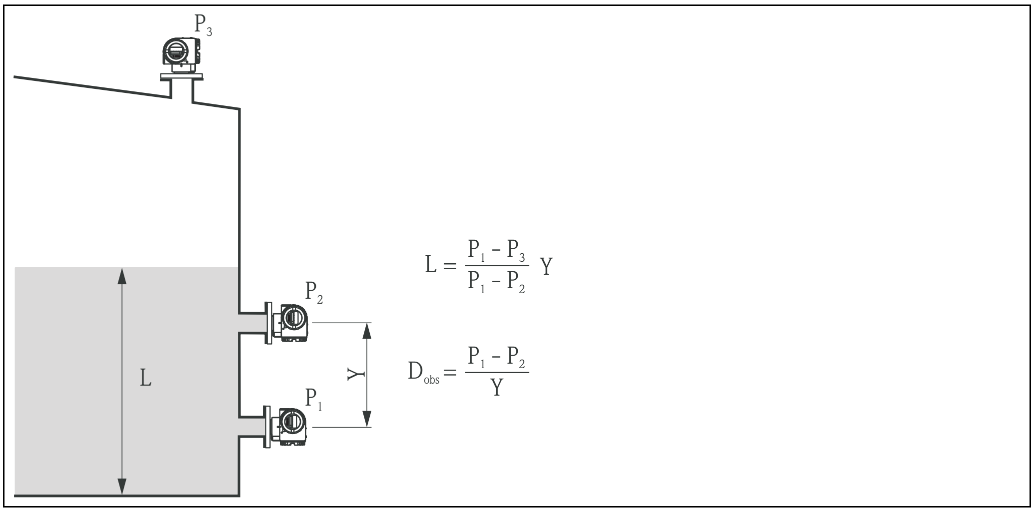
8.3 Mass Measurement

Today, most hydrocarbons in the western world are bought and sold using volume measurement. However, in many eastern countries and in some specialised industries, product are sold based on mass due to traditions in particular markets, so mass calculation can be important in those areas of trade. Mass-based measurement offers other advantages, since mass is independent of product temperature and other parameters.
For custody transfer, high accuracy tank gauging is required, and mass-based calculation is often used.

8.3.1 Hydrostatic Tank Gauging

The advantage of HTG is that it provides direct mass measurement with only pressure transmitters to measure hydrostatic pressure in determining density via a fixed distance and vapor pressure. Therefore, it is a low-cost solution for mass measurement. However, there are substantial disadvantages:

- Level and volume measurements are less accurate, especially when density stratification occurs.
- Density is only measured at the between the two pressure sensors.
- Difficult to verify, commission and calibrate



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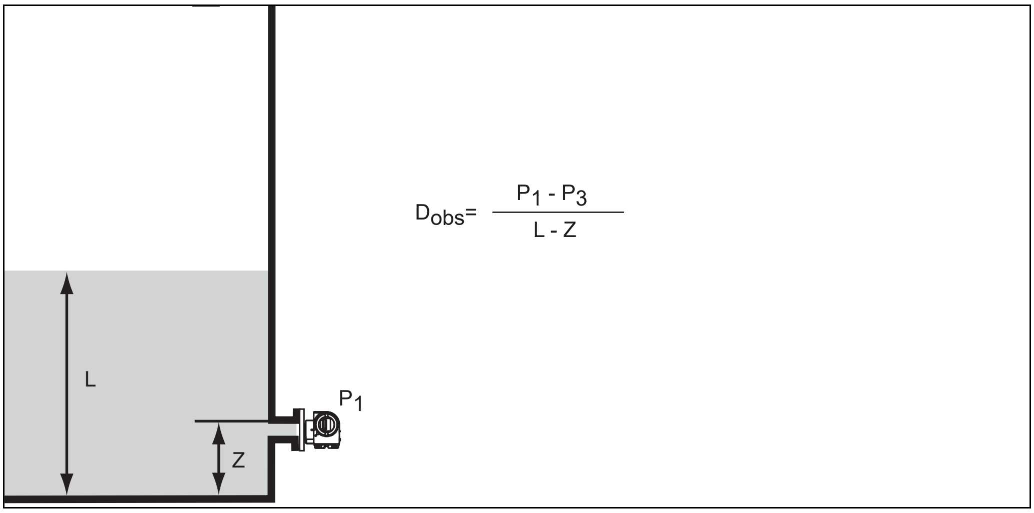
The middle or P_2 transmitter is unique to Hydrostatic Tank Gauging.

8.3.2 Hybrid Tank Measurement Systems

A Hybrid Tank Management System (HTMS) is a combination of conventional level gauging, enhanced with one or two pressure transmitters for continuous measurement of the actual observed density in a bulk liquid storage tank. Or otherwise stated, it is a combination of level and hydrostatic pressure measurement. Pressure measurement, combined with level, provides true average density measurement over the entire product level height. Normally, the vapor (top) pressure is identified as P_3 and the hydrostatic (bottom) pressure is identified as P_1.

Advantage of HTMS
- Accurate level measurement
- Continuous density measurement
- Excellent mass and volume measurements



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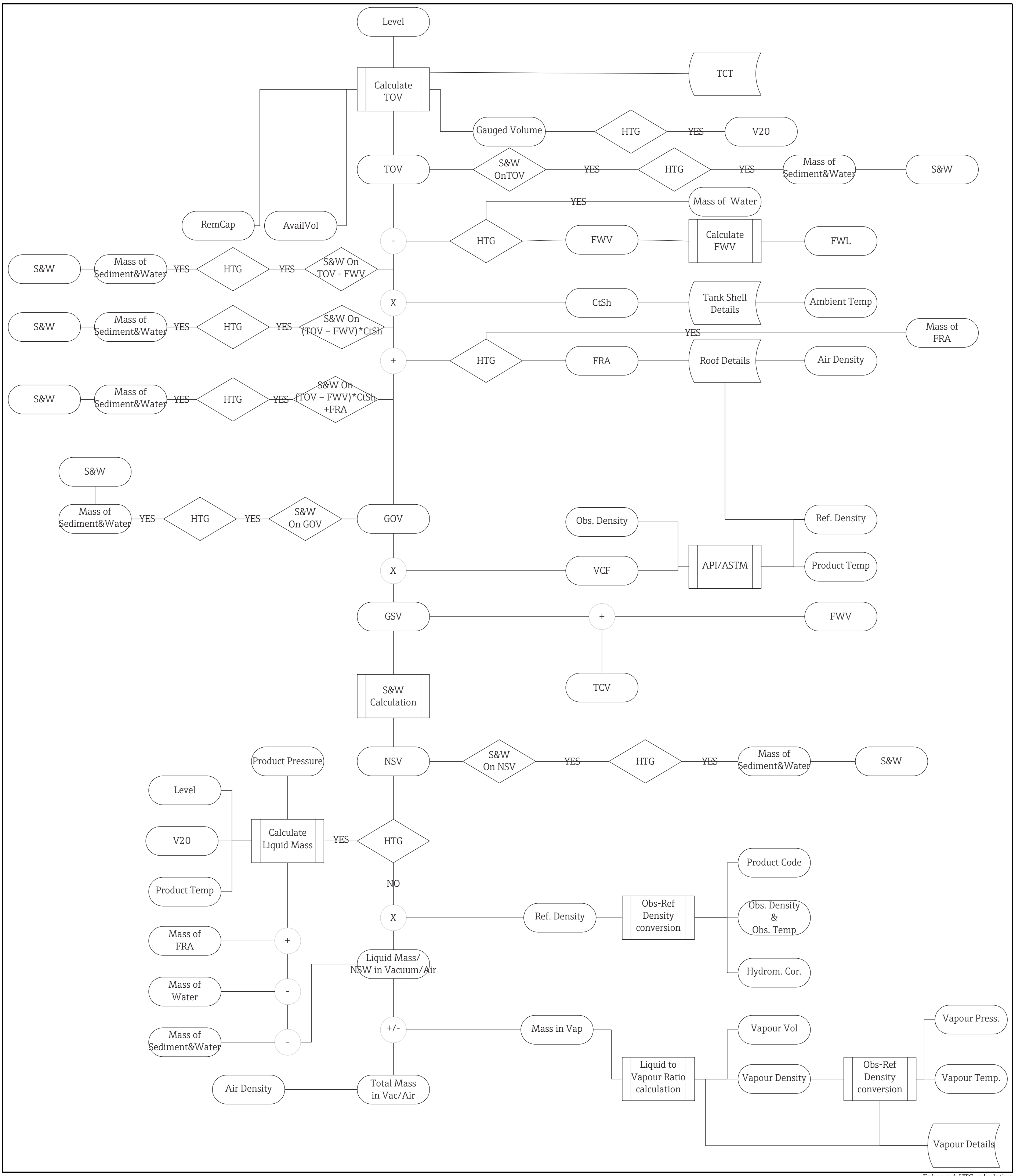
8.3.3 HTG Calculation according to GOST R 8.595-2004



Enhanced-HTG-calculation

In case of indirect method based on hydrostatic principle, the product mass in capacity measures shall be determined by the measurement results of:

- Hydrostatic pressure of a product column – with aid of stationary measuring instrument of hydrostatic pressure.
- The product level – with aid of portable or other means of level measurement.

The stock-tank oil net mass shall be determined as a difference of a stock-tank oil gross mass and a dead matter mass. The dead matter mass shall be determined as a total mass of water, salts and mechanical impurities in stock-tank oil. For this purpose the mass fractions of water, mechanical impurities and chloride salts shall be determined in stock-tank oil and their masses calculated.

The stock-tank net mass shall be calculated using the formula:

- $m = m_{total} - m_{dead\ matter}$

Where:
- m_{total} = the stock-tank gross mass, determined as described below
- $m_{dead\ matter}$ = the dead mass, calculated as described below.

Formula Details

This calculation is based on the correction of volume to 20 °C, in the Tankvision system 15 °C is the default temperature for reference condition – not 20 °C as per requirement for the GOST R 8.595-2004 standard.

The formula is fixed for 20 °C reference condition, configure VCF to use also 20 °C as reference.

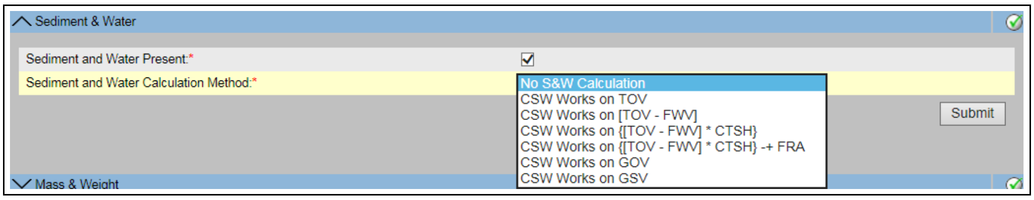
- $m = m_{total} - m_{dead\ matter}$

Where:

- $m_{total} = (1 / g) \times P \times V_{20}(1 + 2\alpha(T_{CT} - 20)) / H$

And

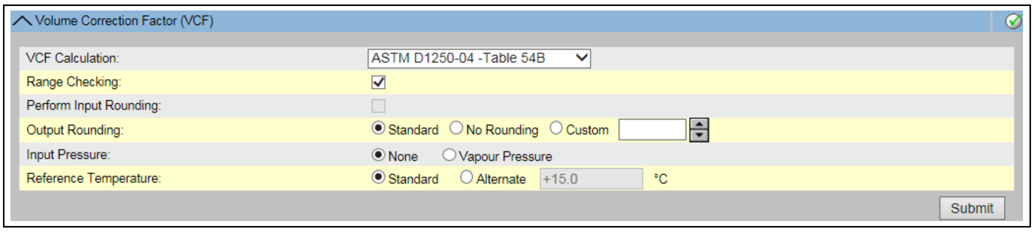
- V_{20} = TOV
- $m_{dead\ matter} = m_{Water} - m_{FloatingRoof} + m_{Sediment\&Water}$
- m_{Water} = FWV × Wat. Density
- $m_{Sediment\&Water}$ = SW_Volume × S&W% × Ref. Density
- $m_{FloatingRoof}$ = FRA × Obs. Density
- g = 9.81 m/sec^2 (adjustabel system environment setting)
- P = Product Pressure (P_PRESS)
- α = Temperature expansion factor (Fixed value shall be used: 12.5×10^{-6} 1/°C)
- V_{20} = Gauged Volume corrected to 20 °C (TOV shall be used)
- T_{CT} = tank wall temperature (PROD_TEMP Product Temperature shall be used)
- H = Product level (P_LEVEL)
- FRA = Floating Roof Adjustment
- Obs. Density = Observed Density
- TOV = Tank Observed Volume
- VCF = Volume Correction Factor
- FWV = Free Water Volume
- Wat. Density = Density of Water
- NSV = Net Standard Volume
- Ref. Density = Reference Density
- S&W% = Percentage of Sediment and Water
- SW_Volume = the volume used according to the configuration set by the user to define how to apply the sediment and water effect, according to this setting it could be equal to:
  - TOV
  - TOV – FWV
  - (TOV – FWV)*CtSh, with CtSh is Tank Shell Correction factor
  - (TOV – FWV)*CtSh +FRA
  - GOV = Gross Observed Volume
  - NSV



NXA82x_Sediment-Water

REF_TEMP = default 15 °C

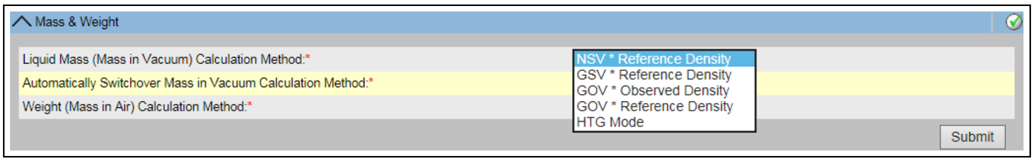
REF_TEMP will be set from the **Reference Temperature** setting from the VCF setting (see figure below: Reference Temperature setting used as calculation input). **Standard** is equal to 15 °C. To change the reference condition to 20 °C, select the **Alternate** setting, which shall be the new REF_TEMP.



NXA82x_VCF

System Integration

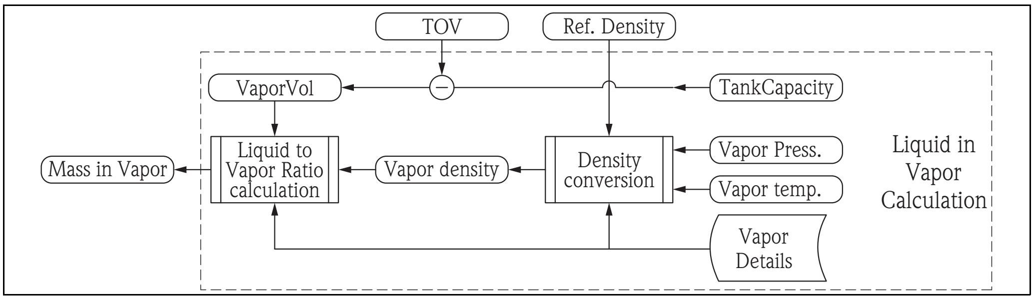
The selection when to use the HTG method to calculate the mass is placed in the product settings in the sub section **Mass & Weight**. In the **Liquid Mass (Mass in Vacuum) Calculation Method** dropdown menu you can find an entry called **HTG Mode**.



NXA82x_Mass-Weight

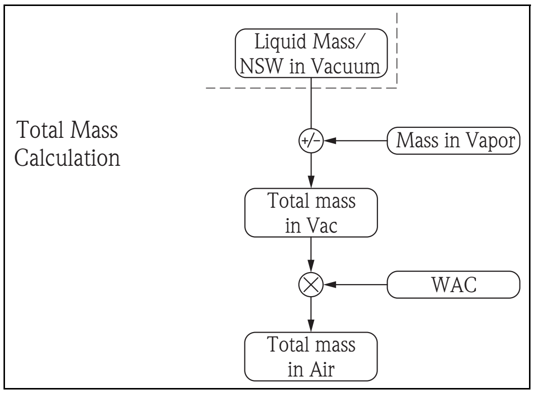
8.4 Calculations for liquefied gases

The mayor difference in the calculation for liquefied gases compared to liquids is that the gas phase must be considered. Therefore a calculation for the mass of the product in the gas phase must be applied.



8.4.1 Total Mass

Total Mass = Liquid Mass + Vapor Mass



8.4.2 MBR method

- The method is based on a specific done by "Moore, Barrett & Redwood" in November 1985. The calculation procedure was specified for "Whessoe Systems and Controls Ltd.".
- Apart from the gas calculation, MBR defines a whole process to calculate VCF and RDC.
- This method is intended only for LPGs, but it might also give acceptable results for other Chemical gases - as long as the density and temperature are within the specified range.
- Density Input Range: 470 to 610 kg/m³.
- Temperature Input Range: -85 to 65 °C (-121 to 149 °F).
- It is not possible to use the M, B & R method for other Reference Temperatures than 15 °C.

The method is based on 10 steps:

1. Measure and input the data
2. VCF Calculation
3. Observed Density calculation
4. Calculate GSV
5. Calculate Liquid Mass
6. Calculate Vapor Volume
7. Calculate Vapor Density
8. Calculate Vapor Mass
9. Calculate Total Mass
10. Calculate Total Weight

MBR - Data to be measured (1)

For the LPG application the following data should be real-time measured on the tank(s):
- Product level
- Product Temperature (spot or average)
- Vapor Temperature (spot or average)
- Vapor space pressure - also called "Vapor pressure"

Input data

- The liquid density at 15 °C (60 °F) has to be input by the operator. This density can either be obtained from a pressurized hydrometer and corrected via an appropriate table or should be established on basis of chemical analysis.
- The method as implemented in Tankvision also allows the operator to enter Observed or Actual density as a manual value. Tankvision will then calculate the corresponding Reference Density.

MBR - VCF Calculation (2)

The following formula shows the calculation method.

```
X   = (DENL15 - 500) / 25
Y1  = 0.296-0.2395*X+0.2449167*X*X-0.105*X*X*X+0.01658334*X*X*X*X
Y2  = 368.8+4.924927*X+13.66258*X*X-6.375*X*X*X+1.087503*X*X*X*X
TR  = 298.2/Y2
TT  = (1-TR)^(1/3)
VO  = 1-1.52816*TT/1.43907*TT*TT-0.81446*TT*TT*TT/0.190454*TT*TT*TT*TT
VD  = (-0.296123+0.386914*TR-0.0427258*TR*TR-0.0480645*TR*TR*TR)/(TR-1.00001)
V1  = VO*(1-Y1*YD)
TR  = (TL+273.2)/Y2
TT  = (1-TR)^(1/3)
VO  = 1-1.52816*TT/1.43907*TT*TT-0.81446*TT*TT*TT/0.190454*TT*TT*TT*TT
VD  = (-0.296123+0.386914*TR-0.0427258*TR*TR-0.0480645*TR*TR*TR)/(TR-1.00001)
V2  = V0*(1-Y1*VD)
VCF = V1/V2
```

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MBR - Observed density (3)

The observed density is calculated using the reference density and the VCF:
- Observed density = Density at 15 °C (60 °F) x VCF

The above equation can not be used to calculate the density under reference conditions (i.e. 15 °C (60 °F)).

MBR - Calculate GSV (4)

The gross standard volume is calculated using the Total observed volume and the VCF
- G.S.V = T.O.V x VCF

MBR - Calculate Liquid Mass (5)

The liquid mass is calculated out of the gross standard volume and the reference density:
- Liquid Mass = G.S.V. x Density at 15 °C (60 °F)

MBR - Calculate Vapor Volume (6)

The vapor volume is obtained using the total tank volume and the liquid total observed volume:
- Vapor volume = Total Tank Volume - TOV

MBR - Calculate Vapor Density (7)

There are some steps to be followed to get the vapor density

- Molecular weight (MW)

$$X = (D.Ref - 500 / 33.3333)$$
$$MW = 43 + 4.4 \times X + 1.35 \times X^2 - 0.15 \times X^3$$

- Critical temperature and pressure

$$TC = 364 + 13.33 \times X + 8.5 \times X^2 - 1.833 \times X^3$$
$$PC = 43 - 2.283 \times X + 0.05 \times X^2 - 0.0667 \times X^3$$

- Reduced temperature and pressure

$$TR = (TV + 273.2) / TC$$
$$PR = (VP + 1.103) / PC$$

- Compressibility

$$W = 0.214 - 0.034333 \times X + 0.005 \times X^2 - 0.0001667 \times X^3$$

Locate smallest root of:

$$Z^3 - Z^2 + Z \times (A - b - B^2) - A \times B$$

With:

$$A = 0.42747 \times L^2 \times PR/TR^2$$
$$B = 0.08664 \times PR/TR$$
$$L = 1 + (0.48 + 1.574 \times W - 0.176 \times W^2) \times (1 - SQRT\ (TR))$$

Compressibility Z should be in the range of 0.2 to 1 for typical LPG applications.

- Vapor density

$$VapDen = (MW \times (VP + 1.013) / (0.08314 \times (TV + 273.2) \times Z$$

The Vapor density is calculated in [kg/m³]

MBR - Calculate Vapor Mass (8)

- The vapor mass (VM) can now be calculated:
  MV = Vapor Space x VapDens
- Calculate Total Mass:
  Total Mass = Liquid Mass + Vapor Mass
- Equivalent Vapor Liquid Volume
  EVLV = Vapor Mass / Liq. Ref. Density

8.5 CTSh

8.5.1 What is CTSh

CTSh stands for "**C**orrection for **T**emperature of the **T**ank **Sh**ell". CTSh is about correcting for when the temperature of the tank shell is different than the calibration temperature of the tank.
This temperature influence affects the calculated Inventory via (1) the gauge reading, and (2) via a change in the capacity of the tank as the tank diameter has changed under the temperature effect.

Temperature difference	Volume change	Temperature difference	Volume change
1.0 °C (34 °F)	0.002%	50.0 °C (122 °F)	0.110%
5.0 °C (41 °F)	0.011%	60.0 °C (140 °F)	0.132%
10.0 °C (50 °F)	0.022%	70.0 °C (158 °F)	0.154%
20.0 °C (68 °F)	0.044%	80.0 °C (176 °F)	0.176%
30.0 °C (86 °F)	0.066%	90.0 °C (194 °F)	0.198%
40.0 °C (104 °F)	0.088%	100.0 °C (212 °F)	0.220%

Temperature Effect on Tank Volume for a given height of liquid (based tec for steel: $22x10^6$/°C

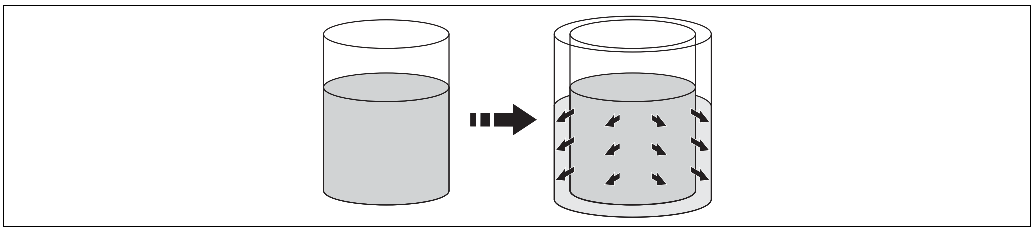
Temperature effect on gauge reading

The temperature effect via the Gauge Reference Height (GRH) affect the level reading and depends on:
- The actual product level in relation to the Gauge Reference Height (GRH),
- The gauge type, for example radar and servo are differently affected,
- The thermal expansion coefficient of the tank steel,
- and the actual tank shell temperature in relation to the tanks shell calibration temperature.

The temperature correction for the Gauge Level reading should be corrected in the Level gauge and NOT corrected in the Tank Inventory System.

Reason is that it makes more sense to this correction in the gauge itself:
- Level reading in Gauge and System should be identical with the same correction applied.
- The required correction depends on the gauge type. A servo, needs for example a different correction as the temperature effects on the measuring wire in the tank partly compensates the temperature effects of the tank shell. For a Radar this is not the case.
- Why burden the Tank Inventory system with corrections that are gauge specific.

Temperature effect on tank capacity



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The temperature effects also the tank capacity via the tank shell diameter. With the changed diameter, the surface area is changed, and as result the tank can contain more or less liquid product depending on whether the tank shell temperature is higher or respectively lower than the tank shell calibration temperature.

While the Level gauge is affected by two influences, one related to the thermal effects on the "wet" part of the tank shell, and one for the "dry" part of the tank shell, the tank capacity is only affected by the "wet" part of the tank shell.
Hence we also only have to establish the temperature of the "wet" part, i.e. the part in direct contact with the liquid product.

Wet tank shell temperature

It is unpractical to measure the tank shell temperature for each and individual tank. Hence one common "estimate" method is used for all tanks. This method is based on the ambient temperature (Tamb) and the actual liquid product temperature. For most tanks the following expression is specified in the standards:

$$T_{shell} = 7/8 * T_{product} + 1/8 * T_{ambient}$$

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Unfortunately there are also tanks which behave differently. This can be tanks with a real thermal insulation, but they can also be buried. Hence we had re-write the above equation so we could use a "insulation factor" I_f.

$$T_{shell} = I_f * T_{product} + (1 - I_f) * T_{ambient}$$

L00-NXA82xxx-16-00-00-xx-003

Where:
- T_{shell} = Temperature of "wet" tank shell
- $T_{product}$ = Temperature of liquid product in tank
- $T_{ambient}$ = Ambient temperature
- I_f = Insulation Factor

Now we can use the I_f and use one common equation. Selecting the Insulation factor is simple:
- I_f = 1.0 for all tanks where the tank is somehow insulated, and
- I_f = 7/8 for all other tanks

Of course you can modify this setting in the configuration of Tankvision.

Observe the following information!

- In Appendix B you can find a table with some examples as illustration.
- How to obtain the ambient temperature is discussed further on.

Thermal expansion

With the Shell temperature we can now calculated the expansion of the tank capacity. This factor is indicated with the name CTSh. Late we will see how it applied to the calculated volume.
The CTSh equation depends on the tank type.

Vertical cylindrical tanks

The equation for vertical cylindrical tanks for the volumetric CTSh is relative easy:

$$CTSh = 1 + 2 * \alpha * \delta T + \alpha^2 * \delta T^2$$

L00-NXA82xxx-16-00-00-xx-004

Where:
- α = Linear thermal expansion coefficient of tank shell material
- δT = Tank Shell Temperature - Tank Calibration temperature

The complexity starts with inconsistencies between the CTSh calculation as specified in various International standards.

In IP PMP No. 11 (paragraph C.2, page 20) the above equation (1) is simplified to:

$$CTSh = 1 + 2 * \alpha * \delta T$$

L00-NXA82xxx-16-00-00-xx-005

In order to be able to combine both equations, we have rewritten the equations to:

$$CTSh = 1 + 2 * \alpha_1 * \delta T + \alpha_S * \delta T^2$$

L00-NXA82xxx-16-00-00-xx-007

Where:
- α_1 = Linear thermal expansion coefficient
- α_S = Area or surface thermal expansion coefficient
- $\delta T = T_{shell} - T_{calib}$

Spherical tanks

Temperature correction for Spherical Tanks is calculated using the following equation:

$$CTSh = 1 + \alpha_1 * \delta T * f'$$

L00-NXA82xxx-16-00-00-xx-008

Where:
- f’ = non-dimension factor representing change in partial volume, corresponding with h/2

The factor f’ can be calculated with:

$$f' = (h^2 * r) / (h^2 * r - (h^3 / 3))$$

L00-NXA82xxx-16-00-00-xx-009

Where:
- h = liquid depth
- r = vessel radius

Observe the following information!

- This calculation is conform to IP PMP No. 11
- Refer to Appendix A3 for values of f’

Horizontal cylindrical tanks (bullets)

Temperature correction for Horizontal Cylindrical Tanks is calculated using the following equation:

$$CTSh = 1 + \alpha_1 * \delta T * f''$$

L00-NXA82xxx-16-00-00-xx-010

Where:
- f’’ = non-dimension factor representing change in partial volume, corresponding with h/r2

The factor f’’ can be calculated with:

$$F'' = 1 + \{2 * (\theta - \sin\theta) / (\theta - \sin\theta * \cos\theta)\}$$

L00-NXA82xxx-16-00-00-xx-011

Where:
- h = liquid depth
- r = vessel radius
- θ = angle subtended by liquid surface at the centre of the circular cross-section

Refer to Appendix A3 for values of f''.

Thermal expansion coefficient(s)

In the previous equations we have used two thermal expansion coefficients:
- α_1 = Linear thermal expansion coefficient
- α_S = Area or surface thermal expansion coefficient

The first one represents the linear thermal expansion of the material of which the tank shell is made. The second factor represents the squared or area thermal expansion coefficient.
It is of paramount importance that the factor used is in the correct engineering units, i.e. as fraction per °C or fraction per °F.

The method for this calculation depends on what equation is to be emulated:
- In case of equation CTSh (3) = $1 + 2 * \alpha * \delta T + \alpha^2 * \delta T^2$
  In this case "α_S" can be derived from "α_1" by squaring, i.e. "a_tec" = "1_tec"
- In case of equation CTSh (4) = $1 + 2 * \alpha * \delta T$
  In this case "α_S" should be set to zero.
- For spherical and horizontal cylindrical tanks "α_S" should be set to zero.

Please also make sure that the exponent value is considered when entering the value in Tankvision.
For example if "α_1" is set to be equal to "1.6 10^-5", while as engineering units shown is "10E-7/°C", the "α_1" value to be entered is "160".

8.5.2 Measurement of ambient temperature

The CTSh should be calculated automatically, which is only possible if we also have the actual ambient temperature measured automatically.
Tankvision is capable of integration of this temperature from field equipment. It can redistribute this information over the whole or part of the Tank Farm. This makes it possible to use one ambient temperature sensor and use the measure temperature for one or more tanks within the same Tankvision system.

Automatic measurement of ambient temperature on site

Exact recommendations on the location, installation and accuracy of the Ambient Temperature sensor are vague. The sensor should be located in the outside environment, be protected from direct sun shine, rain and wind, and preferable be approximately 1 meter (3 ft) from any building or large object.

An external Ambient Temperature sensor can be connected via:
- NRF590 – for example by adding an extra HART converter with temperature sensor, or by using the optional RTD input
- Proservo NMS53x – as above

Other methods may also possible be possible, depending on installed equipment and used field protocol. Please consult Endress+Hauser.
Later we will also see that there is a special setting in Tankvision where we can disable fail propagation if the ambient temperature doesn't work. After all it would be pretty horrific if the calculated inventory data of all tanks is suddenly useless, just because one sensor fails.

Manual entry of ambient temperature

It is also possible to enter the ambient Temperature manual.
This could be used, for either verifying the CTSh calculations, or in the unlikely case the ambient temperature is in fail.

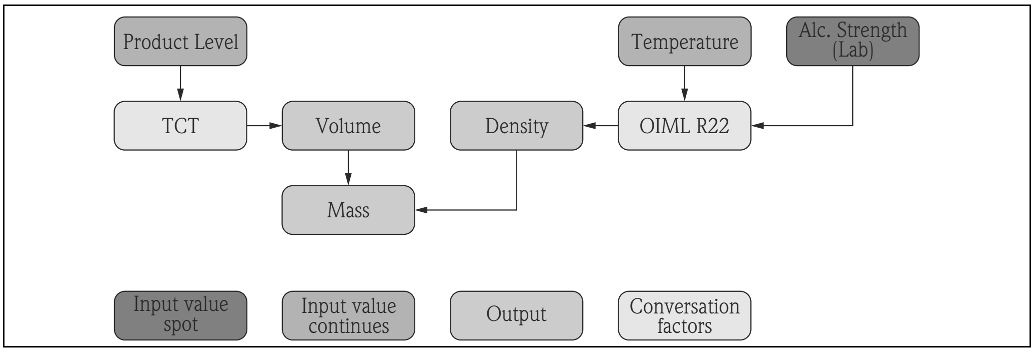
8.6 Alcohol calculations

8.6.1 The OIML R22

The OIML R22, as issued in 1975 deals with the calculations for the basic data "relating to the density and to the alcoholic strengths by mass and by volume of mixtures of water and ethanol". As per OIML R22 standards the range is -20 to +40 °C (-4 to +104 °F) and defines the following:
- Table I:
  Gives the Observe density as a function of the temperature and the alcohol strength by mass
- Table II:
  Gives the Observe density as a function of the temperature and the alcohol strength by volume
- Table IIIA and IIIB:
  Gives the standard (reference) density at 20 °C (68 °F) (Table IIIA) and the alcoholic strength by volume (Table IIIB) as a function of the alcoholic strength by mass
- Table IVA and IVB:
  Gives the standard density at 20 °C (68 °F) (Table IVA) and the alcoholic strength by mass (Table IVB) as a function of the alcohol strength by volume
- Table VA and VB:
  Gives the acloholic strength by mass (Table VA) and the alcoholic strength by volume (Table VB) as a function of the observe density at 20 °C (68 °F)
- Table VI:
  Gives the alcoholic strength by mass as a function of the observe density and temperature
- Table VII:

Gives the alcoholic strength by volume as a function of the observe density and temperature
- Table VIIIA and VIIIB:
  Gives the alcoholic strength by mass (Table VIIIA) and the alcoholic strength by volume (Table VIIIB) as a function of the observe density (density is read from alcoholmeter of soda lime glass at 20 °C (68 °F)) and temperature. Density at a given temperature is calculated by the given formula.
- Table IXA and IXB:
  Gives the alcoholic strength by mass (Table IXA) and the alcoholic strength by volume (Table IXB) as a function of the observe density (taken from hydrometer) and temperature
- Table XA and XB
  Gives the alcoholic strength by mass (Table XA) and the alcoholic strength by volume (Table XB) as a function of the observe density (taken from a instrument made of borosilicate glass) and temperature
- Table XIA and XIB
  Calculates volume using alcohol strength by mass (Table XIA) or alcohol strength by volume (Table XIB)
- Table XIIA and XIIB:
  Calculates volume using alcohol strength by mass (Table XIIA) or alcohol strength by volume (Table XIIB)

Currently Table I, II, IIIA, IVA, VI and VII are implemented in Tankvision NXA820.



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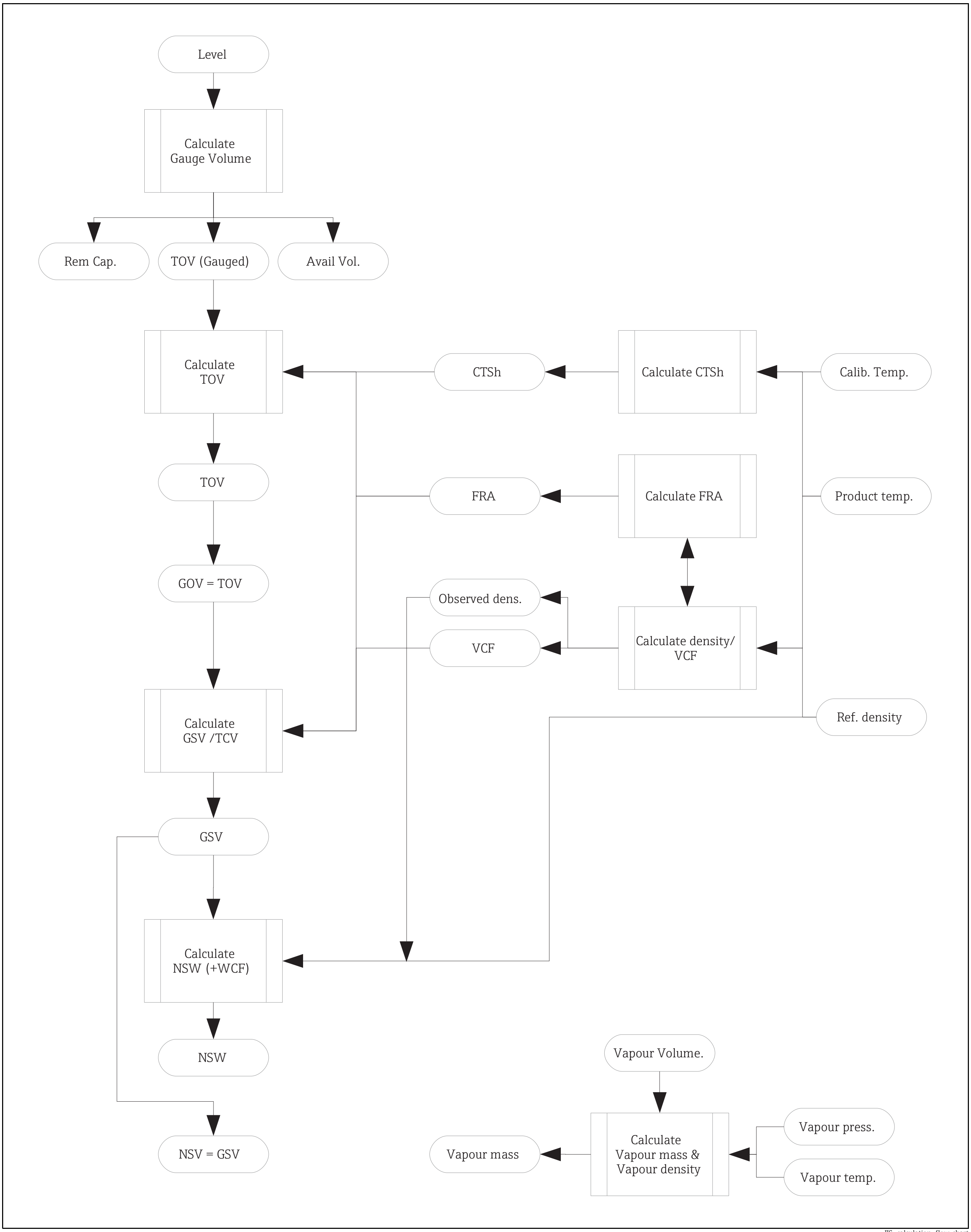
8.7 JIS calculation flow charts

The JIS standard is the Japanese Industrial Standard.



JIS_calculation_flow-chart

8.7.1 Main differences to the API standard

JIS is only available for the following product types:
- Generalized Crudes
- Generalized Refined Products
- Generalized Lubricants
- LPG

8.7.2 Volume Correction Factor - VCF

The following VCF table is implemented:
- JIS K 2249 2A

8.7.3 Density Calculation - RDC

If the user wants to calculate the Observed Density, RDC_JIS has to be selected in the RDC settings of the product:

- Observed Density = Reference Density x VCF

8.7.4 Floating roof adjustment - FRA

The following new options are available for the floating roof adjustments:

- (JIS) No FRA:

$$FRA = 0$$

JIS_FRA_No-FRA

- (JIS) Nippon Kaiji:

$$FRA = (FRW / \rho_{ref}) \times FRP$$

JIS_FRA_Nippon-Kaiji

- (JIS) Shin Nihon 1:

$$FRA = ((1 / \rho_{ref}) - (F / BSG)) \times FRW \times FRP$$

JIS_FRA_Shin-Nihon-1

- (JIS) Shin Nihon 2:

$$FRA = ((1 / \rho_{ref}) - (1 / BSG)) \times FRW \times FRP$$

JIS_FRA_Shin-Nihon-2

- (JIS) Shin Nihon 3:

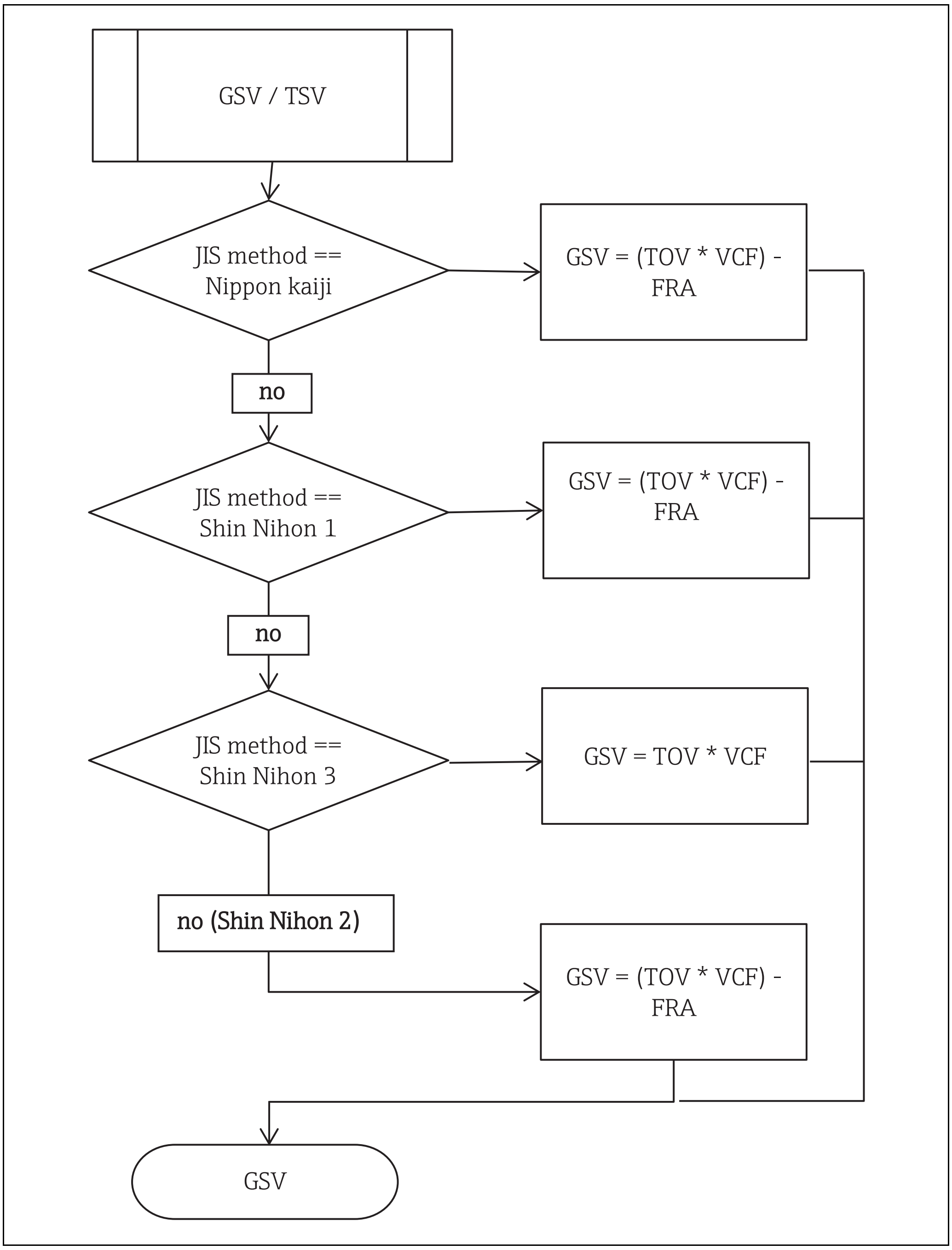
$$FRA = 0$$

JIS_FRA_No-FRA

Where:
- FRW = Floating Roof Weight

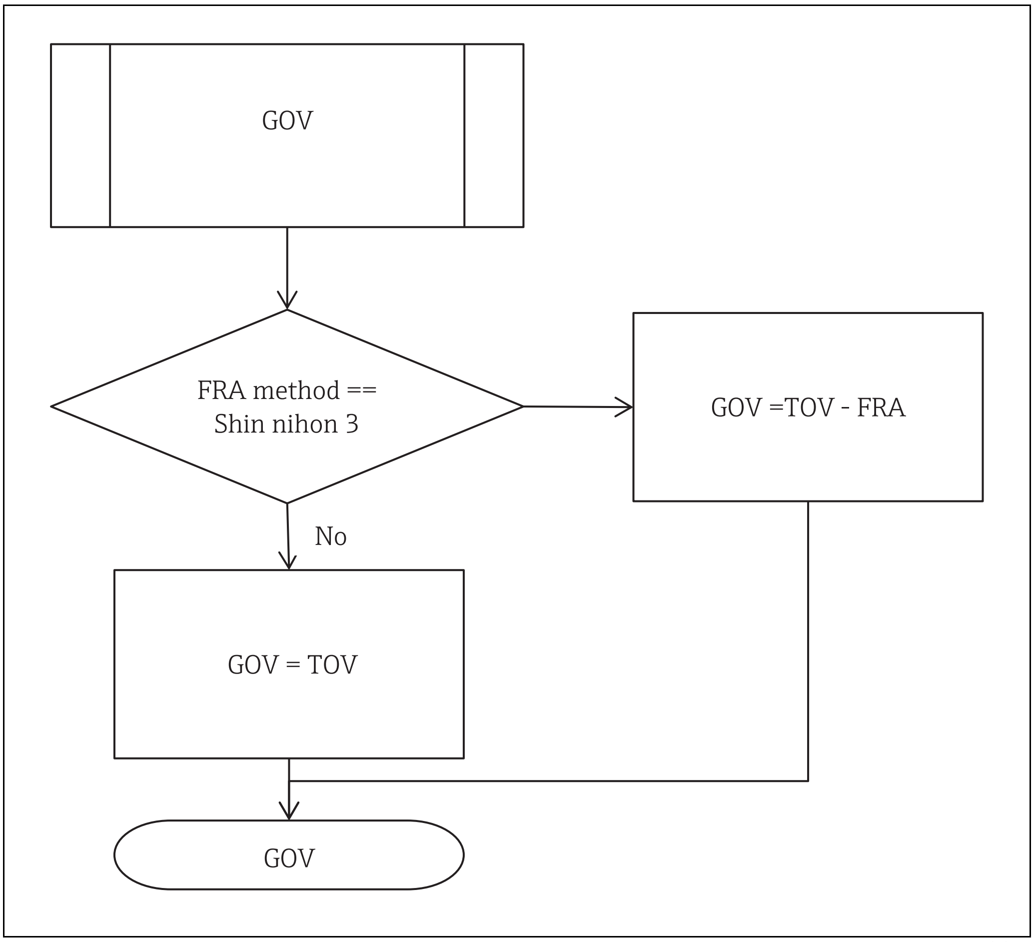
- FRP = Floating Roof Position
- ρ_{ref} = Reference Density
- BSG = calibration density from TCT
- F = VCF (Volume Correction Factor)

Dependent on this selection GSV is calculated in the following way.



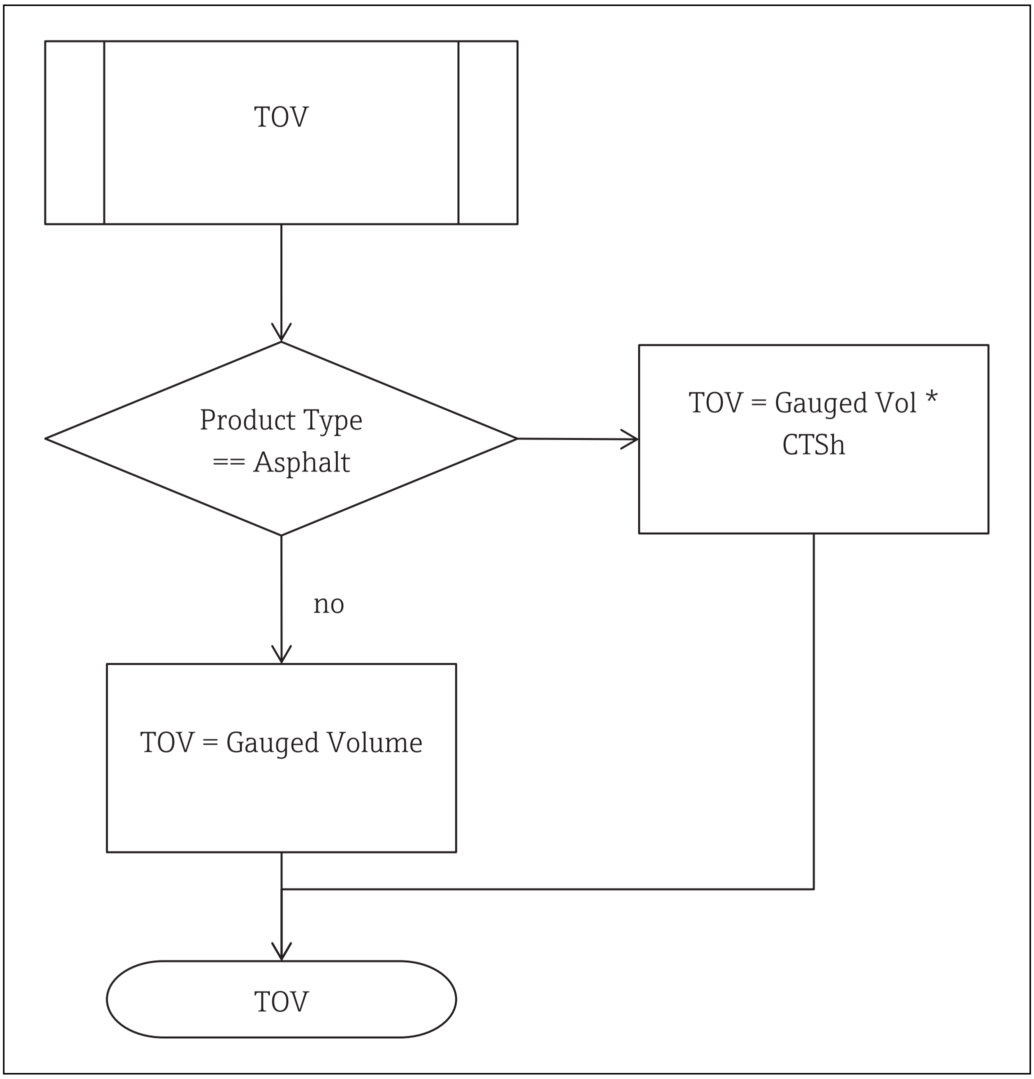
JIS_GSV-calculation

This selection influences also the GOV (Gross Observed Volume) calculation:



JIS_GOV-calculation

8.7.5 Tank Shell Correction - CTSh



JIS_TOV-calculation

If the product type is not Asphalt, CTSh is not calculated. CTSh uses the following formula:

To calculate CF,

$$CF = 1 + 3 \times \alpha \times (T - T_0)$$

JIS_CTSh_CF

Where:
- α = Thermal expansion coefficient
- T = Measured temperature (°C)
- T_0 = Calibration temperature (15 °C)

8.8 Annex A.1

Parameter Name	Gauge Map File Name/ HostLink Param Name	Report Tag Name	Parameter ID/ OPC Server Comm ID	SI Unit	Param Type
Product Level	P_LEVEL	PROD_LVL	622	m	Measured
Secondary Level	S_LEVEL	SECONDARY_LVL	623	m	Measured
Free Water Level	W_LEVEL	FREE_WATER_LEVEL	624	m	Measured
Product Temperature	P_TEMP	PROD_TEMP	625	℃	Measured
Vapour Temperature	V_TEMP	VAPOUR_TEMP	626	℃	Measured
Ambient Temperature	A_TEMP	AMBIENT_TEMP	660	℃	Measured
Vapour Pressure	V_PRESS	VAPOUR_PRESS	627	kPa	Measured
Observed Density	P_OBS_D	OBS_DENSITY	628	kg/m^3	Measured /Calculated
Reference Density	P_REF_D	REF_DENSITY	661	kg/m^3	Measured /Calculated
Lab Density	P_LAB_D	LAB_DENSITY	2887	kg/m^3	Measured
Product Pressure	P_PRESS	PRESSURE	692	kPa	Measured
Total Observed Volume	TOT_OBS_VOL	TOV	717	m^3	Calculated
Rem. Tank Capacity (Dead Stock)	REM_CAP_TANK	REM_CAP	718	m^3	Calculated
Available Volume	AVAIL_VOL	AVAIL_PROD	719	m^3	Calculated
Sediment and Water Volume	SED_W_VOL	SED_WATER_LEVEL	720	m^3	Calculated
Product Level Change Rate	P_LVLCHNG_RATE	PROD_LVL_CNG_RATE	721	mm/sec	Calculated
Volume Flow Rate	TOTOBS_FLW_RATE	TOV_FLOW_RATE	722	m^3/min	Calculated
Net Standard Flowrate	NETSTD_FLW_RATE	NSV_FLOW_RATE	723	m^3/min	Calculated
Mass Flow Rate	TOTMASS_FLW_RATE	TOT_MASS_FLOW_RATE	724	m^3/min	Calculated
Free Water Volume	FREE_W_VOL	FWV	725	m^3	Calculated
Gross Observed Volume	GROSS_OBS_VOL	GOV	726	m^3	Calculated
Total Standard Volume	TOT_STD_VOL	TSV	752	m^3	Calculated
Volume Correction Factor (VCF)	VCF	VOL_CORR_FACT	754	N.A.	Calculated
Vapour Mass	MASS_VAPR	MASS_IN_VAP	756	kg	Calculated
Net Weight in Air	NET_WGHT_AIR	NWA	760	kg	Calculated
Net Standard Weight	NET_STD_WGHT	NSW	761	kg	Calculated
Floating Roof Correction	F_ROOF_ADJUS	ROOF_CORRECTION	762	m^3	Calculated
Floating Roof Position	F_ROOF_POS	ROOF_POS	763	N.A.	Calculated
Tank Shell Correction Factor	TNK_SHELL_CORR	TSHELL_CORR_FACTOR	774	N.A.	Calculated
Gross Standard Volume	GROSS_STD_VOL	GSV	727	m^3	Calculated
Net Standard Volume	NET_STD_VOL	NSV	728	m^3	Calculated
Product Mass	P_MASS	MASS_IN_LIQ	729	kg	Calculated
Total Mass	TOT_MASS	TOT_MASS	730	kg	Calculated
Vapour Room Volume	VAPOUR_ROOM_VOL	VAPOUR_ROOM_VOL	1592	m^3	Calculated
Temperature Element 1	TEMP_1	TEMP_1	1634	℃	Measured
Temperature Element 2	TEMP_2	TEMP_2	1635	℃	Measured
Temperature Element 3	TEMP_3	TEMP_3	1636	℃	Measured
Temperature Element 4	TEMP_4	TEMP_4	1637	℃	Measured
Temperature Element 5	TEMP_5	TEMP_5	1638	℃	Measured

Parameter Name	Gauge Map File Name/ HostLink Param Name	Report Tag Name	Parameter ID/ OPC Server Comm ID	SI Unit	Param Type
Temperature Element 6	TEMP_6	TEMP_6	1639	℃	Measured
Temperature Element 7	TEMP_7	TEMP_7	1640	℃	Measured
Temperature Element 8	TEMP_8	TEMP_8	1641	℃	Measured
Temperature Element 9	TEMP_9	TEMP_9	1642	℃	Measured
Temperature Element 10	TEMP_10	TEMP_10	1643	℃	Measured
Temperature Element 11	TEMP_11	TEMP_11	1644	℃	Measured
Temperature Element 12	TEMP_12	TEMP_12	1645	℃	Measured
Temperature Element 13	TEMP_13	TEMP_13	1646	℃	Measured
Temperature Element 14	TEMP_14	TEMP_14	1647	℃	Measured
Temperature Element 15	TEMP_15	TEMP_15	1648	℃	Measured
Temperature Element 16	TEMP_16	TEMP_16	1649	℃	Measured
Temperature Element 17	TEMP_17	TEMP_17	1652	℃	Measured
Temperature Element 18	TEMP_18	TEMP_18	1653	℃	Measured
Temperature Element 19	TEMP_19	TEMP_19	1654	℃	Measured
Temperature Element 20	TEMP_20	TEMP_20	1655	℃	Measured
Temperature Element 21	TEMP_21	TEMP_21	1656	℃	Measured
Temperature Element 22	TEMP_22	TEMP_22	1657	℃	Measured
Temperature Element 23	TEMP_23	TEMP_23	1658	℃	Measured
Temperature Element 24	TEMP_24	TEMP_24	1659	℃	Measured
Temperature Position 1	TEMP_POS_1,	TEMP_POS_1	1660	m	Measured
Temperature Position 2	TEMP_POS_2,	TEMP_POS_2	1661	m	Measured
Temperature Position 3	TEMP_POS_3,	TEMP_POS_3	1662	m	Measured
Temperature Position 4	TEMP_POS_4,	TEMP_POS_4	1663	m	Measured
Temperature Position 5	TEMP_POS_5,	TEMP_POS_5	1664	m	Measured
Temperature Position 6	TEMP_POS_6,	TEMP_POS_6	1665	m	Measured
Temperature Position 7	TEMP_POS_7,	TEMP_POS_7	1666	m	Measured
Temperature Position 8	TEMP_POS_8,	TEMP_POS_8	1667	m	Measured
Temperature Position 9	TEMP_POS_9,	TEMP_POS_9	1668	m	Measured
Temperature Position 10	TEMP_POS_10	TEMP_POS_10	1669	m	Measured
Temperature Position 11	TEMP_POS_11	TEMP_POS_11	1670	m	Measured
Temperature Position 12	TEMP_POS_12	TEMP_POS_12	1671	m	Measured
Temperature Position 13	TEMP_POS_13	TEMP_POS_13	1672	m	Measured
Temperature Position 14	TEMP_POS_14	TEMP_POS_14	1673	m	Measured
Temperature Position 15	TEMP_POS_15	TEMP_POS_15	1674	m	Measured
Temperature Position 16	TEMP_POS_16	TEMP_POS_16	1675	m	Measured
Temperature Position 17	TEMP_POS_17	TEMP_POS_17	1676	m	Measured
Temperature Position 18	TEMP_POS_18	TEMP_POS_18	1677	m	Measured
Temperature Position 19	TEMP_POS_19	TEMP_POS_19	1678	m	Measured
Temperature Position 20	TEMP_POS_20	TEMP_POS_20	1679	m	Measured
Temperature Position 21	TEMP_POS_21	TEMP_POS_21	1680	m	Measured
Temperature Position 22	TEMP_POS_22	TEMP_POS_22	1681	m	Measured

Parameter Name	Gauge Map File Name/ HostLink Param Name	Report Tag Name	Parameter ID/ OPC Server Comm ID	SI Unit	Param Type
Temperature Position 23	TEMP_POS_23	TEMP_POS_23	1682	m	Measured
Temperature Position 24	TEMP_POS_24	TEMP_POS_24	1683	m	Measured
Alcohol Content in Mass	ALCOHOL_BY_MASS	ALCOHOL_BY_MASS	2101	%	Calculated
Alcohol Content in Volume	ALCOHOL_BY_VOLUME	ALCOHOL_BY_VOLUME	2102	%	Calculated
Sample Temperature	SAMPLE_TEMPERATURE	SAMPLE_TEMPERATURE	1551	℃	Measured
General Purpose Register 01	GP01	GP01	2601	N.A.	Measured
General Purpose Register 02	GP02	GP02	2602	N.A.	Measured
General Purpose Register 03	GP03	GP03	2603	N.A.	Measured
General Purpose Register 04	GP04	GP04	2604	N.A.	Measured
General Purpose Register 05	GP05	GP05	2605	N.A.	Measured
General Purpose Register 06	GP06	GP06	2606	N.A.	Measured
General Purpose Register 07	GP07	GP07	2607	N.A.	Measured
General Purpose Register 08	GP08	GP08	2608	N.A.	Measured
General Purpose Register 09	GP09	GP09	2609	N.A.	Measured
General Purpose Register 10	GP10	GP10	2610	N.A.	Measured
General Purpose Register 11	GP11	GP11	2611	N.A.	Measured
General Purpose Register 12	GP12	GP12	2612	N.A.	Measured
General Purpose Register 13	GP13	GP13	2613	N.A.	Measured
General Purpose Register 14	GP14	GP14	2614	N.A.	Measured
General Purpose Register 15	GP15	GP15	2615	N.A.	Measured
General Purpose Register 16	GP16	GP16	2616	N.A.	Measured
Protocol Alarm 1	PROTOCOL_ALARM_1	PROTOCOL_ALARM_1	2650	N.A.	Measured
Protocol Alarm 2	PROTOCOL_ALARM_2	PROTOCOL_ALARM_2	2651	N.A.	Measured
Protocol Alarm 3	PROTOCOL_ALARM_3	PROTOCOL_ALARM_3	2652	N.A.	Measured
Protocol Alarm 4	PROTOCOL_ALARM_4	PROTOCOL_ALARM_4	2653	N.A.	Measured
Percentage Level	PERCENTAGE_LEVEL	PERCENTAGE_LEVEL	2654	%	Measured /Calculated
VSP Volume	VSP_VOLUME	VSP_VOLUME	2700	m^3	Calculated
Gauge Error	GAUGE_ERROR	GAUGE_ERROR	2755	N.A.	Measured
Gauge Status	GAUGE_STATUS	GAUGE_STATUS	2756	N.A.	Measured
Analog Input	ANALOG_INPUT	ANALOG_INP	2841	%	Measured
HTMS Product Temperature	HTMS_P_TEMP	HTMS_P_TEMP	2201	℃	Calculated
Density Element 1	DENS_1	DENS_1	3001	kg/m^3	Measured
Density Element 2	DENS_2	DENS_2	3002	kg/m^3	Measured
Density Element 3	DENS_3	DENS_3	3003	kg/m^3	Measured
Density Element 4	DENS_4	DENS_4	3004	kg/m^3	Measured
Density Element 5	DENS_5	DENS_5	3005	kg/m^3	Measured
Density Element 6	DENS_6	DENS_6	3006	kg/m^3	Measured
Density Element 7	DENS_7	DENS_7	3007	kg/m^3	Measured
Density Element 8	DENS_8	DENS_8	3008	kg/m^3	Measured
Density Element 9	DENS_9	DENS_9	3009	kg/m^3	Measured
Density Element 10	DENS_10	DENS_10	3010	kg/m^3	Measured

Parameter Name	Gauge Map File Name/ HostLink Param Name	Report Tag Name	Parameter ID/ OPC Server Comm ID	SI Unit	Param Type
Density Element 11	DENS_11	DENS_11	3011	kg/m^3	Measured
Density Element 12	DENS_12	DENS_12	3012	kg/m^3	Measured
Density Element 13	DENS_13	DENS_13	3013	kg/m^3	Measured
Density Element 14	DENS_14	DENS_14	3014	kg/m^3	Measured
Density Element 15	DENS_15	DENS_15	3015	kg/m^3	Measured
Density Element 16	DENS_16	DENS_16	3016	kg/m^3	Measured
Density Element 17	DENS_17	DENS_17	3017	kg/m^3	Measured
Density Element 18	DENS_18	DENS_18	3018	kg/m^3	Measured
Density Element 19	DENS_19	DENS_19	3019	kg/m^3	Measured
Density Element 20	DENS_20	DENS_20	3020	kg/m^3	Measured
Density Element 21	DENS_21	DENS_21	3021	kg/m^3	Measured
Density Element 22	DENS_22	DENS_22	3022	kg/m^3	Measured
Density Element 23	DENS_23	DENS_23	3023	kg/m^3	Measured
Density Element 24	DENS_24	DENS_24	3024	kg/m^3	Measured
Density Element 25	DENS_25	DENS_25	3025	kg/m^3	Measured
Density Element 26	DENS_26	DENS_26	3026	kg/m^3	Measured
Density Element 27	DENS_27	DENS_27	3027	kg/m^3	Measured
Density Element 28	DENS_28	DENS_28	3028	kg/m^3	Measured
Density Element 29	DENS_29	DENS_29	3029	kg/m^3	Measured
Density Element 30	DENS_30	DENS_30	3030	kg/m^3	Measured
Density Element 31	DENS_31	DENS_31	3031	kg/m^3	Measured
Density Element 32	DENS_32	DENS_32	3032	kg/m^3	Measured
Density Element 33	DENS_33	DENS_33	3033	kg/m^3	Measured
Density Element 34	DENS_34	DENS_34	3034	kg/m^3	Measured
Density Element 35	DENS_35	DENS_35	3035	kg/m^3	Measured
Density Element 36	DENS_36	DENS_36	3036	kg/m^3	Measured
Density Element 37	DENS_37	DENS_37	3037	kg/m^3	Measured
Density Element 38	DENS_38	DENS_38	3038	kg/m^3	Measured
Density Element 39	DENS_39	DENS_39	3039	kg/m^3	Measured
Density Element 40	DENS_40	DENS_40	3040	kg/m^3	Measured
Density Element 41	DENS_41	DENS_41	3041	kg/m^3	Measured
Density Element 42	DENS_42	DENS_42	3042	kg/m^3	Measured
Density Element 43	DENS_43	DENS_43	3043	kg/m^3	Measured
Density Element 44	DENS_44	DENS_44	3044	kg/m^3	Measured
Density Element 45	DENS_45	DENS_45	3045	kg/m^3	Measured
Density Element 46	DENS_46	DENS_46	3046	kg/m^3	Measured
Density Element 47	DENS_47	DENS_47	3047	kg/m^3	Measured
Density Element 48	DENS_48	DENS_48	3048	kg/m^3	Measured
Density Element 49	DENS_49	DENS_49	3049	kg/m^3	Measured
Density Element 50	DENS_50	DENS_50	3050	kg/m^3	Measured
Density Position 01	DENS_POS_1	DENS_POS_1	3051	m	Measured

Parameter Name	Gauge Map File Name/ HostLink Param Name	Report Tag Name	Parameter ID/ OPC Server Comm ID	SI Unit	Param Type
Density Position 02	DENS_POS_2	DENS_POS_2	3052	m	Measured
Density Position 03	DENS_POS_3	DENS_POS_3	3053	m	Measured
Density Position 04	DENS_POS_4	DENS_POS_4	3054	m	Measured
Density Position 05	DENS_POS_5	DENS_POS_5	3055	m	Measured
Density Position 06	DENS_POS_6	DENS_POS_6	3056	m	Measured
Density Position 07	DENS_POS_7	DENS_POS_7	3057	m	Measured
Density Position 08	DENS_POS_8	DENS_POS_8	3058	m	Measured
Density Position 09	DENS_POS_9	DENS_POS_9	3059	m	Measured
Density Position 10	DENS_POS_10	DENS_POS_10	3060	m	Measured
Density Position 11	DENS_POS_11	DENS_POS_11	3061	m	Measured
Density Position 12	DENS_POS_12	DENS_POS_12	3062	m	Measured
Density Position 13	DENS_POS_13	DENS_POS_13	3063	m	Measured
Density Position 14	DENS_POS_14	DENS_POS_14	3064	m	Measured
Density Position 15	DENS_POS_15	DENS_POS_15	3065	m	Measured
Density Position 16	DENS_POS_16	DENS_POS_16	3066	m	Measured
Density Position 17	DENS_POS_17	DENS_POS_17	3067	m	Measured
Density Position 18	DENS_POS_18	DENS_POS_18	3068	m	Measured
Density Position 19	DENS_POS_19	DENS_POS_19	3069	m	Measured
Density Position 20	DENS_POS_20	DENS_POS_20	3070	m	Measured
Density Position 21	DENS_POS_21	DENS_POS_21	3071	m	Measured
Density Position 22	DENS_POS_22	DENS_POS_22	3072	m	Measured
Density Position 23	DENS_POS_23	DENS_POS_23	3073	m	Measured
Density Position 24	DENS_POS_24	DENS_POS_24	3074	m	Measured
Density Position 25	DENS_POS_25	DENS_POS_25	3075	m	Measured
Density Position 26	DENS_POS_26	DENS_POS_26	3076	m	Measured
Density Position 27	DENS_POS_27	DENS_POS_27	3077	m	Measured
Density Position 28	DENS_POS_28	DENS_POS_28	3078	m	Measured
Density Position 29	DENS_POS_29	DENS_POS_29	3079	m	Measured
Density Position 30	DENS_POS_30	DENS_POS_30	3080	m	Measured
Density Position 31	DENS_POS_31	DENS_POS_31	3081	m	Measured
Density Position 32	DENS_POS_32	DENS_POS_32	3082	m	Measured
Density Position 33	DENS_POS_33	DENS_POS_33	3083	m	Measured
Density Position 34	DENS_POS_34	DENS_POS_34	3084	m	Measured
Density Position 35	DENS_POS_35	DENS_POS_35	3085	m	Measured
Density Position 36	DENS_POS_36	DENS_POS_36	3086	m	Measured
Density Position 37	DENS_POS_37	DENS_POS_37	3087	m	Measured
Density Position 38	DENS_POS_38	DENS_POS_38	3088	m	Measured
Density Position 39	DENS_POS_39	DENS_POS_39	3089	m	Measured
Density Position 40	DENS_POS_40	DENS_POS_40	3090	m	Measured
Density Position 41	DENS_POS_41	DENS_POS_41	3091	m	Measured
Density Position 42	DENS_POS_42	DENS_POS_42	3092	m	Measured

Parameter Name	Gauge Map File Name/ HostLink Param Name	Report Tag Name	Parameter ID/ OPC Server Comm ID	SI Unit	Param Type
Density Position 43	DENS_POS_43	DENS_POS_43	3093	m	Measured
Density Position 44	DENS_POS_44	DENS_POS_44	3094	m	Measured
Density Position 45	DENS_POS_45	DENS_POS_45	3095	m	Measured
Density Position 46	DENS_POS_46	DENS_POS_46	3096	m	Measured
Density Position 47	DENS_POS_47	DENS_POS_47	3097	m	Measured
Density Position 48	DENS_POS_48	DENS_POS_48	3098	m	Measured
Density Position 49	DENS_POS_49	DENS_POS_49	3099	m	Measured
Density Position 50	DENS_POS_50	DENS_POS_50	3100	m	Measured
Floating Roof Tilt Level 1	FRT_LEVEL_1	FRT_LEVEL_1	3111	m	Measured
Floating Roof Tilt Level 2	FRT_LEVEL_2	FRT_LEVEL_2	3112	m	Measured
Floating Roof Tilt Level 3	FRT_LEVEL_3	FRT_LEVEL_3	3113	m	Measured
Floating Roof Tilt Delta Level	FRT_DELTA_LEVEL	FRT_DELTA_LEVEL	3114	m	Calculated
Floating Roof Tilt Delta Mass	FRT_DELTA_MASS	FRT_DELTA_MASS	3115	kg	Calculated

8.9 Annex A.2

Correction factors for CTSh (spheres (F') and horizontal cylindrical tanks (F''))

h/2r	Spherical f'	Horiztl. Cylinder f''	h/2r	Spherical f'	Horiztl. Cylinder f''
0.00			0.40	1.364	1.664
0.01	1.007	1.503	0.41	1.376	1.670
0.02	1.014	1.506	0.42	1.389	1.676
0.03	1.020	1.509	0.43	1.402	1.682
0.04	1.027	1.512	0.44	1.415	1.688
0.05	1.034	1.516	0.45	1.429	1.694
0.06	1.042	1.519	0.46	1.442	1.700
0.07	1.049	1.522	0.47	1.446	1.707
0.08	1.056	1.525	0.48	1.471	1.713
0.09	1.064	1.529	0.49	1.485	1.720
0.10	1.071	1.532	0.50	1.500	1.727
0.11	1.079	1.536	0.51	1.515	1.734
0.12	1.087	1.539	0.52	1.531	1.741
0.13	1.095	1.543	0.53	1.546	1.748
0.14	1.103	1.546	0.54	1.563	1.756
0.15	1.111	1.550	0.55	1.579	1.764
0.16	1.119	1.554	0.56	1.569	1.772
0.17	1.128	1.557	0.57	1.613	1.780
0.18	1.136	1.561	0.58	1.630	1.788
0.19	1.145	1.565	0.59	1.648	1.796
0.20	1.154	1.569	0.60	1.667	1.805
0.21	1.163	1.573	0.61	1.685	1.814
0.22	1.172	1.577	0.62	1.705	1.823
0.23	1.181	1.581	0.63	1.724	1.833
0.24	1.190	1.586	0.64	1.744	1.843
0.25	1.200	1.590	0.65	1.765	1.853
0.26	1.210	1.594	0.66	1.786	1.863
0.27	1.220	1.599	0.67	1.807	1.874
0.28	1.230	1.603	0.68	1.829	1.885
0.29	1.240	1.608	0.69	1.852	1.896
0.30	1.250	1.613	0.70	1.875	1.907
0.31	1.261	1.617	0.71	1.899	1.920
0.32	1.271	1.622	0.72	1.923	1.932
0.33	1.282	1.627	0.73	1.948	1.945
0.34	1.293	1.632	0.74	1.974	1.958
0.35	1.304	1.637	0.75	2.000	1.972
0.36	1.316	1.642	0.76	2.027	1.986
0.37	1.327	1.648	0.77	2.055	2.001
0.38	1.339	1.653	0.78	2.083	2.017
0.39	1.351	1.658	0.79	2.113	2.033

8.10 Annex A.3

Example CTSh calculations

Tank Type	Vertical Cylindrical	Vertical Cylindrical	Vertical Cylindrical	Spherical	Vertical Cylindrical
Vessel Radius	n.a.	n.a.	n.a.	17.253	n.a.
Product Level	n.a.	n.a.	n.a.	4.6	n.a.
α1 (apha)	6.2 x 10^-6	6.2 x 10^-6	0.000011	110 x 10^-7	6.2 x 10^-6
αs	4.01E-09	0	0	n.a.	4.01E-09
Tcal	60 ℉	60 ℉	15 ℃	20 ℃	60 ℉
Tprod	300 ℉	300 ℉	-43 ℃	23.5 ℃	88.3 ℉
Tamb	70 ℉	70 ℉		n.a.	74.5 ℉
Ifs	0.875	0.875	1	1	0.875
CTSh	1.00279801	1.0026195	0.998724	1.000047	1.00032

8.11 Annex A.4

API Calculation VCF Tables

VCF TABLE	Reference Temperature	Reference Temperature Unit	Generalized Crudes	Generalized Refined Products	Special Application	Generalized Lubricants	Asphalts	Palm Oil	Chemicals	Industrial Aromatics	LPG
ASTM D1250-80 -Table 24A	60	F	X								
ASTM D1250-80 -Table 24B	60	F		X							
ASTM D1250-80 -Table 24C	60	F			X						
ASTM D1250-80 -Table 24D	60	F				X					
ASTM D1250-80 -Table 54A	15	C	X								
ASTM D1250-80 -Table 54B	15	C		X							
ASTM D1250-80 -Table 54C	15	C			X						
ASTM D1250-80 -Table 54D	15	C				X					
IP PMP No. 3 (1988) -Table 60A	20	C	X								
IP PMP No. 3 (1988) -Table 60B	20	C		X							
IP PMP No. 3 (1988) -Table 60C	20	C			X						
IP PMP No. 3 (1988) -Table 60D	20	C				X					
ASTM D1250-80 -Table 6A	60	F	X								
ASTM D1250-80 -Table 6B	60	F		X							
ASTM D1250-80 -Table 6C	60	F			X						
ASTM D1250-80 -Table 6D	60	F				X					
GPA TP-25 Table 24E	60	F									X
GPA TP-27 Table 24E	60	F									X
GPA TP-27 Table 54E	15	C									X
GPA TP-27 Table 60E	20	C									X

VCF TABLE	Reference Temperature	Reference Temperature Unit	Generalized Crudes	Generalized Refined Products	Special Application	Generalized Lubricants	Asphalts	Palm Oil	Chemicals	Industrial Aromatics	LPG
TCF Method	15	-1	X	X	X	X	X		X	X	
ASTM D4311-96M	15	C					X				
ASTM D4311-96I	60	C					X				
ASTM D1555 - Industrial Aromatic HC	60	F								X	
ASTM D1555M - Industrial Aromatic HC	15	C								X	
ASTM D1250-1953 - Table 54 for LHC	15	C						X			
M B & Redwood VCF	15	C									X
Chemical 1	15	-1							X		
Palm Oil	15	-1						X			
1/DCF	0	C	X	X	X	X	X	X	X	X	X
ASTM D1250-04 -Table 24A	60	F	X								
ASTM D1250-04 -Table 24B	60	F		X							
ASTM D1250-04 -Table 24C	60	F			X						
ASTM D1250-04 -Table 24D	60	F				X					
ASTM D1250-04 -Table 54A	15	C	X								
ASTM D1250-04 -Table 54B	15	C		X							
ASTM D1250-04 -Table 54C	15	C			X						
ASTM D1250-04 -Table 54D	15	C				X					
ASTM D1250-04 -Table 60A	20	C	X								
ASTM D1250-04 -Table 60B	20	C		X							
ASTM D1250-04 -Table 60C	20	C			X						
ASTM D1250-04 -Table 60D	20	C				X					
ASTM D1250-04 -Table 6A	60	F	X								
ASTM D1250-04 -Table 6B	60	F		X							
ASTM D1250-04 -Table 6C	60	F			X						
ASTM D1250-04 -Table 6D	60	F				X					
ASTM D1250-80 -Table 24A	60	F	X								
ASTM D1250-80 -Table 24B	60	F		X							
ASTM D1250-80 -Table 24C	60	F			X						
ASTM D1250-80 -Table 24D	60	F				X					
ASTM D1250-80 -Table 54A	15	C	X								
ASTM D1250-80 -Table 54B	15	C		X							
ASTM D1250-80 -Table 54C	15	C			X						
ASTM D1250-80 -Table 54D	15	C				X					
IP PMP No. 3 (1988) -Table 60A	20	C	X								

8.12 Annex A.5

API Calculation RDC Tables

RDC TABLE	Ref. Temp.	Ref. Temp. Unit	Gen. Crudes	Gen. Refined Products	Spec. Appl.	Gen. Lubricants	Asphalts	Palm Oil	Chemicals	Ind. Aromatics	LPG
ASTM D1250-80 -Table 23A	60	F	X								
ASTM D1250-80 -Table 23B	60	F		X							
ASTM D1250-80 -Table 23D	60	F				X					
ASTM D1250-80 -Table 53A	15	C	X								
ASTM D1250-80 -Table 53B	15	C		X							
ASTM D1250-80 -Table 53D	15	C				X					
ASTM D1250-80 -Table 59A	20	C	X								
ASTM D1250-80 -Table 59B	20	C		X							
ASTM D1250-80 -Table 59D	20	C				X					
ASTM D1250-80 -Table 5A	60	F	X								
ASTM D1250-80 -Table 5B	60	F		X							
ASTM D1250-80 -Table 5D	60	F				X					
GPA TP-25 Table 23E	60	F									X
GPA TP-27 Table 23E	60	F									X
GPA TP-27 Table 53E	15	C									X
GPA TP-27 Table 59E	20	C									X
M B & Redwood DCF	15	C									X
Chemical 1	15	-1							X		
Palm Oil	15	-1						X			
RDC = 1 / VCF	0	C	X	X	X	X	X	X	X	X	X
T.P.D.Table	15	C	X	X	X	X	X	X	X	X	X
ASTM D1250-04 -Table 23A	60	F	X								
ASTM D1250-04 -Table 23B	60	F		X							
ASTM D1250-04 -Table 23D	60	F				X					
ASTM D1250-04 -Table 53A	15	C	X								
ASTM D1250-04 -Table 53B	15	C		X							
ASTM D1250-04 -Table 53D	15	C				X					
ASTM D1250-04 -Table 59A	20	C	X								
ASTM D1250-04 -Table 59B	20	C		X							
ASTM D1250-04 -Table 59D	20	C				X					
ASTM D1250-04 -Table 5A	60	F	X								
ASTM D1250-04 -Table 5B	60	F		X							
ASTM D1250-04 -Table 5D	60	F				X					

8.13 Annex A.6

GBT Calculation VCF Table

Table Name	Reference Temperature	Reference Temperature Unit	Generalized Crudes	Generalized Refined Products	Generalized Lubricants
IP PMP No. 3 (1988) -Table 60A	20	C	X		
IP PMP No. 3 (1988) -Table 60B	20	C		X	
IP PMP No. 3 (1988) -Table 60D	20	C			X
ASTM D1250-04 -Table 60A	20	C	X		
ASTM D1250-04 -Table 60B	20	C		X	
ASTM D1250-04 -Table 60D	20	C			X

8.14 Annex A.7

GBT Calculation RDC Tables

Table Name	Reference Temperature	Reference Temperature Unit	Generalized Crudes	Generalized Refined Products	Generalized Lubricants
ASTM D1250-80 -Table 59A	20	C	X		
ASTM D1250-80 -Table 59B	20	C		X	
ASTM D1250-80 -Table 59D	20	C			X
T.P.D.Table	15	C	X	X	X
ASTM D1250-04 -Table 23A	60	F	X		
ASTM D1250-04 -Table 23B	60	F		X	
ASTM D1250-04 -Table 23D	60	F			X
ASTM D1250-04 -Table 59A	20	C	X		
ASTM D1250-04 -Table 59B	20	C		X	
ASTM D1250-04 -Table 59D	20	C			X

8.15 Documentation

Document	Instrument	Description
TI00419G/00/EN	Tankvision	Inventory Management System with completely integrated software for operation via standard web browser
TI01252G/00/EN	Micropilot NMR81	Micropilot NMR8 Series intelligent tank gauges are designed for high accuracy liquid level measurement in storage and process applications. They fulfill the exacting demands of tank inventory management, inventory control, custody transfer, loss control, total cost saving, and safe operation.
TI01253G/00/EN	Micropilot NMR84	
TI01248G/00/EN	Proservo NMS80	Proservo NMS8x Series intelligent tank gauges are designed for high accuracy liquid level measurement in storage and process applications. They fulfill the exacting demands of tank inventory management, inventory control, custody transfer, loss control, total cost saving, and safe operation.
TI01249G/00/EN	Proservo NMS81	
TI01250G/00/EN	Proservo NMS83	

Document	Instrument	Description
TI01251G/00/EN	Tankside Monitor NRF81	Tankside Monitor NRF81 is a robust gateway for collecting and integrating tank gauging data in storage and process applications. It fulfills the exacting demands of tank inventory management, inventory control, custody transfer, loss control, total cost saving, and safe operation.
TI00452G/08/EN	Proservo NMS5	Intelligent tank gauge with high accuracy performance Liquid level, I/F, Density & Density Profile
TI00402F/00/EN	Tank Side Monitor NRF590	Field device for tank sensor operation and monitoring and for integration into inventory control system
TI00344F/00/EN	Micropilot S FMR531	Continuous level transmitter for continuous and non-contact precision level measurement. For custody transfer and inventory control applications with NMi- and PTB-approvals
TI01122F/00/EN	Micropilot S FMR532	
TI00344F/00/EN	Micropilot S FMR533	
TI01123F/00/EN	Micropilot S FMR540	Continuous level transmitter for continuous and non-contact precision level measurement. For custody transfer and inventory control applications with NMi and PTB approvals
TI00042G/08/EN	Prothermo NMT539	Intrinsically safe multi-signal converter with precision average temperature and water bottom sensor for inventory control and custody transfer applications
TI00049G/08/EN	Prothermo NMT532	Intrinsically safe multi-signal converter with precision average temperature sensor for inventory control
TI00345F/00/EN	Micropilot M FMR23x, FMR24x	Continuous and non-contact level measurement. Cost-effective 4 to 20 mA 2-wire technology. Suitable for hazardous locations.
TI00358F/00/EN	Levelflex M FMP40	Continuous Level Transmitter for: - Level Measurement in Bulk Solids and Liquids - Interface Measurement in Liquids
TI01001F/00/EN	Levelflex FMP51, FMP52, FMP54	Level and interface measurement in liquids
TI00436P/00/EN	Cerabar M PMC51, PMP51, PMP55	Pressure transmitter with ceramic and metal sensors; With analog electronics or communication via HART, PROFIBUS PA or FOUNDATION Fieldbus
TI00383P/00/EN	Cerabar S PMC71, PMP71, PMP75	Pressure transmitter with ceramic and metal sensors Overload-resistant and function-monitored; Communication via HART, PROFIBUS PA or FOUNDATION Fieldbus
TI00434P/00/EN	Deltabar M PMD55	Differential presure transmitter with metal sensor Communication via HART, PROFIBUS PA or FOUNDATION Fieldbus
TI00382P/00/EN	Deltabar S PMD70/75, FMD76/77/78	Differential pressure transmitter with ceramic and silicon sensors; Overload-resistant and function monitored; Communication via HART, PROFIBUS PA or FOUNDATION Fieldbus
TI00401F/00/EN	Liquicap M FMI51, FMI52	For continuous measurement in liquids

Document	Instrument	Description
BA00340G/00/EN	Tankvision	Tank Scanner NXA820, Data Concentrator NXA821, Host Link NXA822
BA00339G/00/EN	Tankvision	Tank Scanner NXA820, Data Concentrator NXA821, Host Link NXA822
BA00424G/00/EN	Tankvision	Tank Scanner NXA820, Data Concentrator NXA821, Host Link NXA822
BA01137G/00/EN	Tankvision	Tankvision NXA820 OPC Server

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