



Exploration & Production

GENERAL SPECIFICATION

INSTRUMENTATION

GS INS 111

**Design and supply of liquid custody transfer
metering units**

01	10/03	Revised as per marking – Change of Group name and logo
00	10/02	First Issue
Rev.	Date	Notes



Contents

1. Scope	3
2. Reference documents.....	3
3. Deviations or restrictions from reference documents	4
3.1 Measurement of gross volumes	4
3.2 Use of "Universal performance curve".....	4
3.3 Deviation from section 7.2.4 of the API: temperature measurement.....	4
3.4 Pressure and temperature measurements to determine quantities	5
3.5 Measurement of water content and density.....	5
4. Additional specifications.....	5
4.1 Uncertainty on quantities measured	5
4.2 Expression of results.....	6
4.3 Prover loop	6
4.4 Sampling.....	6
4.5 General arrangement of the unit	7
4.6 Arrangement of the computing system.....	7
4.7 Particular points	9
5. Documentation	10
6. Tests.....	11
6.1 Factory tests of the turbine.....	11
6.2 Prover loop calibration	11
6.3 Factory tests of the unit.....	11
6.4 Site tests.....	11



1. Scope

This document defines the minimum requirements for the design of liquid metering units intended for installation at custody transfer points.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
IEC 60079	Electrical apparatus for explosive gas atmospheres
ISO 4124	Liquid hydrocarbons -- Dynamic measurement -- Statistical control of volumetric metering systems
ANSI/ISA-5.1	Instrumentation Symbols and Identification

Professional Documents

Reference	Title
API	Manual of Petroleum Measurement Standards

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	



Total General Specifications

Reference	Title
GS PVV 112	Piping materials classes
GS PVV 211	Design and fabrication of pressure vessels according to ASME VIII
GS PVV 771	Thermal insulation (hot service)
GS COR 350	External protection of offshore and related structures and equipment by painting
GS INS 101	Instrumentation engineering, supply and construction general requirements

3. Deviations or restrictions from reference documents

In ranges where MPMS or ISO allow for consideration of turbines or positive displacement meters, turbines shall be used preferably to positive displacement meters. Positive displacement meters shall be used only for crude oil with viscosity greater than the viscosity handled by turbines.

3.1 Measurement of gross volumes

Where turbines are selected, they shall be with helical blades. Each flow metering element shall have two (2) detectors, one for metering and the other for checking the readings of the first one.

For light hydrocarbons, the use of Coriolis meters can be considered.

Ultra-sonic devices shall be reserved to very specific uses where other techniques are not practical. A careful study shall be made and an extensive qualification program shall be run.

3.2 Use of "Universal performance curve"

The "Universal performance curve" (also known as "Q/V" curve) specified by [ISO 4124](#) can be applied in case of fluctuations of the flow-rate and / or the viscosity at operating conditions.

The CONTRACTOR shall indicate the acceptable range of flow-rates and acceptable range of viscosity within which the meter factor remains valid. The calculation of acceptable ranges of flow rates shall be performed around the nominal flow-rate of the unit and the calculation for viscosity shall be performed around the nominal viscosity of each crude to be measured.

An alarm shall be activated every time the actual flow rate or viscosity are out of the ranges for which the meter factor is valid.

3.3 Deviation from section 7.2.4 of the API: temperature measurement

Temperatures shall be measured to within $\pm 0.1^{\circ}\text{C}$. The piping shall be heat insulated 50 cm either side of the thermowell and the head of measuring device shall be included in the heat insulation.

The calibration loop shall be fitted with one thermowell at the loop inlet and another at the loop outlet.

3.4 Pressure and temperature measurements to determine quantities

Each temperature and pressure used to calculate the quantities shall be measured by two separate devices. One device shall supply the measurement required for the calculation and the other shall check the measurement. The difference between the two measurements shall be monitored and, if it exceeds a pre-set value, shall generate an alarm at the operator interface.

If this "Pay and Check" system is not economically justified, a validation of the measurements may be done by software comparison between the measurements of devices that should give the same readings (for instance the TT's that are on the meter runs).

3.5 Measurement of water content and density

3.5.1 Case of systems dedicated to batches

Measurement shall be as specified in the MPMS. The reports shall be generated from the laboratory measurements. It shall be possible to include the laboratory measurement result of the water content in the calculations before the measurement ticket is produced.

3.5.2 Case of systems dedicated to continuous measurements

The water shall be measured with an online analyser, preferably installed directly on the main stream line.

An automatic sampling shall also be used as a back-up solution.

An online density measurement will be considered on a case by case basis.

3.5.3 Special case of high water content and low available homogenisation energy

Void.

4. Additional specifications

4.1 Uncertainty on quantities measured

This includes the uncertainties concerning:

- Gross volume, temperature and pressure measuring instruments.
- Signal conversion instruments and calculation algorithms.
- Volume of the calibration loop.
- Variations in flow and consistency of the crude (density and viscosity) between two calibrations.
- Characteristics of the flow measurement device.

The degree of uncertainty on the measurement of the delivered quantity (standard gross) shall be less than $\pm 0.1 \%$.

Lower uncertainties may be acceptable depending on economical conditions or financial risks. However, the uncertainty shall never exceed $\pm 0.25 \%$.



4.2 Expression of results

The metered volumes shall be expressed in US barrels at 60°F / 14.696 psia and in m³ at 15°C / 1.01325 bara.

4.3 Prover loop

If it is not practical to operate a prover loop or if a prover loop is not economically justified, the "Universal performance curve" or other methods like master meter may also be used.

If the metering unit includes a prover loop, it shall be bi-directional. It may be of the "small volume" type, but not of the "piston" type.

4.3.1 Initial calibration of the prover loop

This shall be done using the "water draw" method. The volume shall be the average of three consecutive readings within the range specified in the MPMS.

The uncertainty of the measurement shall be calculated.

4.3.2 Construction of the prover loop/tools

If, during a meter proof (for a flow rate corresponding to the normal rate measured by a turbine), the climatic conditions are likely to alter the fluid temperature by more than $\pm 0.05^{\circ}\text{C}$ as it passes through the loop, the loop shall be insulated. Note that $\pm 0.05^{\circ}\text{C}$ is a value that is calculated based on expected atmospheric and process conditions.

All precautions shall be taken to ensure that no paraffin deposit can build up in the loop (insulation and, if necessary, electrical trace heating). A way of cleaning the loop by flushing with a non waxy fluid shall be applied.

The launching chambers of the spheres shall be vertical.

The loop shall include a double set of sphere detectors defining two different volumes.

The loop shall be fitted with all the taps needed to measure, on site, its internal volume using the "water draw" method or equivalent.

The loop shall be fitted with necessary tackle assembly and tools to take the sphere out of the launching chamber.

The supply shall include a sizing ring designed to fit the diameter of the inflated sphere, a spare sphere and a net to store it.

4.3.3 Operation of the prover

It shall be possible to prove the turbines at any flow-rate commonly encountered during normal operations.

4.4 Sampling

The metering unit must have an automatic flow proportional sampling system.

The calculations used to determine the location of the sampling probe shall be approved by an independent authority.

The sample receptacle shall have a minimum capacity of 20 litres. It shall protect the sample from the atmosphere.



A sample homogenizer shall be supplied. It shall produce sample partitions, which are identical in composition. The size of the water droplets produced by the homogenisation shall be compatible with laboratory measurement techniques used to determine water content.

The sampler performance factor shall be automatically calculated and printed out with the measurement ticket.

Every precaution shall be taken to ensure that there is no risk of paraffin deposit in the sample receptacle or in the sampler lines (trace heating and insulation).

4.5 General arrangement of the unit

The flow being measured shall be equally divided between the lines in use.

It shall be possible to measure the nominal flow rate with one line stopped (kept available as a backup, ready to be brought into service at any time).

Any measurement fault on a line (failure of the flow computer, of a turbine detector, measuring pressure or temperature transmitter, etc.) shall cause the line to be automatically isolated. In the cases where isolation could cause technical problems or damages, only an alarm shall be raised.

All piping (by-passes, drains, etc.) not shown on the typical API diagram and likely to divert the oil after it has been metered must be fitted with a "double block and bleed" system (combinations of valves and blind flanges are acceptable depending on the practicality of the operations). The piping shall be designed and arranged to ensure that the pressure relief valves are upstream of the turbines.

Metering systems shall be designed and supplied to take into account all aspects related to safety, space, location and operation constraints. They can be delivered in separate modules provided performances are guaranteed.

Environmental and external conditions like sun, flare ...which can generate failure, errors or generate difficulties in operation shall be considered.

Systems shall be designed, installed and operated in accordance with safety & environmental rules. Special care shall be paid for instance to sampling, venting, degassing, draining, over pressures due to quick closure of valves on the take off tanker...

4.6 Arrangement of the computing system

4.6.1 Flow computers

Each run line shall have its own computer capable of indicating the oil volume readings converted to standard conditions. It shall be possible to generate the measurement ticket and the proving report from the data issued by these computers (fallback solution if there is a failure of the higher level computer).

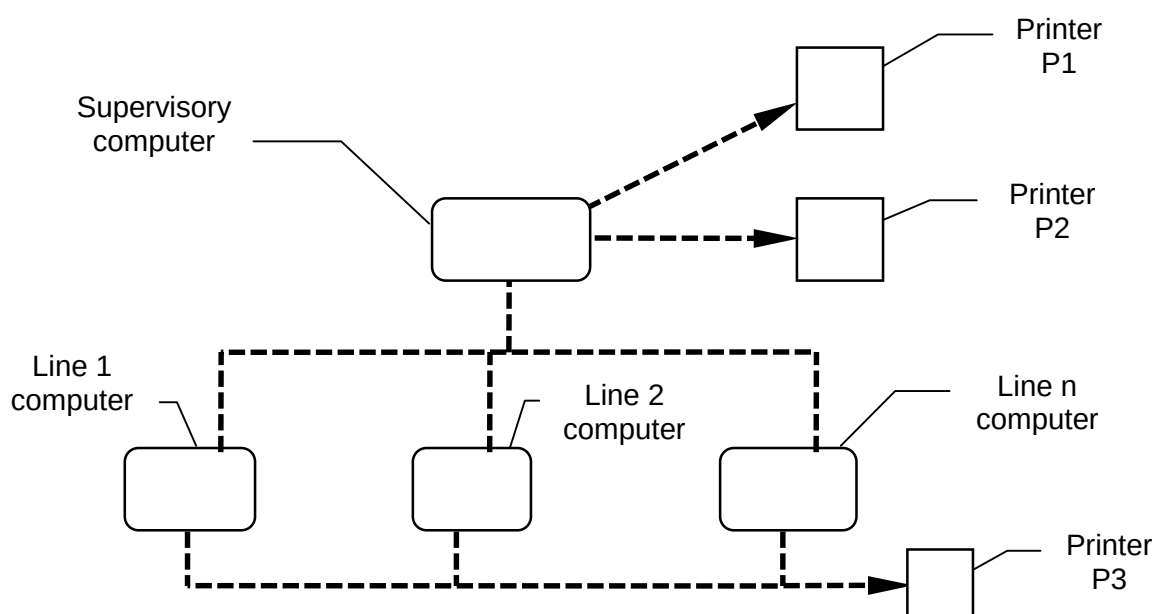
4.6.2 Higher level computer

A higher level computer shall:

- Centralise the measurements taken by all the flow computers of the lines in service
- Control the sampling units
- Print out the reports (the measurement ticket, the proving report and the sampling report) according to MPMS format.

- Print out the intermediate reports (systematically and at the operator's request), the alarms and the configuration of the flow computers.
- Store all meter factors of each turbine and elaborate follow-up charts as described in MPMS. Store all performance factors of the sampling unit and elaborate similar charts as for meter factors
- Allow for the control of the metering unit by an operator.

4.6.3 Bloc diagram for a regular availability system



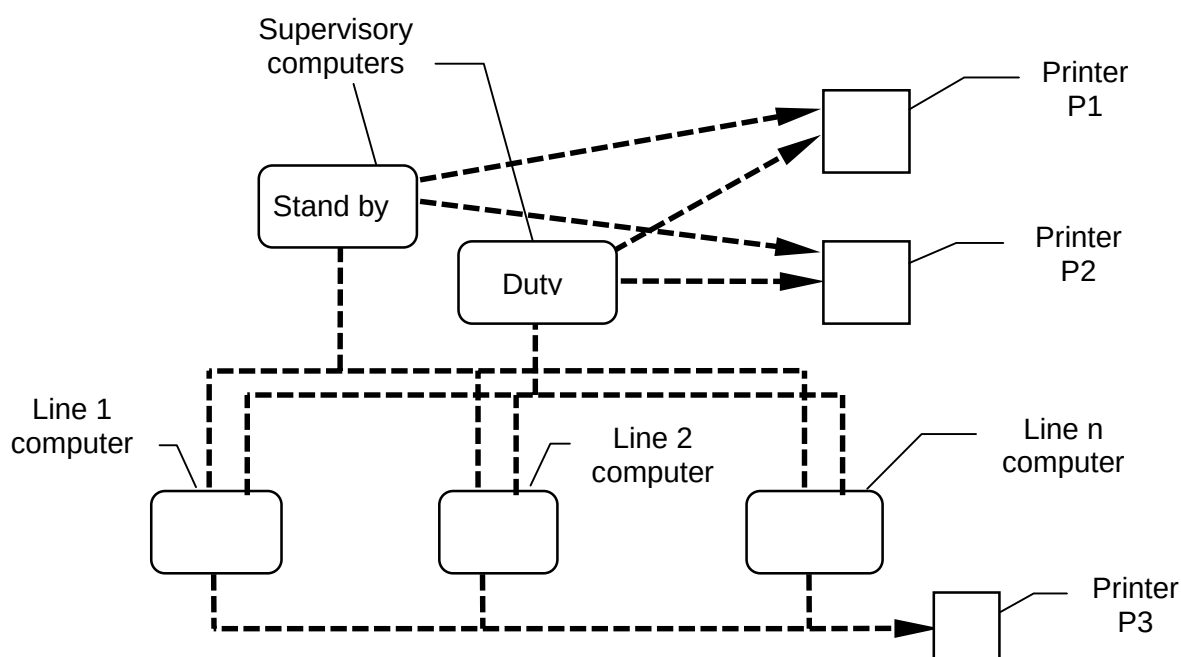
4.6.4 Enhanced availability

Dual redundancy at the supervisory system level can be applied if extreme availability is requested.

“Hot redundancy” of supervisory computers shall be avoided because it is extremely difficult to make it reliable. Manual switching on of a spare computer standing next to the duty one shall be preferred.

The robustness of the supervisory system shall be evaluated through its sensitivity to spurious power shut downs and communication failures applied randomly at any device of the network. It is recommended to reject a system that could not cope with that.

Recommended Bloc diagram for an enhanced availability computing system :



Dual redundancy shall be applied to the communication network too.

4.7 Particular points

The metering unit shall have all branch points and clearances needed to carry out profile tests as per MPMS Chapter 8 section 2.

Every precaution shall be taken to avoid a wax build-up in the measurement runs and the instruments impulse lines (insulation, electrical trace heating, etc.).

The supply shall include fine mesh filters (3 mm) which can temporarily be fitted into the filters during the flushing operations.

During start-up or after heavy maintenance operations of the upstream piping, the flow shall not be routed through the unit to avoid damages to the measuring devices.

The differential pressure meter monitoring the pressure drop caused by the filter, as required by the MPMS, must be fitted with an alarm that is relayed to the operator interface.

Beneath the metering unit, there shall be a pan to collect drips. The slope of the drip-pan shall be 5 %. The low point shall have a 2 inch drain equipped with a liquid trap (gooseneck).

The measurement lines shall be fitted with lifting tackle to lift out the filters and handle the turbines.

Housing of electronic equipment exposed to the weather shall be of stainless steel.

Each device or item of equipment shall be identified by a firmly attached, stamped stainless steel plate.

5. Documentation

The unit shall be supplied with:

- A dossier containing all information needed for the approval of the authorities of the country where the unit is to be installed.
- The unit documentation, including the operating and maintenance manuals in the language appropriate to the site of use.
- The certificates issued by the MANUFACTURER or his SUBCONTRACTORS stating that the equipment complies with the specified standards.
- The certified calculations of an independent, professionally recognised authority showing that the equipment and procedures used by the MANUFACTURER are capable of measuring to the degree of uncertainty specified in the section entitled "Uncertainty on quantities measured".
- The calculations of the accuracy of the measurement of the base volume of the prover loop.
- The calculations of the temperature variations in the fluid passing through the prover loop during a proving of a turbine.
- The calculations justifying the position of the sampling probe and the approval of those calculations by an independent authority. If an on line water analyser is used on line, the certificates specified in chapter 3.5.3.
- The calculations of the acceptable variations in flow rates and viscosity.
- Process calculation including pressure drop calculation, back pressure calculations, sampling flow loops calculations, ...
- The report of the initial calibration of the turbine meters, produced by an independent authority.
- The report of the initial loop calibration, produced by an independent authority.
- The unit factory test report.
- Availability calculations.
- Operating parameters calculations like filling and degassing time when required.
- A first version of Metering unit handbook.



6. Tests

The test procedure shall be submitted to the COMPANY for comments at least 60 days before the planned date of the FAT.

The report of internal tests shall be sent together with the confirmation of the date of the test.

All tests shall be witnessed by COMPANY.

6.1 Factory tests of the turbine

The turbine tests at the factory shall include proving at a viscosity as close as possible to the most viscous crude to be measured across the range of flow rates from 10 to 100 % of the turbine maximum capacity.

6.2 Prover loop calibration

It shall be done at the factory and witnessed by COMPANY.

6.3 Factory tests of the unit

The tests of the unit at the factory shall include:

- A test of water flow rate, at the rated nominal flow of a measurement run. During this test, the unit head loss shall be measured with a DP cell and all the instruments and the sampling unit shall be checked for correct operation.
- Determination of the meter factor of the turbines on water with the calibration loop. The repeatability of the meter factor shall comply with the MPMS.
- Flow calculations formulae and operator interface test.

6.4 Site tests

Tests on site shall include:

- A check of the repeatability of the meter factor (on crude).
- A check of the temperature change throughout the calibration loop during a proving operation.
- A profile test if the mixing energy is close to the minimum acceptable value.