

GENERAL SPECIFICATION

INSTRUMENTATION

GS EP INS 112

Design and supply of gas custody transfer metering units

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1. Scope

This document defines the minimum requirements for the design and supply of gas metering units intended for custody transfer points, for allocation or sale purposes.

This specification applies to continuous transfer (pipeline metering) of single phase gas with no liquid and no solid particles.

Metering design and supply shall also be in accordance with principles and operational metering requirements described in the project metering philosophy document.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
IEC 60079	Parts related to the Electrical apparatus for explosive gas atmospheres
ISO 17025	General requirements for the competence of testing and calibration laboratories
ISO 17089-1	Measurement of fluid flow in closed conduits-ultrasonic meters for gas - Part 1: Meters for custody transfer and allocation
ISO 5167	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 1: General principles and requirements - Part 2: Orifice plates
ISO 5168	Measurement of fluid flow - Evaluation of uncertainties
ISO 9951	Measurement of gas in closed conduits. Turbine meters
ISO/CEI guide 98-1	Introduction to the expression of uncertainty in measurement
IML R 137-1	Legal Metrology: Gas meters - Part 1: Requirements

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Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP ECP 103	Process sizing criteria
GS EP ELE 079	Electrical apparatus for potentially explosive gas atmospheres
GS EP INS 101	Instrumentation engineering, supply and construction general requirements
GS EP INS 110	Instrumentation for package units
GS EP INS 900	Instrument hook-up diagrams
GS EP PVV 112	Piping material classes
GS EP PVV 142	Valves
GS EP PVV 211	Design and fabrication of pressure vessels according to ASME VIII
GS EP PVV 771	Thermal insulation (hot service)

3. Basis for metering system design

Design of gas custody transfer metering systems shall be performed in compliance with:

- Local regulations
- Contracts and agreement in force
- Uncertainty target
- Process conditions (pressure, temperature, flow rate ranges), pressure drop in the custody transfer metering system, maximum velocity
- Fluid properties and analysis (gas composition, water content, dew point pressure, erosion or deposition risks, etc.)
- Location
- Installation constraints.

4. Standards

ISO shall be used. AGA or API equivalent standards can be used in addition for some specific points or if there are specific requirements due to regulations or agreements. For a better consistency, it is recommended to select for the design of the metering unit either one, or the other standard, without mixing them.

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5. Units and base conditions

ISO units and reference conditions shall generally be used:

- Standard volumes Sm^3 at 15°C and 1.01325 bar abs
- Mass tons
- Energy MJ or GJ

Others units can be used if required by local regulations or specific agreements.

6. Metering system uncertainty for measured quantities

6.1 Quantity measurements

Global uncertainty to be obtained on quantity for the total metering unit shall range between 0.5% maximum for high accuracy systems and 1%.

On a case by case basis, higher uncertainties may be specified and accepted by Company (reference shall be made to specific Metering Philosophy) to comply with economical conditions and financial risks.

The global metering uncertainty on mass, volumes and energy indicated here below should include:

- The uncertainties of the instruments and analysers (that are supposed to be calibrated according to the Manufacturer's specifications)
- The uncertainty caused by flow disturbances
- The uncertainty in the models and the calculations.

Uncertainty calculation of the metering skid shall be compliant with [ISO 5168](#) and [ISO/CEI guide 98-1](#).

6.2 Calorific value

The accuracy shall be better than 0.2%.

In case an ultrasonic meter is used, the calorific value shall not be based on the value provided by the meter, but based on the composition analysis from a gas chromatograph.

7. Flow measurements technology

Metering technologies acceptable for gas custody transfer are:

- Differential pressure measurement using orifices
- Time of flight Ultrasonic flow meter
- Turbine gas meters (refer to the end of this section).

The selection of the raw volume measurement devices shall be made using a unit equipped with orifice plates as a base case.

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Ultrasonic meters shall be used when their advantages over the conventional orifice meters are needed and/or demonstrated (high throughputs, large turn down ratio, possibility of bi-directional measurement, high reliability, cost effective design, reduced maintenance costs) and if there is no risk of noise influence on meters. The decision to use ultrasonic meters shall not be taken before the upstream process and the lay out are known.

Moreover, the call for tender shall always require a backup solution based on a conventional technique in order to make it possible to come back to conventional solution at a later stage in the project.

Turbines flow meters shall only be used as Master Meter to calibrate the meter in service, if required in the project metering philosophy.

7.1 Orifices

Orifice plate insertion or removal will only be carried out after meter run is isolated and depressurised.

Retractable orifice holder, single-chamber fittings that house accurately the orifice plate and permit quick removal and insertion shall be used.

The orifice holder shall have a chamber isolating door fitted with tamper proof position indicator and double seals safe isolation from process.

Gaskets shall be of the "O" ring type and anti-explosion decompression (AED) certified as per the relevant ASTM listed in the **GS EP PVV 142** - Appendix 8 - Type testing procedure.

7.2 Ultrasonic flow meters UFM

They shall be multipath (minimum 4) equipped with a speed of sound measurement feature.

The internal diameter of the meter shall be exactly equal to the internal diameter of the pipe it is installed on, in order to avoid any turbulence of the flow.

The measurement of UFM shall be used at velocities from 0.3 m/s to 30 m/s.

The meter shall include "meter diagnostic package" in order to detect any coating of scale on the pipe or on meter internals or obstacle, and faulty sensors that could decrease UFM performances.

Main parameters to be checked are as a minimum/ transmitter signal gain (AGC), signal to noise ratio (SNR), performance of pulses, flow profile and velocity of sound (VOS).

7.3 Turbines

They shall be with flat blades and integrated flow straightener. Each flow metering element shall have two (2) detectors, one for metering and the other for checking the readings of the first one. The two detectors shall work on different principle, for example: 1° blade detection, 2° count of revolutions of the rotor.

8. Temperature & pressure measurements

The temperature is usually measured downstream of the meter (from 5D to 15D for orifice plate and from 2D to 5D for UFM).

It shall be corrected to the pressure where the flow metering device is located.

9. Gas properties and gas quality

9.1 Use of on line systems

Measurement strategy for gas quality shall be compliant with project metering philosophy.

Measurements shall be as specified in the regulations or contract.

On line analyzer shall be used for gas composition, density and to some extent for water dew point or water content.

9.2 Gas density

Gas density at metering conditions shall be provided:

- "Pocket" technology or similar is recommended
- Calculation from gas composition shall be used to check the densitometer figures.

9.3 Gas composition

On line gas chromatography shall be used to determine gas composition.

9.4 Gas quality

Specific measurements shall be implemented to verify gas quality specification.

Typical measurements are:

- Water content and/or Water dew point
- Hydrocarbon dew point
- Sulphur
- Heavy metals like mercury.

The choice between automatic analysers and gas sampling will depend on the metering philosophy requirements.

10. Automatic Sampling

Automatic gas sampling shall be selected as alternative if reliable on line systems are not available.

Sampling points shall be provided to allow manual checks.

11. Flow meter calibration

The standard practice for gas custody transfer using ultrasonic or turbines flow meters is to ship them to a flow loop for regular calibration.

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Other flow meter calibration principles may have been defined in project metering philosophy and may be applied in metering system design. Such methods are generally master meter method or the possibility to put two meter runs in series.

12. General arrangement of the unit

12.1 Lay out

Necessary valves and elasticity shall be provided on the headers and on the meter runs to make it possible to dismount a run or add a new run, the unit being in operation.

12.2 Capacity

In case of failure of a meter run or if the flowrate exceeds the range where the specified accuracy is obtained, an additional meter run shall be automatically put into operation.

Failure of a meter run includes the meter, associated transmitter or flow computer. The faulty meter run will be automatically isolated. In case isolation could cause technical problems or damages, only an alarm shall be raised.

12.3 Geometry

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

12.4 Tightness

Any diverting piping around or downstream the meter must be fitted with a "double block and bleed" system and combinations of isolation valves (typically blind flanges) as per **GS EP ECP 103** section 11.1.3.

12.5 Piping

In case of applications which may imply excessive vibration, the Package Vendor shall take into account the entire piping arrangement in joint cooperation with the Contractor to ensure the entire piping arrangement is adequately sized, supported and protected against erosion, pipe stress taking into account fatigue due to flow-induced vibrations, meeting the maximum vibration criteria in section 11 of **GS EP ECP 103**.

12.6 By pass

By-pass facility might be implemented as per project metering philosophy and shall be subject to Company approval. For instance, in cases the Contract specifies a continuous supply; the unit might be equipped with a bypass that automatically opens if an abnormal pressure drop across the unit is detected.

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.

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12.7 Meter runs

12.7.1 Upstream straight lengths of pipe

For orifices and turbines, equipped with the flow conditioner described in [ISO 5167](#), the straight length indicated in this standard shall be increased by 50%.

For ultrasonic meters, the upstream straight length shall be set as indicated in the [ISO 17089](#) section 5.9.3.2. This length is defined such as any installation configuration cannot create an additional uncertainty greater than 0.3%. Typical disturbances representative of installation configuration encountered are defined in [ISO 17089](#) section 6.4.4.

- This length can be reduced if a comparative study can show that the actual upstream pipe isometrics do not create more perturbations than the recommended arrangement. For example, studies have shown that two 90° bends in a same plane located upstream of the straight length can reduce the turbulence substantially. However, the straight length shall not be shorter than 20D.
- Flow conditioners can also be proposed and used to reduce size and/or improve metering accuracy if the design is based on accepted practices and/or tests.
- For information, a fully developed flow profile (that corresponds to the profile for which the meter is supposed to be the most accurate) is assumed to be recovered after perturbation disturbances, by using a flow conditioner and a certain number of upstream straight length piping between the flow conditioner and the USM
 - USM DN600: $\geq 40D$ straight upstream piping
 - USM DN500: $\geq 30D$ straight upstream piping
 - USM DN300: $\geq 23D$ straight upstream piping.

In addition the UFM supplier will ship the UFM to a flow calibration facility that is compliant with [ISO 17025](#). Refer to section 12.6.6 of this specification.

12.7.2 Downstream straight length of pipe

The minimum downstream straight length is 3D for UFM according to section 5.9.3.2 of [ISO 17089](#).

For orifice plate refer to section 6.2 of [ISO 5167-2](#).

12.7.3 Description of a meter run

If required by the project metering philosophy, the meter run shall be insulated from the upstream flow conditioner, along the straight length and the meter, down to 5D after the thermowells.

A typical meter run is made of:

- Upstream double block and bleed (DBB), expanding gate valve; locally or remotely actuated as per project metering philosophy
- Dedicated pressurisation line to avoid any damage of the main valves

- No strainer¹
- Smooth finished piping
- Flow conditioner² and upstream and downstream straight lines
- Meter
- Thermowells(s), pressure tapings, differential pressure tapings (for orifice plates) and densitometer tapings
- Depressurisation line to vent header
- Sampling fast loop to feed the gas chromatographs, water dew point analysers and a manual sampling bottle
- Downstream double block and bleed expanding Gate valve, motor operated.

12.7.4 Case of a differential pressure device

The pressure is usually measured at the high pressure tapping of the DP cell.

The usable range of the DP is from 30% to 95% of its nominal range. Two or three (depending on the flow rate fluctuations) DP cells of decreasing ranges shall be used if necessary.

In case of differential pressure metering, on line densitometer shall be used and installed close to the metering point. "Pressure recovery method" is recommended.

12.7.5 Case of a turbine

Recommendations of [ISO 9951](#) shall be applied.

12.7.6 Case of an ultrasonic meter

High velocity, up to 30 m/s, is possible if it is proved that there is no risk of erosion.

Special attention shall be paid to the noise generated by equipment like flow conditioner, thermowells, control valves and even noise damper of control valves. The choice and the location of such equipment shall be submitted to the Vendor of the ultrasonic meter, for approval.

The internal surface of the pipes shall be smooth, including the welding that shall be ground. The flanges or the gaskets shall not create changes in diameters.

The metering unit shall be installed several hundred of meters away from compressors or back pressure control valves because of the noise or the pulsating flow they can create.

No electrical noise (radio frequency, variable speed motors...) shall be made close to the meter. If they cannot be avoided, noise suppression systems, data processing & filtering can be proposed based on a detailed analysis of real noise spectra on the field and available experiences.

Calculations notes shall be provided to Company for acceptance if there is a noise effect risk.

¹ Because Fiscal gas is supposed to be dry and clean. If, for any reason a strainer was required it would be equipped with 3 mm mesh, fitted with a differential pressure device that is able to trip an alarm in the operator interface.

² The use of flow conditioner will be studied on a case by case basis depending on the meter technology, upstream disturbances and upstream meter run straight length available.

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Deposits on the walls of the meter or on the transducers can significantly alter the measurements. Meter diagnostic package is theoretically able to detect such scale and will be provided.

Equipment to perform internal meter inspection shall be provided (e.g. borescope). If a tapping is used, it should not generate any noise.

UFM Calibration

In case a flow conditioner is associated with the UFM the overall package will be tested in the flow loop test before installation in the metering skid. Calibrations shall be carried out at 6 different flow rates, 3 runs per flow rate.

Calibration report of the flow loop test will allow eliminating the systematic error of the meter using a method described in the relevant standards (polynomial algorithm or FWME³ method). This correction shall be introduced in the meter flow computer.

At the beginning of operations, coating of pipe scale that builds up as a film on the piping/ meter internals can occur. Then, a calibration, typically after one year of operation, will then set a more representative curve. The meter diagnostic package (refer to section 7.1.2 of this specification) will help to set up the trigger of this calibration. Therefore the access to this package shall be available from the supervisory computer.

12.8 Analyser installation

The analysers shall be located in an insulated cubicle, potentially air conditioned if the ambient temperature is not compatible with instrument operating temperature.

The line shall be heat traced and insulated. The transit time between the sampling point and the analyser shall be smaller than 1 minute.

The status and performances of the analysers shall be reported on a daily basis.

12.9 Miscellaneous

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

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

13. Heat tracing & insulation

In particular cases where location of metering installation is exposed to thermal severe constraints (such as flare proximity or extreme cold), full insulation / heat tracing of metering units and analysers systems shall be investigated as per project metering philosophy.

³ Refer to OIML R137-1 section 5.4 and ISO 17089 section 6.3.4 and Annex B.

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14. Arrangement of the computing system

14.1 Flow computers

Each run line shall have its own flow computer able to calculate the quantities, to store the results and to print out the measurement ticket and the parameter report on a daily basis. All these operations shall be possible even in case of a failure of the supervisory computer(s) or the data network.

The flow computer shall be designed to take into account the calibration curve of the measurement device.

Each meter run flow computer is connected to the other runs.

A manual control of the valves from the flow computers shall be possible.

The additional meter run shall be equipped with a dedicated flow computer identical to other meter runs.

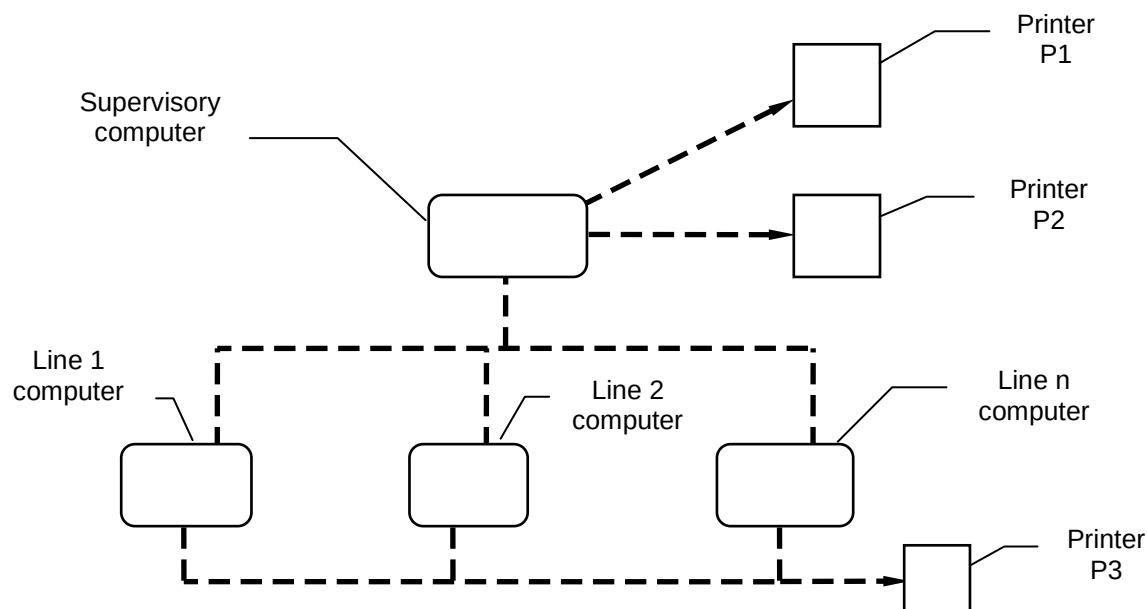
14.1.1 Supervisory computer

A supervisory computer shall:

- Centralise the measurements taken by all the flow computers of the meter runs in service
- Control the sampling units and analysers
- Print out automatic periodic reports (the daily and hourly reports, the event and alarm reports). A printer shall be dedicated to the reports requested by the commercial agreement and a second one to the other reports. In case nothing is specified, the daily report shall be printed on one printer, the hourly, alarm and event reports on the other printer
- Print out intermediate reports (systematically and at the operator's request), the alarms and the configuration of the flow computers
- Store all data, trends, reports, etc.
- Allow the control of the metering unit by an operator.

A backup Supervisory (ready to work but not connected) shall be provided.

14.1.2 Bloc diagram for a regular availability system



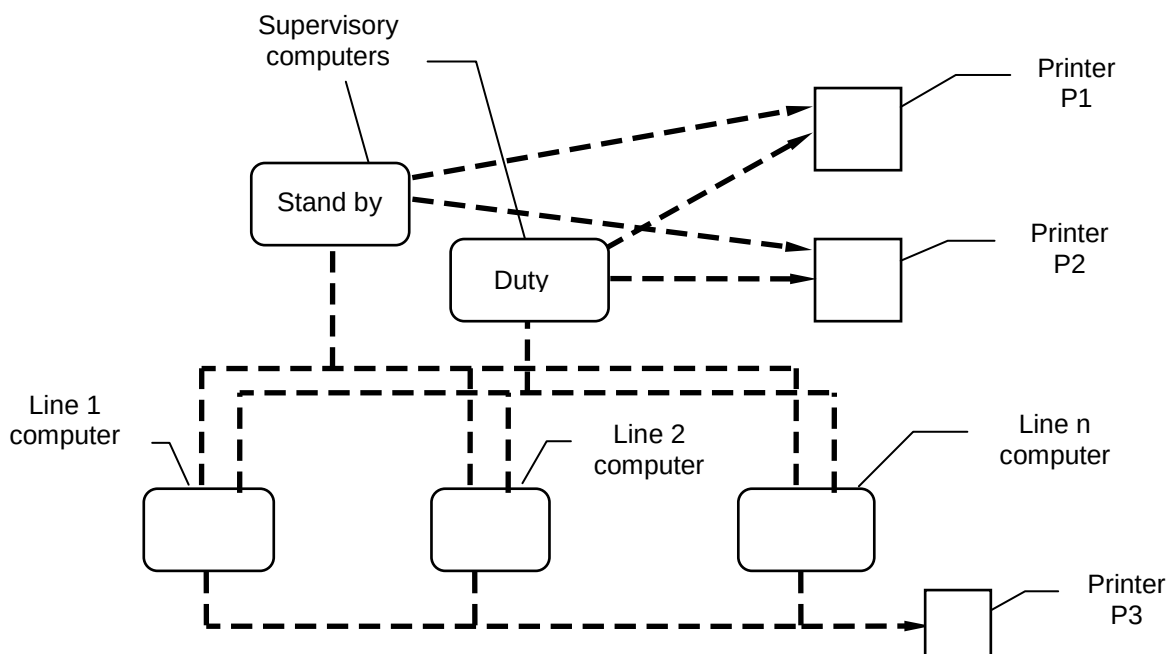
14.2 Enhanced availability

Dual redundancy of the supervisory system level can be applied if required in the project metering philosophy.

“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 withstand spurious power shut downs and communication failures applied randomly at any device of the network.

Recommended bloc diagram for an enhanced availability computing system:



Dual redundancy shall also be applied to the communication network.

15. Measurement verifications & calculation checks

15.1 Measurement verifications

Several measurements that should indicate the same values in normal operation shall be compared on a real time basis. In case of a discrepancy, an alarm shall be raised and print out of all data required for a manual calculation shall be initiated.

- **P & T**

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. 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 TTs' that are installed on the various meter runs).

- **Density**

Densitometer will be doubled (pay & check) only if required in the project metering philosophy. The density measured by the densitometer and the density calculated from the chromatograph results shall be compared. They shall also be compared to the reading from the Ultrasonic meters if any.

- **Flow rate**

The flow rate measured by each run shall be continuously recorded. Any deviation exceeding the nominal flow rate tolerance through each meter run shall raise an alarm.

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Pulses from the pickup coils of a same turbine shall be compared.

15.2 Calculations and checks

15.2.1 Instantaneous flow rates

This calculation shall be performed in the flow computer, with no interference of the supervisory computer.

To verify these calculations, keypad fixed values shall be entered in the flow computer and the result shall be compared to reference tables of programs. The deviation at this stage shall be smaller than 0.01%.

The result and all the necessary parameters required for the calculations shall be printed directly on a specific printer, with no transit through the supervisory computer.

15.2.2 Daily quantities

The daily quantities shall be calculated in the flow computer and stored in non resettable counters of the flow computers, with no interference of the supervisory computer.

To verify the daily quantities, during commissioning, a test shall be carried out during two consecutive days with fixed user values introduced in the flow computers. Verification will allow to check that the total over 24 hours is exactly equal to the flow rate times the duration. It shall also be checked that total volumes are transferred from one day to the next one.

15.2.3 Duration test under dynamic conditions

The test consists of creating variations in the process values to verify that the average is correct.

15.2.4 Inputs

The minimum sampling frequency shall be 2 hertz.

In case of differential pressure device, the Pressure and Differential pressure inlet samples shall be "root mean square" averaged.

15.2.5 Time cycle of the flow computer

The time cycle shall not exceed 1 second.

16. Additional specifications

The statements and requirements of this specification shall be completed by relevant Company's General Specifications [GS EP COR 350](#), [GS EP ELE 079](#), [GS EP INS 101](#), [GS EP INS 110](#), [GS EP INS 900](#), [GS EP PVV 112](#), [GS EP PVV 211](#) and [GS EP PVV 771](#).

Recommendations and prescriptions of [IEC 60079](#) shall also be followed.

17. Safety

Metering systems shall be designed and supplied to take into account all aspects related to safety, space, location and operation constraints.

Environmental and external conditions like sun, flare, etc., 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, etc.

18. Tests

Testing activity shall comply with the requirements of the [GS EP INS 110](#) - Appendix 5.

The testing shall include the following:

18.1 Factory acceptance tests of the flow meters

The factory acceptance test shall include proving operating in conditions as close as possible to the site conditions.

Flow calibration facility shall be compliant with [ISO 17025](#).

18.2 Factory acceptance tests of the unit

The FAT of the unit at the factory shall include the verification of the calculations and of the operator interface. It shall also include spurious power shut downs of each device of the system, to verify that the system can recover automatically as soon as the power is restored.

18.3 Site acceptance tests

Tests on site shall include:

- Different connections and communication between different components up to ICSS and printers
- Software configurations: flow computers, analyzers, PLC, etc.
- Venting & degassing system, if required
- Check of the repeatability of the meters putting two lines in series, if the design of the unit allows
- Print out reports.

19. Certification

In case of Fiscal application subject to approval from National regulation Authorities, necessary approvals shall be obtained for the supply of metering system.

Those approvals shall be obtained through one or several⁴ third Party Certifying Agency.

⁴ depending on their own domain of certification

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The Third Party Certifying Agency shall certify that the fiscal metering system is compliant with relevant standards and [OIML R 137-1](#), in the following domains:

- Metering skid construction:
 - Piping
 - Equipments
 - General architecture
- Flow Meters:
- Instrumentation:
 - Instrumentation that takes part in the fiscal figures is designed and will be operated according to the relevant standards.

For each project and details on typical approval, reference shall be the project Metering Philosophy.

20. Documentation

In addition to documents required by the table 2.4 of Appendix 2 of the [GS EP INS 110](#), documentation shall be provided as follows:

- 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 achieving the uncertainty required in section 6.1
- The calculations of the acceptable variations in flow rates with regard to the choice of the measurement technique.
- Process calculation including pressure drop calculation, back pressure calculations, sampling & analyzers flow loops calculations, etc.
- The report of the initial calibration of the turbine or of the ultrasonic meter, produced by an independent authority.
- The factory acceptance test report
- Availability calculations
- A first version of metering unit handbook.

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Bibliography

Reference

Title of the publication

AGA 3	Orifice calculations when ISO 5167 is not applicable
AGA 8-92DC	Natural Gas: calculation of compression factor: equivalent to ISO 12213-2
AGA 9 report	Measurement of gas by Multipath Ultrasonic Meters
AGA 10	Speed of sound in Natural gas
API MPMS	Manual of Petroleum Measurement Standards: chapter 21-1: Flow measurement using electronic gas measurements
ISO 6974	Natural gas - Determination of composition with defined uncertainty by gas chromatography
ISO 6976	Calculation of calorific values, density, relative density and Wobbe index from composition
ISO 10715	Natural Gas - Sampling guidelines
ISO 10723	Natural gas - Performance evaluation for on-line Analytical systems
ISO 12213	Calculation of compression factor: Part 1: Introduction and guideline; Part 2: Calculation using molar- composition analysis
ISO 13343	Natural Gas - Standard references conditions
MID 2004/22/EC	European Measuring Instrument Directive