



Exploration & Production

GENERAL SPECIFICATION

INSTRUMENTATION

GS 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.

It is based on following background:

- Single phase gas, with no liquids,
- No solid particles,
- Continuity of the supply.

Metering design and supply shall be in accordance with metering and allocation philosophy documents describing general principles and operational requirements for metering and allocation.

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

Professional Documents

Reference	Title
API	Manual of Petroleum Measurement Standards
AGA 9 report	Measurement of gas by Multipath Ultrasonic Meters
ISO 12	Compressibility factor
ISO 5167	Measurement of fluid flow by means of pressure differential devices
ISO 5168	Uncertainty calculation
ISO 6712	Sampling
ISO 6976	Calculation of calorific values, density, relative density and Wobbe index from composition.
ISO 17089	Measurement of fluid flow in closed conduits – ultrasonic meters
AGA 3	Orifice calculations when ISO 5167 not applicable
AGA 8	
AGA 9 report	Measurement of gas by Multipath Ultrasonic Meters

Regulations

Reference	Title
	Local regulations, if any

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. Generalities

3.1 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 advisable to use in the design of the metering unit either one or the other standard, without mixing them.

3.2 Units

ISO units and reference conditions shall generally be used:

- Standard volumes : Sm³ 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.

4. Measurements

4.1 Flow measurement principle

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

Turbines shall normally be used for very clean gas in locations where vendors and calibration facilities are easily available.

Ultrasonic meters shall be used when their advantages over the conventional 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). However, due to the sensitivity of these devices to noise and dirt, the decision to use Ultrasonic meters shall not be taken before the upstream process and the layout are known. Moreover, the call for tender shall always ask for an alternative back up solution based on a conventional technique in order to make it possible to come back to a conventional solution at a late stage in the project.

4.2 Uncertainty

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 supplier's specifications)
- The uncertainty caused by flow disturbances
- The uncertainty in the models and the calculations.

4.2.1 Quantity measurements

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

4.2.2 Flow Measurement verification / calibration

On sites where the stakes are high, the unit shall be equipped with the possibility to put in series each meter run with one reference measurement device. This is to increase the confidence level in the readings.

4.2.3 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 density value measured by the meter.

4.3 Equipment

4.3.1 Orifices

The use of orifice holders meant to ease the change of orifice plates shall be prohibited. They have caused accidents.



4.3.2 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.

4.3.3 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.

It is advisable to order a ultrasonic meter that has the same dimensions and connecting flanges as turbines for a possible interchange in case of problem.

The measurement of UFM shall not be used at velocities smaller than 0.3 m/s.

5. Design of the unit

5.1 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.

5.2 Capacity

It shall be possible to measure the nominal flow rate with one line stopped, in stand by mode, ready to be put into operation in case of a failure in another line or if the flow rate in an other line exceeds the range where the specified accuracy is obtained.

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

5.3 Geometry

The geometry shall be equilibrated enough to make the flow separate between the runs about equally.

5.4 Tightness

Any piping that is likely to divert the gas around the meters or 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).

5.5 By pass

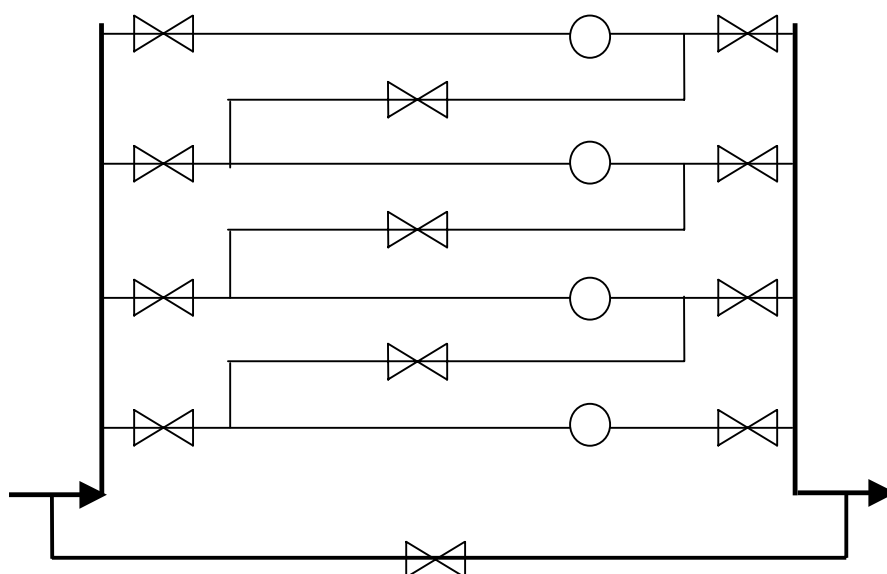
In cases the contract specifies a continuous supply, the unit shall be equipped with a by pass that automatically opens if an abnormal pressure drop across the unit is detected.

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

5.6 Measurement verification

For metering systems with high financial stakes, it is recommended to make it possible to put two meter runs in series, in order to verify one meter against the other. The totality of the straight length will have to be included in the circuit.

Following example for a 3-meter run unit, plus one stand by.



Other metering schemes can be proposed to improve confidence in metering.

5.7 Meter runs

5.7.1 Upstream straight lengths of pipe

For orifices and turbines, with the flow profiler described in the ISO standard, the straight length indicated in the standard shall be increased by 50 %.

For ultrasonic meters, the upstream straight length shall be as indicated in the ISO standard 17089 (draft) ie :

- A fully developed flow profile may be assumed by using a flow conditioner and a diameter dependent length of straight upstream 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 case these lengths are not practical, they 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 be also proposed and used to reduce size and / or improve metering accuracy provided the design is based on accepted practices and / or tests.

Deviations from standards should in that case be submitted to COMPANY specialists approval based on clear references and / or on CFD studies

5.7.2 Downstream straight length of pipe

As recommended by the relevant standard.

5.7.3 Description of a meter run

The meter run shall be insulated from the flow profiler, along the straight length and the meter, down to 5D after the thermowells.

A typical meter run is made of :

- An inlet valve,
- A strainer with 3 mm mesh, fitted with a differential pressure device able to trip an alarm in the operator interface,
- The flow conditioner and the straight line,
- The meter,
- The thermowell, the pressure tap and the sampling point,
- An outlet valve, motor operated.

5.7.4 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

5.7.5 Case of a turbine

Apply the recommendation of the relevant standard.

5.7.6 Case of an ultrasonic meter

High velocities, up to 30 m/s are possible with ultrasonic meters. This kind of velocity shall be used only if there is no risk of erosion.

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

The internal surface of the pipes shall be smooth, including the weldings 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.

Deposits on the walls of the meter or on the transducers can alter the readings very much. Inspection shall be carried out every month (at the beginning of the operation) to verify that no deposit has been building up. Provision for making this inspection easy shall be taken. If a tapping is used, it should not generate any noise.

Calibration of an ultrasonic meter:

It is not always possible to flow calibrate the big units, for lack of adapted calibration facilities. It is possible to rely on a "dry" calibration that is a verification made on the site, even if replacing a flow calibration by a dry calibration decreases the accuracy of the measurement. Of course, all necessary equipment must be embarked on the unit:

- Tight valves,
- Thermal insulation that stays efficient in time, particularly around the body of the meter, after having been dismantled several times,
- Possibility to pressurise the meter at the operating pressure with a gas whose speed of sound is perfectly known. Nitrogen or air are normally used. In case the air is used, safety precautions must be adequate.

5.7.7 Temperature value for calculations

The temperature is usually measured downstream of the meter. It shall be corrected to the pressure where the flow metering device is at.

5.8 Gas properties

5.8.1 Gas density

Gas density at metering conditions shall be measured. Calculation from composition shall be considered as an alternative if accuracy targets can be achieved.

5.8.2 Gas composition

On line gas chromatography shall be used in priority.

Automatic gas sampling shall be issued as a alternative.

Sampling points shall be provided for checks.

5.8.3 Gas quality

Specific measurements shall be implemented to comply with Metering Philosophy. Typical measurements are:

- Water content,
- Water dew point,
- Hydrocarbon dew point,
- Sulphur,

- Heavy metals like mercury.

The choice of using automatic analysers or to perform the measurement manually is to be made with regard to the quantities of gas transferred and to the fluctuations of the value other time.

5.8.4 Sampling

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 analysers shall be located in an air conditioned cubicle.

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

The gas diverted for analysis shall be added to the quantities if it is not re-injected in the main line.

5.9 Miscellaneous

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

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

6. 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, ..., 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...

7. Data processing and verifications

7.1 Consistency of measurement

Several measurements that should read the same in normal operation shall be compared on a real time basis. In case of a discrepancy, an alarm shall be raised and a 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 TT's that are on the various meter runs).

- Density:

On orifice metering systems for large quantity, densitometer will be doubled (pay & check). The density measured by the densitometer and the chromatograph 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 recorded over time. Any deviation of the percentage flowing through each run for a given configuration shall raise an alarm.

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

7.2 Calculations and verifications

7.2.1 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 input 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.

7.2.2 Daily quantities

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

To verify the daily quantities, a test case shall be run during three consecutive contractual days with fixed values keypad into the flow computers. Verify that the totals over 24 hours is exactly equal to the flow rate times the time. Should there be a difference (due for example to a time cycle of the flow computer), verify that it is transferred on to the total of the following day.

7.2.3 Duration test under dynamic conditions

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

7.3 Inputs

The minimum sampling frequency shall be 2 hertz.

In case of differential pressure device, the Pressure and Differential pressure inlet samples shall be "Square Mean Root" averaged.

7.4 Time cycle of the flow computer

The time cycle shall not exceed 1 second.

8. Design of the system

8.1 Arrangement of the computing system

8.1.1 Flow computers

Each run line shall have its own flow computer able to calculate the quantities, store the results and 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.

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

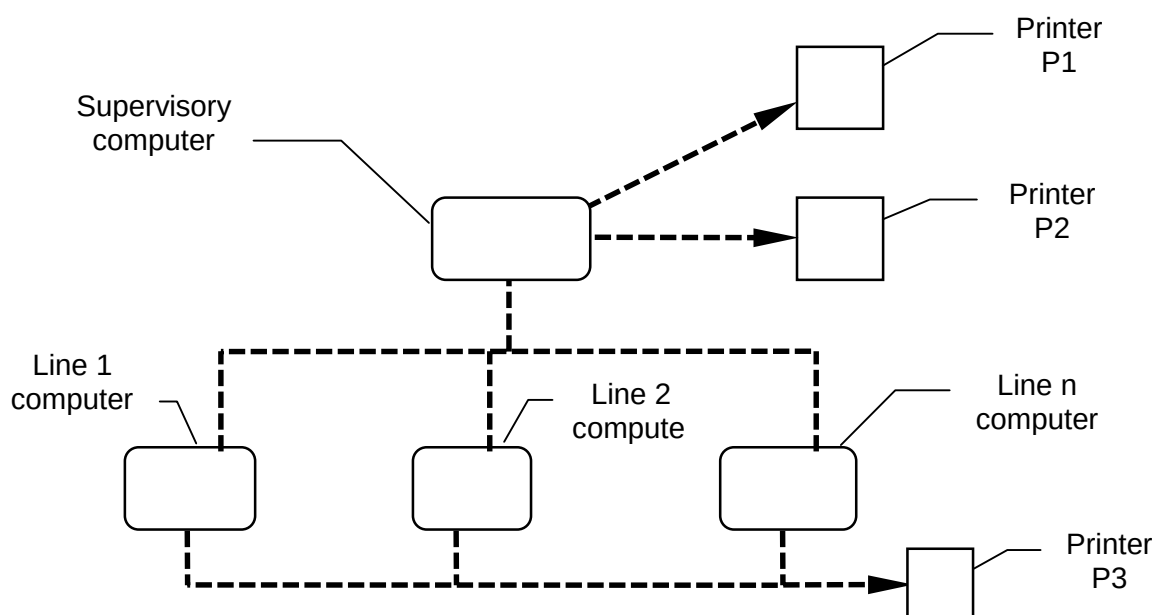
The spare meter run shall be equipped with a dedicated flow computer identical to other meter runs.

8.1.2 Supervisory computer

A supervisory computer shall:

- Centralise the measurements taken by all the flow computers of the lines 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 historic data, trends, reports...
- Allow for the control of the metering unit by an operator.

8.1.3 Bloc diagram for a regular availability system



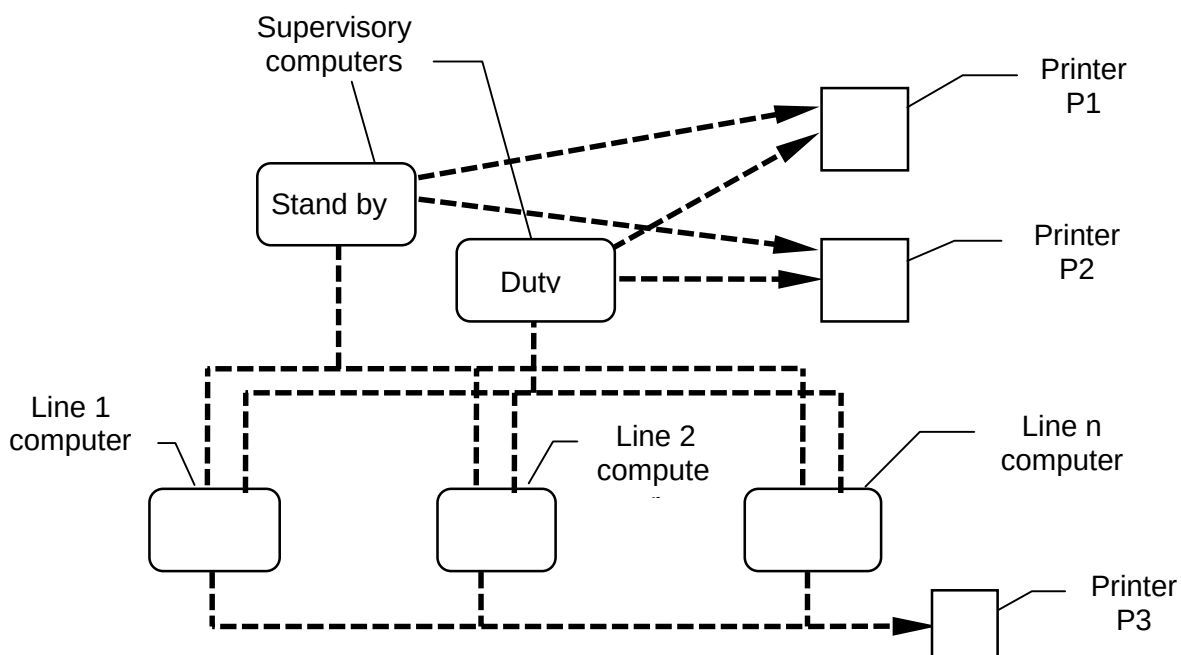
8.2 Enhanced availability

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.

8.3 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". (as per ISO 5168 or equivalent)

- The calculations of the acceptable variations in flow rates with regard to the choice of the measurement technique.
- The report of the initial calibration of the turbine or of the ultrasonic meter (if any), produced by an independent authority.
- The factory acceptance test report.
- Availability calculations.
- A first version of Metering unit handbook.

9. Testing

The test procedures shall be submitted to the COMPANY for comments at least 50 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 tests.

All tests shall be witnessed by COMPANY specialists.

The testing shall include the following:

9.1 Factory acceptance tests of the turbine or the ultrasonic meter

The factory acceptance test shall include proving at conditions as close as possible to the site conditions. The calibration curve shall be established on 6 points.

9.2 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.

9.3 Site acceptance tests

The SAT shall include a check of the repeatability of the meters putting two lines in series, design of the unit permitting.