

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

TURBINE FISCAL METERING SYSTEMS FOR LIQUID HYDROCARBONS

PTS 32.32.00.11
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PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication, of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU/Divisions in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use PTS they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the PTS. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

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- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) and 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

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1. INTRODUCTION

1.1 SCOPE

This PTS defines the minimum requirements for turbine metering systems (including in-situ proving equipment) for the measurement of the quantity and the quality of liquid hydrocarbons passing through an accounting facility such as at the inlet or outlet of an oil pipeline or at a ship loading station.

This PTS is a revision of the PTS of the same title and number dated November 1993. A summary of changes from the previous edition is listed in (1.7).

The Principal may consider alternate measurement systems, e.g., Pd meters, Coriolis, vortex, etc., but these are not covered by this PTS.

This PTS shall be used in conjunction with Requisition Sheet PTS 32.32.00.93

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of or managed by PETRONAS, and to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is primarily intended for use in oil and gas production facilities, but may also be used in oil refineries, chemical plants, gas plants and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with respect to health, safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this PTS which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 ABBREVIATIONS

CCR	-	Central Control Room
DCS	-	Distributed Control System
IP	-	Institute of Petroleum
LCR	-	Local Control Room
MESC	-	Materials, Equipment, Standards and Code
NEMA	-	National Electrical Manufacturers Association
RTD	-	Resistance Temperature Detection Element
SCADA	-	Supervisory Control and Data Acquisition System

1.5 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced in this PTS are listed in (9).

1.6 ORDER OF PRECEDENCE

In case of conflict between documents relating to the enquiry/order, the following priority of documents shall apply:

1. National or legal codes or regulations
2. The Purchase Order
3. The Requisition, see PTS 32.32.00.93
4. This PTS
5. Other PETRONAS, industry, national and international standards referenced herein.

Any conflict of requirements that cannot be resolved by the above order of precedence shall be referred to the Principal for resolution.

1.7 CHANGES FROM PREVIOUS EDITION

The previous edition of this PTS was dated November 1993. Other than editorial changes, the following are the major changes to the previous edition.

Section	Subject
1.1	Added reference to Requisition Sheet, PTS 32.32.00.93
2	Recommendation to use commercially available flow computers.
3.1	Use of uncertainty instead of accuracy in line with ISO TR 5168.
3.2	Added new section on system availability.
3.3	Added new section on rangeability.
3.4	Added new section on validation.
3.8	Added recommended use of digital transmission from field transmitters to flow computers.
3.9	Added further details on vital power supply requirements.
4.3	Added additional details on hazardous area classification and certification. Added reference to IEC 60654 and 60721 on environmental conditions.
4.9 and 6.5	Added optional requirement for supply of field calibration standard for verification / calibration of equipment.
9	Updated references to standards.
Appendix 2	Added optional Hart or other digital communication.

2. MANUFACTURER'S RESPONSIBILITY

The Manufacturer's scope of work shall include design, fabrication, inspection, testing, delivery, supply of documentation and the initial calibration of the complete liquid metering systems.

The Manufacturer shall assume full system responsibility. This means that the Manufacturer shall ensure the operability, accuracy and quality of all components including those of the Manufacturer's sub-suppliers and, in addition, conformance to authority and code requirements.

Equipment offered by the Manufacturer shall be in accordance with the Principal's Preferred Vendor List for Instrumentation and Computers. Equipment shall be proven and shall comply with the relevant codes.

The Manufacturer's design shall recognise that simplicity, and consequently minimisation of field installation work, is of prime importance. The design shall also provide ease of access to all components, maximise maintainability (including calibration) and include facilities to contain (and properly dispose of) liquid spills resulting from operational assembling and raining activities.

The Manufacturer shall prepare a detailed specification for the microprocessor instrumentation and for programming software. The Manufacturer shall apply commercially available, state-of-the-art flow computers, approved by local fiscal authorities. Deviation from this is subject to approval in writing by the Principal. Where applicable, the Manufacturer shall be required to liaise with the main data acquisition system Supplier (to be advised by the Principal) to arrange the data links and protocols necessary for monitoring of the metering system.

The Manufacturer shall immediately inform the Principal if there is doubt on the specified requirements. The Manufacturer shall not proceed with any aspect of the work until he has received the necessary written confirmation from the Principal.

3. METERING SYSTEM DESIGN

3.1 GENERAL

The metering system shall be considered as two major sub-systems. These are:

- i) the field-mounted skid including the sampling and proving equipment, and
- ii) the computing facility in the CCR, LCR or local equipment room for calculation, display and control.

The metering system shall indicate measurement uncertainty for accounting purposes as required by this PTS for mass and volumetric quantities and the flow rates of the liquid hydrocarbon together with its temperature, pressure, density, and water content prior to delivery into downstream systems. It shall incorporate sufficient parallel meter runs to enable the maximum and minimum flow rates to be measured at the specified uncertainty, and to within the specified availability and to cater for validation exercises when one of the meter runs is taken offline. Fiscal metering installations are usually subject to approval by local authorities. This normally covers approval of the design through to final installation. Those authorities should be consulted at the earliest possible stage and thereafter, in order to gain acceptance of the metering philosophy and to simplify final approval of the installation.

Although sales contracts frequently specify accuracy to define the performance of the system, this PTS uses uncertainty in line with ISO TR 5168. The final metering system uncertainty shall be better than the figure specified in the sales agreement(s).

The skid package shall be suitable for the location's prevailing environmental conditions as specified in the Requisition. The skid shall include all pipework manifolds, metering streams, valves, instruments and fittings. It shall be supplied as a fully piped, cabled, and instrumented package.

Operational experience has shown that the maximum differential pressure across the complete metering system should be less than 200 kPa.

A typical flow scheme for a fiscal metering station is contained in [\(Appendix 1\)](#) of this PTS.

3.2 SYSTEM AVAILABILITY

The metering system shall be arranged in such a way that a single failure with its related failures does not result in a complete loss of measurement. This means:

- The power supply of the measuring station up to and including the field instrumentation shall be redundant. However, failure of the power supply in combination with a failure of the back-up supply need not be assumed in the design.
- The pressure measurement and temperature measurement shall be redundant.
- At least the flowmeter with the highest range shall be redundant.
- The flowcomputer shall have back-up facilities. The turbine meter electronics shall have non-resettable mechanical counters.
- A spare instrument or an alternative method shall be available to determine physical properties of the liquid.

The metering system availability shall be as specified in the Requisition. This can be achieved by the following combined set of measures:

- Selection of components with a high inherent availability.
- Installation of a number of parallel streams (for instance 2 x 100 % or 3 x 50 %, which may also be required for turndown reasons)
- Availability at site of the required spares and the appropriate resources to replace the faulty components.

The Manufacturer shall include an availability calculation with his proposal.

3.3 RANGEABILITY

The design capacity of the metering system is the maximum flowrate that can be measured. This is the sum of all but the spare runs to 100 % of max. output.

The minimum capacity is the flowrate of the smallest single run with an uncertainty (2σ) equal to the design specification of the turbine meter.

The rangeability is defined as the ratio of these flowrates and shall be as specified in the Requisition.

Provisions shall be made to stop the flow at rates below a preset minimum value.

3.4 VALIDATION

3.4.1 General

As part of the tender, the Manufacturer shall propose auditable procedures and instructions pertaining to the validation and maintenance of the metering station. These procedures shall ensure that the measuring station is validated and maintained so as to retain its design performance during its service life.

Validation comprises calibration and, if necessary, adjustment of the turbine meters and the secondary instrumentation pertaining to the metering station. A component shall only be adjusted if its calibration shows errors outside the maximum permissible error limits.

3.4.2 Traceability

Calibration procedures and instructions shall be traceable to national standards.

3.4.3 Calibration equipment

Equipment used for calibration, if included in the scope of supply, shall have a valid calibration certificate issued by a national or accredited laboratory. Such equipment shall have an uncertainty of measurement of maximally one third of the uncertainty of the instruments to be calibrated under the conditions at which the tests take place. Calibration certificates shall specify the systematic error in the measurement result as a function of calibrated range and include a statement on the uncertainty of the calibration results.

3.4.4 Calibration intervals

Initial minimal calibration intervals shall be established per type of instrument, based on the assessment of the drift and its associated uncertainty, and be stated in the tender.

3.4.5 Records

All data pertaining to calibrations, adjustments (measurement data, calibration factors, events, etc.), and changes in parameters shall be registered and stored for a period of time required by regulation or agreement. This information shall be accessible for inspection by contract parties (witnessing).

3.4.6 Initial calibration and meter check

The initial calibration certificate of a turbine meter shall be based on a comparative calibration against an approved and traceable metering standard. At the time of initial calibration, a full metrology and geometry check of the meter shall be carried out. The calibration and checks shall together constitute the "footprint" of the meter, which will be used in future verifications.

3.4.7 Uncertainty

The uncertainty of the turbine meters and the secondary instrumentation shall at least comply with the overall metering system requirements.

The maximum permissible planned accuracy errors shall be specified for the following:

- the components of the measuring system that can be calibrated and adjusted individually and can be replaced in case of failure;
- the measuring system as a whole, if required by the contract. A systematic error in one component of the measuring system shall not be cancelled out by an opposite systematic error in another component.

3.4.8 Uncertainty analysis

The Manufacturer shall be able to demonstrate that the error of each component of the measuring system for which a maximum permissible error has been specified and/or of the measuring system as a whole lies within the maximum permissible uncertainty (2σ). For this purpose, a well-documented uncertainty analysis of the measuring system is required.

3.4.9 Station manual

The Manufacturer shall prepare a station manual comprising comprehensive and detailed instructions for the operation, validation/calibration, adjustment, maintenance and documentation of the primary and secondary fiscal flow measurement devices at the metering station.

These instructions shall include:

- preparation and leak testing;
- calibration of turbine meters through meter provers;
- calibration of secondary instruments: pressure, differential pressure, temperature transmitters, water content cell and liquid density cell;
- determination and documentation of the accuracy and measurement error per instrument and of the overall station;
- check of signal transmission between sensors and computer;
- judgement of instrument and/or station performance, preferably via a statistical approach in order to facilitate comparison of results;
- initiating changes in calibration and maintenance intervals;
- handling and communication of acknowledged measurement deviations exceeding agreed limits, with special attention to the notification of this sensitive information to parties and authorities.

A practical procedure including rules for intervention in the setting of instruments and handling of measurement deviations should be agreed between parties and include the following aspects:

- Intervention shall be based on control and significance limits established per instrument or instrument group and registered in the station manual. The control limit (CL) is the measurement deviation that, if exceeded, justifies adjustment of the instrument. The significance limit (SL) is the measurement deviation that, if repeatedly exceeded in one direction, justifies adjustment of the instrument.
- Setting and adjustment of the limits.
- Definition of maximum allowable deviation of the total measurement system and its control limit.
- Procedure to be followed if SL and CL are exceeded, especially as to their possible effects on the overall deviation of the measurement system.
- Determination of the overall deviation of the measurement system for a mutually agreed yearly averaged flow rate.

3.5 INLET HEADER

The inlet header should incorporate the following:

- pressure transmitter and pressure gauge;
- temperature transmitter and thermowell;
- temperature indicator and thermowell;
- sampling stream for the specified analyser systems (including density). Alternatively, the sampling stream may be located downstream of the meters and downstream of the prover loop connection.

3.6 METERING RUN

Parallel metering runs should be provided, each fitted with the following:

- inlet valve;
- strainer with differential pressure monitoring;
- flow straighteners;
- turbine flowmeter, complete with dual pick-ups and pre-amplifiers;
- temperature transmitter and thermowell;
- pressure transmitter and pressure gauge;
- temperature indicator and thermowell;
- stream flow control valve;
- outlet valves, one to isolate the stream and one to divert to the prover loop, with leak check facilities to confirm tight shut-off;
- thermal relief valves.

3.7 METER PROVER

Uni- or bi-directional mechanical displacement meter provers, generally as defined in API Manual of Petroleum Measurement Standards, Chapter 4, are currently applied. However, should the fiscal authorities accept compact proving devices, these may be applied if approved by the Principal.

For offshore applications, where space and weight are important considerations, either the bi-directional or compact prover will provide a smaller and lighter solution for a given meter capacity.

3.8 MICROCOMPUTER-BASED MONITORING AND CONTROL SYSTEM

Metering and meter proving shall be managed by a microcomputer system. This system shall be installed in the CCR, LCR or local equipment room. Normally, separate microcomputers should be dedicated to each of the metering runs, to the station and to prover control. However, the functionality of the microcomputers may be combined into one or more computers if it can be demonstrated that the required reliability, availability and redundancy standards will be met. Such an arrangement will often be subject to approval by local authorities.

Control of the metering station, selection of metering runs to suit production profiles, equal distribution of flow between streams and initiation of flow meter calibration shall be executed from the CCR or LCR. This includes measurement and logging of pressures, temperatures, cumulative volumes, water content and density.

In view of the redundancy (to maintain production) of the metering streams, it is not considered necessary to provide redundancy in the individual metering stream computers. Failure of a microcomputer should be easily rectified by replacing it with a plug-in spare unit.

If a data link is required between the metering package and a SCADA or DCS system, the Manufacturer shall liaise with the Principal and the SCADA or DCS Supplier to develop, or supply, the necessary software system. All necessary controls, monitoring, printer and display facilities shall be supplied as part of the metering system.

The input signal conditioning and analogue-to-digital conversion, including linearity, resolution and repeatability, of the microcomputer system shall be specified to have an overall uncertainty of less than 0.020 %. The metering station measurement uncertainty due to computation and digital output of calculated quantities shall be less than 0.001 %.

A digital transmission protocol from transmitter to microcomputer system (such as Hart or Foundation Fieldbus) is preferred to eliminate digital-to-analogue and analogue-to-digital conversion errors.

The equipment shall be installed in a location and protected so as to minimize the effects of electromagnetic interference. Unless otherwise specified in the Requisition, the equipment shall be installed in accordance with PTS 33.64.10.33

Any undesired effects that may disturb the equipment shall be taken into account, such as:

- frequent use of mobile radios and cell phones;
- nearby overhead lines and substations;
- nearby welding and power switching;
- likelihood of nearby lightning strikes;
- use of long cables, possibly in parallel with power cables.

The system shall be powered by an uninterruptible electrical power supply and be able to retain for at least 31 days volatile memory data and the integrated flow totals in the event of a power supply failure.

The signal connections between the metering skids and the microcomputer system are summarised in [\(Appendix 2\)](#). The display, transfer and utilisation of data and calculated values are shown in [\(Appendix 3\)](#).

The following features shall be included in the metering system to minimise the probability of undetected corruption:

- analogue signals shall have alarm settings just above and below the nominal zero and full-scale values;
- manually entered data and configuration changes shall be protected by a key lock or other suitable security measure, e.g., password;
- any alarm, log-on, software or parameter change shall be logged with date and name of the initiator in an "Event Log" to provide a complete audit trail.

3.9 UTILITIES

The electrical power supply requirements shall be in accordance with PTS 33.64.10.10

The metering system will be classified as a "vital service" load, and complete duplication of the energy source and the lines of supply will be provided by Principal.

On 50 Hz systems the nominal LV power supply voltage shall be 400/240 VAC three phase and neutral.

A.C. UPS systems shall have their neutrals solidly earthed. This applies equally to single phase and three phase systems. The battery autonomy time for the UPS will be no less than 30 min after which the metering system shall provide its own back-up for retention of all historical data and parameters.

A separate, non-vital 400/240 VAC feed for utilities will be made available for the metering station.

In his technical proposal, the Manufacturer shall list the expected loading of UPS.

The Principal will provide instrument air. It shall be clean, dry and oil-free. Unless otherwise specified, the connections on air supply lines forming part of mechanical engineering shall terminate in a ½ inch NPT female thread. Instrument air pressure shall be as defined in the Requisition.

Only AISI 316L stainless steel tubing components shall be used on the metering skid. For sour service (hydrogen sulfide), Monel or Hastelloy C may be used. The use of copper tubing is not allowed.

4. TECHNICAL REQUIREMENTS – FIELD-MOUNTED COMPONENTS

4.1 SKID, STRUCTURAL AND BASEPLATE

The configuration of the metering skid shall meet the requirements and comply with the dimensional constraints of the Requisition. The Manufacturer shall propose a design within these constraints that combines compactness with compliance with quoted standards and codes, and ensures maintainability of equipment.

On offshore platforms, the weight of equipment is of paramount importance and equipment shall be designed to weigh as little as possible without degrading safety, environmental performance or efficiency. The Manufacturer shall identify equipment mass, centre of gravity in relation to plan, and elevation for all assembled skid units.

The metering skid shall be of all-welded steel construction with a rigid base. The baseplate shall be adequately supported. Lifting facilities shall be provided as part of the skid and these shall permit the complete assembly to be lifted without causing permanent deformation or damage to the skid or to any of the equipment mounted on the skid.

Structural integrity of the skid shall not be reliant on any equipment fixed to it.

A drip-pan shall be provided over the entire skid base, inclined so that it drains to a single point, which shall be designated as a hazardous drain. The drain shall be terminated in a 2 in. rated ASME B16.3 150 lb. flange for connection and continuation by the Principal. Vents and drains shall be provided at all high and low points in the piping system, with the low point drains manifolded to the baseplate edge. Visual indication shall be provided at each drain so that liquid discharge can be observed.

4.2 MATERIALS

Piping and Valves: all materials shall comply with the piping classes specified in the Requisition.

All other components exposed to process conditions (meters, strainers, instrumentation etc.): all materials shall comply with the Requisition; if not specifically stated on the Requisition, materials shall be selected in accordance with PTS 39.01.10.11. If any materials substitutions are required, these shall be approved by the Principal.

**Amended per
Circular 63/03**

Piping design shall comply with PTS 31.38.01.10 and PTS 31.38.01.11. For EP applications, the design shall also comply with EP 95-0230 (in particular, the minimum mandatory isolation requirements).

Process inlet and outlet piping connections shall be located in accordance with the schematic drawings included with the Requisition.

The metering skid shall have a common inlet header and a common outlet header to ensure uniform measuring conditions at all meter streams.

Thermal expansion relief valves are required in liquid-full systems if the system can be blocked in and subjected to heat input from atmosphere or process. For the application of thermal expansion relief valves, see PTS 80.45.10.10.

Spool pieces shall be provided to replace the turbine meters during hydrotesting, installation and pre-commissioning. The spools shall be manufactured to the same piping standard as the skid piping and be provided complete with gaskets.

The inlet and outlet piping of parallel metering devices with common inlet and outlet headers shall have sufficient flexibility to cope with differences in thermal expansion when one device is not in operation and to facilitate component removal.

The meter run outlet and the prover inlet and outlet valves shall be in accordance with the API Manual of Petroleum Measurement Standards, Chapter 4.

The meter run inlet and outlet and the prover inlet and outlet valves shall be fitted with open and closed position switches for remote indication, and a valve leakage detection alarm. The meter run inlet and outlet and the prover inlet and outlet valves shall be fitted with manual, electric or pneumatic actuators.

Electric actuators (if fitted) shall be furnished with interposing relays to the control circuit of the three-phase motor. Actuator motors shall be of the cage induction type with integral starters incorporating stall protection, limit switches and anti-condensation heaters.

4.3 INSTRUMENTATION AND ELECTRICAL

4.3.1 Area Classification

All field-mounted electrical/electronic instruments installed in hazardous areas shall be certified for use in such locations. Refer to the Requisition Sheet for Zonal Classification, Gas Group and Temperature Class. The types of protection for electrical equipment installed in hazardous areas shall be selected and implemented as defined in PTS 33.64.10.10, Appendix 1. The preferred method of protection shall be as specified in the Requisition. The Principal shall approve any deviation from the preferred method of protection.

Equipment certification by CENELEC recognised test houses shall be obtained.

4.3.2 Climatic Conditions

Field-mounted instruments shall be suitable for operation in the prevailing climatic conditions and shall be adequately protected according to the electrical area classification. For a description of the climatic conditions as categorized in IEC 60654-1 and IEC 60721-3-4 refer to the Requisition.

The default climatic location class in the requisition sheet is described as Class D, Outdoor location.

Severities of environmental parameters:

4K4 is described by:

- | | |
|---------------------------|------------------------|
| a) Low air temperature | -65 °C |
| b) High air temperature | +55 °C |
| c) Low relative humidity | 4 % |
| d) High relative humidity | 100 % |
| e) Low absolute humidity | 0.003 g/m ³ |
| f) High absolute humidity | 36 g/m ³ |
| g) Rain intensity | 15 mm/min |

All environments are covered by:

- | | |
|----------------------------|-----------------------|
| h) Rate of change of temp. | 0.5 °C/min |
| i) Low air pressure | 70 kPa |
| j) High air pressure | 106 kPa |
| k) Solar radiation | 1120 W/m ² |
| n) Condensation | Yes |
| o) Precipitation | Yes |
| r) Ice and frost formation | Yes |

4K4 applies to locations that are not protected against the weather and are directly exposed to:

- the Restricted Group of Open-air Climates (see IEC 60721-2-1);

Warm Temperate Type of Climate

- the Moderate Group of Open-air Climates including:

Cold Temperate

Warm Dry and

Mild Warm Dry Types of Climate.

- the General Group of Open-air Climates including:

Cold,
Warm Damp and
Warm Damp, Equable Types of Climate.

- the Worldwide Group of Open-air Climates including:

Extremely Cold and
Extremely Warm Dry Types of Climate.

plus:

4Z4 air speed up to 30 m/s

4B1 presence of mould, fungus and rodents

4C4 effects of salts and other chemicals, including hydrogen sulfide, also for coastal areas

4S2 effects of sand and dust (this is the heaviest classification under this category)

4M4 mechanical conditions (vibration and shock).

All electrical equipment shall be weatherproof and corrosion resistant to IP or NEMA requirements, as defined by the Principal. Junction boxes, cable racking and tray work shall be AISI 316L stainless steel.

4.3.3 Cabling and Earthing

The Manufacturer shall provide and install all electrical cabling to connect the various components within both the metering skid and the computing facilities. Interconnecting cables between the two shall be specified by the Manufacturer for supply by the Principal.

Earthing of the system shall be the Manufacturer's responsibility and electrical equipment shall be bonded together to form a continuous low-impedance path to earth. Each skid shall be provided with two diagonally opposite earth bosses in accordance with Standard Drawing S 68.004. Special electronic/computer earthing requirements shall be as specified in PTS 32.37.20.10

Signals from the skid shall be segregated according to the various voltage levels and types. The segregation shall be in accordance with PTS 32.37.20.10

Field equipment and cabling in areas that are not protected by either earthed steel structures or dedicated lightning conductors shall be provided with lightning protection as detailed in PTS 32.37.20.10

4.4 TURBINE METERS

Turbine meters shall be selected to conform to the following requirements:

Linearity of each meter shall be better than $\pm 0.25\%$ over a 10:1 flow range at the specified operating viscosity. The meters shall be calibrated initially, preferably on a liquid with the viscosity for which the system is designed, or if unavailable, on water by an independent authority. Viscosity performance shall be established when the meters are in operation. The repeatability under stable conditions shall be better than $\pm 0.05\%$ of the mean pulse count. This shall be checked at minimum and maximum flow and at evenly distributed flow rates within the specified 10:1 range, on both water and fluid of the relevant viscosity. The former checks shall be carried out at the Manufacturer's works during system test and the latter during location tests.

The turbine meters shall be provided with meter tubes and flow straighteners as necessary, in accordance with ISO 2715. Minimum upstream and downstream run lengths shall be 10D and 5D respectively, where D is the inside diameter of the run.

The turbine meter installation shall ensure that the meter run remains completely filled with liquid, including during no-flow conditions.

Two pick-up heads shall be provided for the checking of pulse integrity. The design shall permit the pick-up coils to be changed without the turbine meter being removed from the meter run. The connections shall permit sealing to the satisfaction of the appropriate authority.

Turbine meters shall be provided with vane failure detection.

The meter calibration factor (K-factor) for each turbine meter shall be determined initially by tests carried out by the Manufacturer and entered manually or downloaded from the database into each respective meter stream microcomputer.

4.5 STRAINERS

The strainers shall be provided with the following:

- single basket stainless steel material with a mesh insert size as recommended by the turbine meter Manufacturer;
- flanged davit closure for easy removal and replacement of basket;
- flanged vent and drain connections;
- differential pressure monitoring.

4.6 FLOW STRAIGHTENERS

Flow straighteners shall be designed and fabricated in accordance with ISO 2715.

4.7 FLOW CONTROL VALVES

The metering stream flow control valves should be pneumatically operated valves to control the proving flow from minimum to maximum conditions and to avoid hydraulic shock during start-up and shutdowns. A side-mounted, de-clutchable handwheel should be provided for manual operation. The preferred installation of flow control valves is downstream of the meter.

The equipment Manufacturer shall perform the sizing calculations in accordance with IEC 60534-2.

4.8 TEMPERATURE MEASUREMENT

For temperature measurement, electrical resistance thermometry shall be used. The measurement transducer shall be a Pt 100 Platinum RTD, 100 Ω at 0 °C, alpha coefficient 0.00385 $\Omega/\Omega/^{\circ}\text{C}$ as defined in IEC 60751. Tolerance class A shall be applied.

Resistance thermometers shall be interrogated directly by the relevant microcomputers utilising the four-wire technique. This is for ease of calibration and to avoid large temperature cycles in a field mounted transmitter. Typically the temperature span will be 0 °C to 100 °C; however, narrower spans shall be applied where operating temperature stability permits.

The RTDs shall be mounted in flanged thermowells (refer to Standard Drawing S 38.113) to enable replacement without de-pressuring or draining the system. A test thermowell shall be installed adjacent to the RTDs to allow a temperature check during commissioning and at periodic meter station inspections. The two thermowells shall be installed on different radial axes to minimise vibration fatigue of the downstream well by vortex shedding from its upstream partner.

The temperature element shall be installed and connected so that it can be readily disconnected and extracted whenever it has to be calibrated.

Thermowells shall be provided for all temperature applications, in accordance with the applicable piping classes. Test thermowells shall be provided with bore of minimum 6.5 mm, suitable for the insertion of mercury-in-glass high accuracy thermometers. If so specified in the Requisition, the Manufacturer shall provide two mercury-in-glass precision thermometers for calibration check purposes. Thermometers shall be certified with accuracy better than 0.1 °C.

4.9 PRESSURE MEASUREMENT

Pressure and differential pressure transmitters should be of the "Smart" type with an analogue 4-20 mA output signal. They shall be in accordance with PTS 32.31.00.32 Tolerance class A shall be applied.

Digital signal transmission based on generally standardised communication protocols shall be used.

If so specified in the Requisition, the Manufacturer shall provide a precision dead-weight tester for calibration check purposes. The dead-weight tester shall be certified with an uncertainty better than half that of the pressure instruments calibrated.

To facilitate calibration, a dedicated impulse line connection to the transmitter manifold block shall be available to allow calibration of the transmitter from a dead-weight tester without the transmitter being removed from the field. Local pressure gauges shall be of the Bourdon tube type with a 100 mm minimum diameter, in accordance with PTS 32.31.00.32

4.10 DENSITY MEASUREMENT

The Manufacturer shall provide a dual parallel densitometer system. The signals of both transducers shall be compared to monitor transducer operation. A deviation of 0.5 kg/m³ to 1.0 kg/m³ (this value shall be specified by the Principal) between the two measurements shall initiate an alarm.

A representative slipstream shall be taken from and returned to the metering station header through the two vibrating-tube-type density transducers.

The physical installation and calibration verification requirements shall be as detailed in IP Petroleum Measurement Manual, Part VII, Section 2.

If so specified in the Requisition, the Manufacturer shall provide a precision densitometer for calibration check purposes. The densitometer shall be certified with an uncertainty better than half that of the densitometer calibrated.

4.11 WATERCUT MEASUREMENT

Two watercut systems are normally specified in the Requisition. The systems shall be operated on a duty/standby basis, with the station microcomputer initiating changeover on receipt of a system fault output. If this measurement is not used for net oil computations, but as an operating guide only, then one watercut meter will suffice.

Sensor range shall be 0 % - 5 % water in oil with an accuracy of ± 0.2 % absolute.

If so specified in the Requisition, the Manufacturer shall provide a precision watercut analyser for calibration check purposes. The watercut analyser shall be certified with an uncertainty better than half that of the watercut meter.

Correction of crude oil quantity to allow for water content shall normally be a retroactive accounting procedure using the results of the sample analysis [\(4.12\)](#).

The output of each water-in-oil measurement instrument shall be a 4-20 mA analogue signal.

4.12 SAMPLER

A 'grab' type sampler and collection system shall be fitted to the inlet manifold of the metering pipework. It shall act on impulses from the station microcomputer and collect a flow rate proportional sample whose composition is representative of the total fluid flowing through the metering station.

The requirements for sample extraction and collection are defined in ISO 3170 with Amendment 1. The system shall be fitted with a console-mounted indicator and a voltage-free contact output to verify that pulses have transferred to the sampler solenoid valve.

The sampler shall operate at constant pressure and shall be maintained at a temperature sufficient to keep the viscosity at an acceptable level.

4.13 METER PROVER

4.13.1 General

The meter prover shall be equipped with a quick-opening closure for sphere removal.

The number of meter pulses generated over the calibrated volume shall be not less than 10,000 pulses and resolution of the detector and sphere system shall be compatible with this requirement. The sphere velocity shall not exceed 3 m/s. The length between detector switches (or round trip length for bi-directional provers) shall be at least 10,000 times the detector repeatability. The prover connection shall be downstream of the turbine meters.

The prover shall have two dual detector switches at each end of the calibrated volume in order to prevent the loss of the prover function in case of a faulty detector switch. The detector should be designed so that the contacting head of the detector protrudes into the prover pipe to ensure switching takes place at all flow rates during calibration and normal operation. Detectors and switches shall be suitably weatherproofed for their environment.

If mechanical switches are used, each sphere detector shall have a dedicated micro-switch. The actuation of each detector shall be set during manufacture so that, should it be necessary to replace a detector during service, there will be a negligible change in prover calibrated volume so that the accuracy of the prover will not be affected.

Connections shall be provided on the prover loop to facilitate recalibration with a portable master prover equipped with a master meter.

4.13.2 Four-way valve

The four-way flow diverter valve in a bi-directional prover shall be in accordance with the API Manual of Petroleum Measurement Standards, Chapter 4.

4.13.3 Freedom from shock

When the prover is operating at its maximum design flow rate, the sphere shall come to rest safely at the end of its travel, without shock.

4.13.4 Prover internal coating

The internal coating of the prover shall have a uniform bore and a durable and smooth surface. The Vendor shall provide full details of the coating, maximum allowable fluid temperature and methods of surface preparation, application, and repair. The lining shall be non-porous and not prone to explosive decompression.

4.13.5 Guide bars/tees

Guide bars or tees should be carefully designed to avoid damage to spheres.

4.14 PAINTING

For the specification of the painting, refer to PTS 30.48.00.31-P. The painting schedule shall be as specified in the Requisition. Colour schemes shall be as specified in the Requisition and may be governed by local regulations and customs.

5. TECHNICAL REQUIREMENTS - MONITORING AND CONTROL SYSTEM

5.1 STREAM MICROCOMPUTER

Each stream microcomputer shall have, as a minimum, the following facilities:

- alphanumeric displays providing interface to the operator;
- alarm/indicators for status information;
- keyboard for data entry commands, etc.

NOTE: The stream microcomputers shall have no functions other than those associated with the metering.

Each stream microcomputer shall, as a minimum, perform the following functions and where necessary, display relevant data:

- receive dual pulse inputs from the associated turbine meter and carry out pulse security checking in accordance with IP Petroleum Measurement Manual, Part XIII, Section 1;
- introduce the meter calibration factor in pulses per volume unit (often referred to as the meter K-factor), entered either manually or downloaded from the data base;
- calculate gross volume through the meter;
- receive input signals from the associated pressure, temperature and density transmitters;
- calculate the stream mass flow, utilising gross volume flow and density;
- compensate gross stream volume for the effect of pressure and temperature, to obtain net stream reporting volumes at 15 °C and 101.325 kPa absolute;
- transmit, via the data bus, on demand from the station microcomputer, selected measured and calculated variables;
- display all measured and calculated variables. The resolution on the visual display shall be sufficient to verify the requirements for calculation accuracy;
- output alarm messages to the station microcomputer for logging and control;
- permanently display the totalised mass quantity with sufficient digits to accumulate three months' maximum flow without roll-over; the figures shall be stored for the time period deemed necessary by fiscal authorities;
- displayed manually entered parameters shall not be rounded off nor truncated;
- display on demand the totalised daily mass flow (reset to zero daily);
- operate in a fully automatic mode with the station microcomputer;
- operate in a manual mode with the operator manually launching the sphere when the station microcomputer is out of service;
- store in memory the applicable tables detailed in ASTM D 1250-80 (or the appropriate formula and procedures), for use in compensating gross volume during normal throughput flow;
- automatically generate an alarm and stop flow counting when flow is detected but the meter stream is not selected, i.e., off-line;
- downloading of meter calibration factors should be time stamped and identified. The stream microcomputer should also hold the previous meter calibration factor used;
- the microcomputer system shall provide (standardised) facilities for data communication of real time process data and totalised values with other (computer) systems.

5.2 STATION MICROCOMPUTER

The station microcomputer shall act as the prime interface for metering, entry and display of data. The station microcomputer shall have as a minimum the following facilities:

- alphanumeric display of all data, control requests, alarm, etc.;
- keyboard for data entry commands, etc.;
- alarm indication facility.

The station microcomputer shall, as a minimum, perform the following functions and where necessary, display the relevant data:

- form a database of selected alarms, measured and calculated variables, obtained via the data bus from the stream measurement microcomputers, or directly from the station common signals;
- compile station data in an agreed format and feed this to a dedicated printer, either at specified times or on demand from the operator;
- receive and act on keyboard commands from the operator;
- if required by the specification, interface with the SCADA or DCS system via a (serial) data link using a protocol agreed between the Manufacturer and the SCADA or DCS system Supplier for the two-way interchange of data;
- display valve status and selected parameters;
- display an index of all the commands and functions available to the operator;
- permanently display meter station mass flow with sufficient digits to accumulate three months' maximum design flow without roll-over; the figures shall be stored for the time period deemed necessary by fiscal authorities;
- display on demand the station daily totalised mass flow (reset to zero daily);
- proportional flow control of the sampler;
- watercut system switch over on receipt of a watercut system fault output;
- receive input signals from watercut systems for net oil calculation;
- print daily or hourly reports;
- print alarm reports.

NOTE: All functions shall be interactive and the system shall have the capacity for utilising a question-and-answer type of dialogue through the keyboard and the alphanumeric display.

5.3 PROVER MICROCOMPUTER

The prover microcomputer shall perform the following functions:

- receive a 'prove initiate' command, which may be automatic, semi-automatic, manual or a combination of these;
- check that the rates of change of prover temperature and pressure are within preset limits;
- count raw unscaled meter pulses between detector switch operations for one prover stroke;
- correct the prover volume to operating conditions of temperature and pressure;
- calculate the meter calibration factor (the K-factor) in pulses per volume unit, in accordance with API Manual of Petroleum Measurement Standards, Chapter 4;
- automatically conduct a series of proving runs, terminating when five consecutive runs provide results which have a spread of less than 0.05 %;
- queue future proof runs at the operator's discretion;
- transfer data to the station microcomputer via a (serial) data link;
- control the meter run flow control valve and monitor the prover isolation valves and position switches;
- check that the alignment of all stream prover inlets and outlets is correct;
- display four-way valve leakage alarm;
- generate and print validation (meter proving) report;

- compare new meter factor (the K-factor) with the previous one and prompt alarm if meter factor deviates more than $\pm 0.15\%$.

The prover microcomputer shall be similar to the units described in (5.1). The prover microcomputer shall be responsible for computing the meter calibration factor using average temperature and pressure. This computation shall be achieved by counting raw meter pulses from the individual stream microcomputer between detector switch operations. The microcomputer shall provide all necessary prover sequence control.

The proving function shall be controlled from the station microcomputer via the prover microcomputer. The 'prove initiate' command shall be transmitted to the skid equipment when the following parameters are stabilised and accepted:

- prover inlet and outlet temperature;
- prover pressure;
- prover inlet and meter run outlet isolation valve seal status;
- proving flow rate.

The selection of a meter for proving shall set up an automatic sequence of valve control procedures. Valve seal integrity shall be monitored throughout.

If the first 5 consecutive meter-proving runs are not within the required accuracy, an alarm should be activated to alert the operator. Should the meter fail to achieve the required performance after 10 consecutive meter-proving runs, the proving sequence shall be aborted. The system should then wait for an operator command to resume the next proving run in the queue. All calculations and reports shall be generated in the usual way for aborted runs, but they shall be annotated to indicate a failed prover run.

Should any of the prover monitored parameters exceed pre-determined limits, then the proving run shall be automatically aborted, an alarm generated and the calculation discarded.

On completion of a proving sequence, the revised meter factor shall be displayed. Provided that it is satisfactory, the new meter calibration factor shall then be downloaded to the relevant line microcomputer, automatically, initiated by a command from the operator. It shall be possible to perform this function manually if required. Should preset limits of the meter calibration factor be exceeded, then an alarm shall be initiated.

The prover microcomputer shall be provided with a re-settable high-speed totaliser, with a minimum of eight digits, for the accumulation of meter pulses. Resolution shall be ± 1 pulse.

The following inputs shall be provided:

- position detector switch signals;
- inlet and outlet temperature;
- prover pressure;
- prover four-way diverter valve position status;
- valve seal status on prover inlet and meter run outlet isolation valves;
- (serial) data link from stream and station microcomputers;
- unscaled meter pulses from each individual stream meter via the stream microcomputer.

The following outputs shall be provided:

- serial data link to station and stream microcomputer;
- stream control valve;
- inlet temperature;
- outlet temperature;
- prover pressure.

5.4 DATA INTEGRITY AND SECURITY

The overall logical and physical security of a microcomputer configuration shall be demonstrated and ensured.

Continuously running diagnostics shall monitor the microcomputers for proper functioning and alarm for abnormal situations. The diagnostics shall enable the station microcomputer to identify a malfunctioning stream microcomputer or data link and to initiate the appropriate action, e.g., shut down a stream if the microcomputer is faulty, or alarm if the data link is faulty.

The fiscal flow application shall include a security module that restricts the accessing of parameters, the fiscal flow application itself, and maintenance and calibration functionality to authorised personnel, and registers and stores all such accessing operations.

Each (new) version of the fiscal flow application shall be uniquely distinguished by its version number, displayed on both the microcomputer display and printout. The installation of new releases shall be traceable by registration of the initiator, the date, and for parameters, the as-found and as-left values.

Malfunctioning of datalink(s) between mutual microcomputers of the system and/or DCS/SCADA shall not disrupt the proper operation of the individual microcomputers.

6. FACTORY AND FIELD INSPECTION AND TESTING

6.1 GENERAL

In addition to the provisions for testing and inspection stated in the terms and conditions of purchase, the Manufacturer shall give the Principal adequate notice of his intention to perform tests so that arrangements can be made to witness the event.

The appropriate authority may wish to approve the equipment design and witness calibration tests. This requirement will be stated in the Requisition.

In the purchase order the Principal shall indicate whether or not he wishes to perform inspection during fabrication. If so, the Principal shall indicate the scope of his inspection, which typically may include:

- ensuring dimensional compliance with the flow metering design;
- ensuring that the performance of instrumentation meets specification accuracy;
- ensuring that the computing system fulfils the functional performance requirements, including immunity from external interference sources;
- ensuring that the basic skid and piping fabrication meets structural and piping code requirements;
- ensuring that the electrical/electronic installation complies with electrical safety requirements and that components to be used in hazardous areas have recognised certification.

6.2 INSPECTION FOR COMPLIANCE WITH METERING DESIGN

Metering tubes shall be inspected before they are incorporated into the pipework fabrication to ensure compliance with the requirements of ISO 2715, in particular the dimensions of the upstream flow conditioning section and of the downstream section, including the locations of the thermowells and pressure tappings.

The turbine meter Manufacturer shall provide a calibration certificate for each meter. The calibration shall be carried out by an accredited laboratory (in accordance with ISO 9002) and be traceable to national standards. If possible, the calibration fluid should have a similar viscosity to the specified operating liquid. If this cannot be achieved, calibration using water shall be performed, with account being taken of the Manufacturer's prediction of performance on the operating liquid.

An independent accredited calibration company shall calibrate the meter prover at the Manufacturer's premises. The calibration should be witnessed by the appropriate authority and recorded on a formal certificate.

The instruments detailed in (4.4, 4.7, 4.8, 4.9, 4.10 and 4.11) shall be inspected and tested in accordance with PTS 62.10.08.11

6.3 INSPECTION AND TESTING OF PIPING SYSTEMS

All materials used in fabricating the process pressure-retaining system, e.g., pipework, valves, fittings, etc., shall have relevant mill certificates, casting melt certificates, etc., in accordance with the applicable MESC specification.

Prior to commencement of fabrication, the welder(s) for the process piping fabrication shall be certified to the requirement of the piping design specification.

During fabrication, welds shall be inspected as defined in PTS 31.38.01.31 Records shall be kept and witnessed as appropriate.

Hydrostatic pressure tests shall be performed in accordance with ASME B31.3 and PTS 31.38.01.31 Specifically, the entire pipework system shall be maintained at maximum rated pressure for the recommended time, following removal of the turbine meters and their

replacement by pipe spools. A certified chart record of temperature and pressure shall be produced covering the duration of the test.

All flanges and swing elbows shall be capable of being opened without pipe spring or malfunction. The Principal may require the Manufacturer to open joints for spot checks.

6.4 INSPECTION FOR ELECTRICAL SAFETY

Safety documentation for the selected type of protection for the installed electrical instruments shall be compiled for scrutiny and to ensure that any certification requirements have been incorporated in the installation.

All wiring shall be tested for insulation resistance, earth fault and earth continuity. To prevent damage to low-voltage equipment, the instrument equipment shall be disconnected at both ends of the cable before these tests are carried out and re-connected prior to the functional tests.

All terminations, glands, junction boxes and other electrical and electronic equipment enclosures on the skid shall be inspected for correct application, assembly and closure.

6.5 CALIBRATION FACILITIES

The following calibrating facilities shall be included, if so specified in the Requisition:

- temperature bath for temperature elements (after removal from the thermowell);
- dead-weight tester for pressure transmitters (transmitters to remain in the field, only manifold valves to be switched using dedicated impulse lines to the console);
- calibration liquid for the densitometer (facilities shall be provided to allow the calibrating fluid to be routed through the densitometer at the required rate);
- calibration liquid for the watercut meter (facilities shall be provided to allow the calibrating fluid to be routed through the watercut meter at the required rate);
- Hart communicator;
- portable pressure calibrator.

If a dead-weight tester is included in the calibration equipment, the Manufacturer shall determine the gravitational constant for the location of the metering station. This constant can be calculated based on a formula from the International Association of Geodesy (see address below) with data derived from satellite orbital variations (1970) and is always to within 10^{-3} m/s^2 and usually within $5 \times 10^{-4} \text{ m/s}^2$.

NOTE: International Association of Geodesy Central Bureau,
c/o Department of Geophysics,
Juliane Maries Vej 30,
DK-2100 Copenhagen Ø,
Denmark.

6.6 MASS AND VOLUME FLOW COMPUTATION SYSTEM

6.6.1 Functional tests

A detailed test programme to confirm compliance with the design requirement shall be developed by the Manufacturer for approval by the Principal. These tests shall include, but not be limited to the following:

- functional and performance check of all conversions of analogue and frequency measured variables into digital values;
- confirmation of correct flowrate computation and quantity integration operations with simulated measurement inputs;
- confirmation of correct output signals to the totalisers, analogue indicators or recorders, meter prover, watercut measurement, sampler and SCADA or DCS systems;
- confirmation of correct generation of operating function alarms, e.g. high flow rate, etc.;

- confirmation of computer system and health monitoring alarms;
- confirmation of event logging and reports;
- demonstration of immunity of the system to electromagnetic interference in accordance with (3.8);
- demonstration of short circuit protection of inputs and outputs. A representative sample of inputs and outputs shall be subjected to sustained short circuit, to ensure that devices can survive both a fleeting and a sustained short circuit;
- demonstration that malfunction of an input/output channel shall not cause failure of any other input/output channel;
- demonstration that signal isolation between input or output channels shall be clearly defined;
- demonstration of auto start-up and recovery after power failure;
- functional check of a representative sample of spare parts by inserting these into the main equipment and performing tests described above;
- functional check of Manufacturer/Supplier-supplied tools and test equipment with the main equipment.

NOTE: The tests are to be made over the full ambient temperature range to demonstrate statistical compliance with design criteria.

6.6.2 Heat-soak tests

The system shall be operated by the Manufacturer in its final on-site configuration for a minimum period of 200 h (burn-in period). A minimum of 10 % of digital inputs, 10 % of digital outputs and all analogue inputs and outputs shall be simulated for this period, with simulation equipment provided by the Manufacturer.

All deliverable equipment used in the system shall be subjected to an elevated temperature of 45 °C (typical) for 100 h during the demonstration period. The system environment shall be cycled between 45 °C and the site ambient temperature at 12-h intervals, until the 100-h elevated temperature period is completed.

During the heat-soak test, the system equipment shall be fully energised. Fully-loaded operating conditions shall be simulated at 24-h intervals by demanding reports, selecting displays, exercising calculations and sending and requesting data over communication channels.

If a component failure occurs, all tests shall be repeated after the replacement of the faulty component, unless otherwise agreed by the Principal. This ensures that all essential components are subjected to the specified minimum testing.

6.6.3 Dynamic tests

A specific programme of dynamic tests shall be agreed between the Manufacturer and the Principal. The programme shall include but not be limited to the following tests:

- verification that meter run and meter prover selection valves operate correctly, that the valves seal, and correctly signal the valve positions;
- verification that the meter stream flow control valves function correctly and that flow balance between meter runs is achieved;
- verification that the measurement data presented at the operator's interface to the microcomputer are correct and that commands given at the interface are executed correctly;
- verification that alarms are initiated at appropriate measurement conditions;
- demonstration of all event, alarm, and routine log formats.

6.7 FUNCTIONAL TESTING OF THE COMPLETE METERING SYSTEM

The wet functional test shall demonstrate that all the sub-systems, already tested in isolation, operate successfully as an integrated system under actual flowing liquid conditions.

The Manufacturer shall assemble the complete metering system, or sub-system such as a single stream, for a functional test. The assembly shall include a suitable pump or pumps, a liquid break tank and additional temporary pipework to allow inhibited water to be circulated through the system. The pump(s) and temporary facilities shall be capable of achieving a variable flow rate up to at least twice the capacity of a single meter run. All measurement transducers shall be installed and connected by temporary cables to the microcomputers and all control output signals from the microcomputers to selection valves, control valves, etc., shall be connected and commissioned.

All aspects of system software, including any required data link protocol, shall be tested during the system functional test to ensure correct operation. This testing shall include connecting the system to a device that simulates the full control system (DCS/SCADA, etc.) to ensure correct reflection of metering data. Such a device may need to be provided by the DCS/SCADA supplier.

After satisfactory completion of the functional tests, the test liquid shall be drained off and the piping system dried, e.g. by blowing through warm dry compressed air.

It should be noted that the water quality to be used for functional testing depends on the material(s) from which the equipment is manufactured.

The special water and drying requirements to be met are the same as for "Hydrostatic Pressure Test" as specified in PTS 31.38.01.31

6.8 WATERCUT MEASUREMENT, DENSITY MEASUREMENT AND SAMPLERS

Sections (6.1, 6.3 and 6.4) also apply to these systems.

These systems should be tested as part of the functional test described in (6.6). If this is not possible, the Manufacturer shall develop a site acceptance test. This shall include a functional test of each system, including any interface with the main metering skid and its microcomputers.

6.9 SITE ACCEPTANCE TEST

The site acceptance test shall be developed by the Manufacturer to demonstrate that the completely assembled and installed metering system, including meter-prover, watercut measurement, density measurement and samplers at the metering station, operates successfully under real conditions on the real process fluid, and communicates properly with the live DCS/SCADA system.

7. PRESERVATION AND PREPARATION FOR SHIPMENT

7.1 PRESERVATION

Full consideration should be given to the need for long-term preservation of the skid and metering electronics after testing has been completed. The Manufacturer shall furnish recommendations for long-term preservation (18 months) at a designated site for the periods prior to installation and after float-out for an offshore installation.

7.2 PREPARATION FOR SHIPMENT

All packaging shall be in accordance with BS 1133.

The Manufacturer shall provide a complete packaging and handling specification to cover both skid and electronic panels.

Prior to shipment, all high-accuracy skid-mounted instruments and densitometers shall be removed, packed separately, and shipped with the skid. Turbine meters shall be replaced with pipe spools and shipped with the skid.

The skid pipework shall be prepared and sealed for preservation purposes. The Manufacturer shall provide blanking flanges as well as filling and draining facilities.

Painting of the complete assembly shall be suitable for the location and in accordance with PTS 30.48.00.31-P.

8. DOCUMENTATION

8.1 REQUIREMENTS

The Manufacturer shall supply the documentation in accordance with the Data Requirement Schedule of the Requisition.

In addition to the foregoing, the Manufacturer shall provide the following information:

8.2 MANUALS

During the manufacture, testing, installation and final commissioning, a system dossier shall be assembled containing as a minimum:

- a narrative description of the metering function, design philosophy, and operating procedures and conditions;
- methods and criteria for measurement corrections in case of dispute;
- process engineering flow schemes of the metering system, showing breakpoints between upstream and downstream process equipment;
- design specifications and Manufacturer documentation for the component parts of the system;
- a computer handbook documenting the equations and routines being used;
- calculations for flow metering system uncertainties utilising as-built dimensions and performance criteria;
- agreed tolerances of measurement;
- a list of alarms (diagnostic as well as operational);
- the full calibration audit trail of all equipment used in calibration;
- witnessed results of computing system inspection and testing;
- outline of prover calibration and verification methods;
- listing of computer programs;
- material certificates of all piping and equipment items;
- operating and maintenance manuals containing, amongst other methods, procedures and criteria applicable for the quality assurance of the flow measuring station;
- spare parts list as defined in PTS 70.10.90.11

8.3 CERTIFICATES

- electrical equipment certification for hazardous areas;
- calibration certificates and calibration references for meters and prover;
- calibration certificates for the calibration and test equipment.

9. REFERENCES

In this PTS reference is made to the following publications:

NOTE Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

PETRONAS STANDARDS

Index to PTS publications and standard specifications	PTS 00.00.05.05
Index to standard drawings	PTS 00.00.06.06
Protective Coatings & Lining	PTS 30.48.00.31-P
Piping classes - basis of design	PTS 31.38.01.10
Piping - general requirements	PTS 31.38.01.11
Shop and field fabrication of piping	PTS 31.38.01.31
Instruments for measurement and control	PTS 32.31.00.32
Turbine fiscal metering system for liquid hydrocarbons	PTS 32.32.00.93
Instrument signal lines	PTS 32.37.20.10
Electrical engineering guidelines	PTS 33.64.10.10
Electromagnetic compatibility (EMC) requirements	PTS 33.64.10.33
Selection of Materials for Life Cycle Performance (EP)	PTS 39.01.10.11
Inspection and functional testing of instruments	PTS 62.10.08.11
Spare parts	PTS 70.10.90.11
Pressure relief, emergency depressuring, flare and vent systems	PTS 80.45.10.10
Amended per Circular 63/03	
Safety engineering in facilities design	EP 95-0230
Materials and Equipment Standards and Code	MESC

PETRONAS STANDARD DRAWINGS

NOTE: The latest edition of Standard Drawings can be found in PTS 00.00.06.06

Flanged thermowell DN 40, ASME classes up to 1500 incl.	S 38.113
Earthing boss for steel structures, tanks, vessels, etc.	S 68.004

AMERICAN STANDARDS

Malleable iron threaded fittings classes 150 and 300	ASME B16.3
Process piping	ASME B31.3
<i>Issued by:</i> American Society of Mechanical Engineers ASME International Three Park Avenue New York NY 10016-5990 USA	
Manual of petroleum measurement standards Chaper 4 – Proving systems	API MPMS 4.1 – 4.8
<i>Issued by:</i>	

*American Petroleum Institute
1220 L Street
Northwest Washington, DC 20005, USA*

Standard guide for petroleum measurement tables

ASTM D 1250

*Issued by:
American Society for Testing and Materials
ASTM International
100 Bar Harbor Drive
West Conshohocken, PA 19428-2959
USA*

BRITISH STANDARDS

Packaging code

BS 1133

*Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
UK*

Petroleum Measurement Manual

IP Code

- Density, continuous density measurement
- Fidelity and security of measurement data transmission systems, electric and/or electronic pulsed data cabled transmission for fluid metering systems

Part VII, Section 2

Part XIII, Section 1

*Issued by:
Institute of Petroleum
61 New Cavendish Street
London W1M 8AR
UK*

INTERNATIONAL STANDARDS

Industrial-process control valves. Part 2: Section 1-
Sizing equations for incompressible fluid flow under
installed conditions

IEC 60534-2

Industrial-Process Measurement and Control Equipment -
Operating Conditions - Part 1: Climatic Conditions

IEC 60654-1

Classification of environmental conditions
Part 2 Environmental conditions appearing in natural
temperature and humidity first edition

IEC 60721-2-1

Classification of Environmental Conditions
Part 3: Classification of Groups of Environmental Parameters
and Their Severities - Section 4: Stationary Use at Non-
Weatherprotected Locations

IEC 60721-3-4

Industrial platinum resistance thermometer sensors

IEC 60751

*Issued by:
International Electrotechnical Commission
3 Rue de Varembe
1211eva 20
Switzerland*

Copies can also be obtained from most national standards
organisations.

Liquid hydrocarbons; Volumetric measurements by
turbine meter systems

ISO 2715

Petroleum liquids – Manual sampling

ISO 3170

Petroleum liquids – Automatic pipeline sampling

ISO 3171

Measurement of fluid flow – Evaluation of
uncertainties

ISO TR 5168

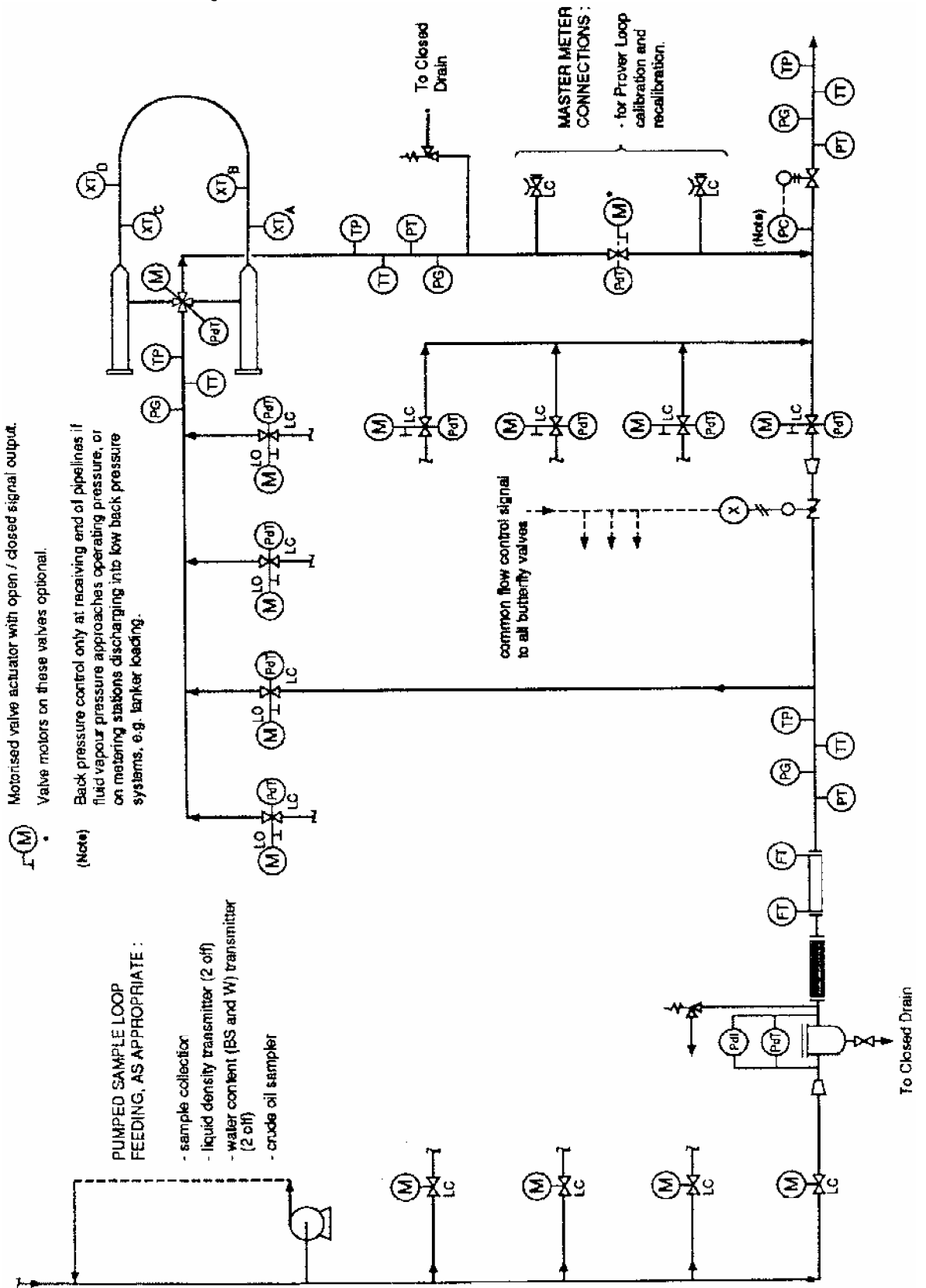
Quality systems – Model for quality assurance in
production, installation and servicing.

ISO 9002

Issued by:
Central Secretariat of ISO
1 Rue de Varémbe
1211eva 20
Switzerland

Copies can also be obtained from most national standards organisations.

APPENDIX 1 TYPICAL LIQUID HYDROCARBON FISCAL MEASUREMENT FLOW SCHEME



APPENDIX 2 FIELD SIGNAL CONNECTIONS AND TRANSFER

SIGNAL		MICRO COMPUTER		
DESCRIPTION	Type	Meter Run	Meter Prover	Station
pulse train from turbine meter (dual)	F	XX	PP	
density transducer frequency (2 off)	F	XX		XX
meter run outlet pressure	A/H	X	T	T
meter run outlet temperature	()	X	T	T
meter prover pressure	A/H	T	X	T
meter prover inlet temperature	()	T	X	T
meter prover outlet temperature	()	T	X	T
meter station inlet header pressure	A/H			X
Watercut	A	T		X
density transducer inlet header pressure	A			X
meter station outlet header pressure	A/H			X
meter station outlet header temperature	()			X
meter run outlet valve status	S	X	T	T
meter run outlet valve leakage signal	S	X	T	T
meter run proof inlet valve status	S	X	T	T
meter run proof inlet valve leakage signal	S	X	T	T
meter prover 4 way, or launch, valve status	S		X	
meter prover 4 way valve leakage signal	S		X	T
meter prover detector switches (4 off)	S		XXXX	
meter run outlet valve open/close command	S	X		
meter run proof valve open/close command	S	X		
meter run outlet flow control valves modulated control	A/H		X	
meter prover 4 way (launch) valve command	S		X	
total flow proportional signal to sample system	A			X

A = Analog

H = Hart or another digital protocol

F = Frequency

P = Connection only when a particular meter is in proof operation

S = Change of state (digital)

T = Data transferred from microcomputer having primary connections

X = Primary connections

Note: Temperature is not analog as it is a four-wire connected to the A/D converter in the microcomputer.

APPENDIX 3 DISPLAY, TRANSFER AND UTILISATION OF DATA AND CALCULATED VALUES

DATA	MICRO COMPUTER		
	Meter Run	Meter Prover	Station
turbine meter pulse counts (dual)	S	S	
turbine meter 'k' factor	D	S	D
gross volumetric flow-rate	S	D	D
gross standard volumetric flow-rate	S	D	D
density transducer periodic time (2 off)	D or S		S
density computed (2 off)	D or S		S
meter run outlet pressure	S	D	D
meter run outlet temperature	S	D	D
mass flow-rate per meter run	S		D
accumulated volume, per meter run	S		D
accumulated mass, per meter run	S		D
total volumetric flow-rate for metering station			S
total mass flow-rate for metering station			S
accumulated volume for metering station			S
accumulated mass for metering station			S
pulse discrepancy counter, per meter run	S		D
density transducer constants (key-pad entered)	D		S
high and low flow alarms, per meter run	S		D
density deviation alarm			S
turbine meter counts per proof run (dual)		S	D
meter prover pressure		S	D
meter prover inlet temperature		S	D
meter prover outlet temperature		S	D
meter run outlet valve status (per meter run)	S	D	D
meter run proof inlet valve status (per meter run)	S	D	D
temperature and pressure correction factors for steel and liquid		S	D
meter proof initiation command	D	D	S
Watercut	D		S
meter proof required alarm			S
meter run outlet valve leakage signal	S	D	D
meter run proof inlet valve leakage signal	S	D	D
meter prover 4-way valve leakage signal		S	D

S = Source of calculated data.

D = Destination of data calculated elsewhere.