PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

TURBINE FISCAL METERING SYSTEMS FOR LIQUID HYDROCARBONS

PTS 32.32.00.11
SEPTEMBER 2002

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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' OPUs 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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2) Other parties who are authorised to use PTS subject to appropriate contractual arrangements.
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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

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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.

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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.

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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.

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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 (2 σ) 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.

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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 (2 σ). 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.

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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.

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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.

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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.

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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.

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