

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

MANUAL

LIQUID HYDROCARBON CUSTODY TRANSFER AND ALLOCATION MEASUREMENT

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This New **PTS 32.32.00.43 - Liquid Hydrocarbon Custody Transfer and Allocation Measurement** has been developed incorporating:

1. PETRONAS Lessons Learnt
2. Best Practice
3. New information issued by relevant industry code and standards.
4. Replacement of Current PTS 20.221 (deleted).

All updates in the document are highlighted in *Summary of Changes*.

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PREFACE

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The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU 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.

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1. INTRODUCTION

1.1 SCOPE

This PTS (guidelines) specifies the minimum requirements in the design, installation, testing, commissioning, operation and maintenance of Liquid Hydrocarbon Custody Transfer and Allocation Metering System, for installations in Malaysia or in any other countries. It is intended for use by the Principal and Contractor when preparing a specification for equipment packages and also during the operation and maintenance of the system.

For specifications on metering system using turbine meters, please also refer to PTS 32.32.00.11 and also Requisition Sheet PTS 32.32.00.93.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY

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

It is intended for use in oil refineries, chemical plants, gas plants and, where applicable, in onshore and offshore exploration and production facilities 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 as regards 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

1.3.1 General 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** is a requirement.

The word **should** is a recommendation.

1.3.2 Specific definitions

Accuracy

The measure of the closeness of a measurement to the true value.

Allocation Metering System (for liquid hydrocarbon)

A measuring system comprising mechanical, instrument and computer parts whose registered measured quantity is used for allocation between two or more Contractors which involved in sharing the same facilities for their operation. This system normally has an uncertainty of +/- 1%.

Automatic Sampler

A system which when installed in a pipe and actuated by automatic control equipment, enables a representative sample to be obtained from the liquid flowing in the pipe. The system generally consists of a sampling probe, a sample extractor, an associated controller and a sample receiver. Normally it is also equipped with a sampler performance monitoring device.

Computer Part

The part of the metering system that consists of digital computers and receives digital signals from A/D converters or from digital instrument loops.

Control Chart

A graphical chart of the constancy measurement used for evaluating whether meter proving operations are in or out of statistical control. On it are shown the +/- 3 sigma limits of dispersion from the average system factor, $\bar{x}$ (standard deviation), within which the measurement system considered to be in control (API Chapter 13).

Custody Transfer Metering System (for liquid hydrocarbon)

A measuring system comprising mechanical, instrument and computer parts whose registered measured quantity is used for sale where there is a change in ownership. This system normally, has an uncertainty of +/- 0.25% of standard volume.

Density

The density of a quantity of a homogeneous substance is the ratio of its mass of its volume. The density varies as the temperature changes and is therefore generally expressed as the mass per unit of volume at a specific temperature.

Displacement Prover

Prover which operate on the principle of the repeatable displacement of known volume of liquid from a calibrated section of pipe between two detectors. These include prover that was commonly referred to as either "conventional" pipe prover or "small volume" prover.

Flow computer

It is an arithmetic processing unit and associated memory device that accepts electrically converted signals representing input variables from a liquid measurement system and performs calculations for the purpose of providing flow rate and total quantity data.

Flow meter

Flow measuring device which, indicates the measured flow rate. In some cases, it is also a device that indicates the total amount of fluid passes during a selected time interval.

Instrument Loop

Includes all elements that form part of the measurement of each individual quantity from sensor to input of the A/D converter or input of digital signal to the computer part.

Linearity

The deviation or spread of calibration data points from an acceptable straight line over the defined flow range.

Linearity of a Meter

The ideal accuracy curve of a volume meter is a straight line denoting a constant meter factor. Meter linearity is expressed as the total range of deviation of the accuracy.

Maximum Meter Flow Rate

The maximum rate of flow recommended by the meter manufacturer or authorised by a regulatory body. The maximum rate is determined by considerations of accuracy, durability, pressure drop, repeatability and linearity.

Meter Proving

An exercise carried out in accordance to the proving procedure in order to determine the relationship between the volume of liquid passing through a meter at one set of conditions and the indicated or reference volume at the same conditions.

Meter Run

A flow measuring device complete with associated strainers, entry/exit pipework, upstream and downstream straight lengths, flow meter and flow straighteners.

Minimum Meter Flow Rate

The minimum rate of flow recommended by the meter manufacturer or authorized by a regulatory body. The minimum rate is determined by considerations of accuracy, repeatability and linearity.

Online Density Meter

A density meter also known as densitometer operating on a representative sample of the process material withdrawn continuously from the process line or vessel via a sampling system.

Positive Displacement Meter

A meter in which the measuring element is the discrete volumetric segments in the meter and volume is directly measured by continuous separating (isolating) a flow stream into discrete volume segments and counting them.

Prover Computer

It is an arithmetic processing unit and associated memory device which consists only the proving function for the proving of meters and calculation of meter factors.

Pulse Interpolation

Any of the various techniques by which the whole number of meter pulses is counted between two events (such as detector switch closures) and any remaining fraction of a pulse between the two events is calculated.

Repeatability

The quality which characterize the ability of a measuring instrument to give identical indications or responses, for repeated applications of the same value of the measured quantity under stated conditions of use.

Sampling

An exercise in accordance to the procedure that is carried out either automatically or manually to obtain a sample that is representative of the contents of any pipe, tank or other vessel and to replace that sample in a container from which a representative test specimen be taken for analysis.

Small Volume Prover

Any pipe prover used to calibrate a meter, having a volume between detectors that does not permit a minimum accumulation of 10,000 whole (unaltered) pulses from the meter. Small volume provers require meter pulses discrimination by pulse interpolation or other technique to increase the resolution.

Standard Reference Conditions

The conditions of temperature and pressure to which measured volumes are to be corrected. Standard reference conditions for pressure and temperature shall be 101.325 kPa (abs) and 15°C respectively, in accordance with ISO 5024.

Station Computer

It is an arithmetic processing unit and associated memory device which sends commands and accepts calculated data from Flow Computer and Prover Computer for Station Totalisation computation and archiving.

Turbine Meter

A meter in which the measuring element is a multi bladed rotor or impeller to which the metered stream imparts a rotational velocity that is proportional to the mean velocity of the stream. Measured volume is registered by counting rotor revolutions.

Uncertainty

The part of the expression of the result of a measurement which states the range of values within which the true value of, if appropriate, the conventional true value is estimated to fall within stated confidence level as defined in ISO 5168.

For the purpose of this PTS, all uncertainty quoted, are stated at 95% confidence level.

Validation

The process of confirming or substantiating the accuracy of input variables to a measurement system at normal operating conditions, using reference equipment traceable to certified standards.

1.4 ABBREVIATIONS

AC	-	Alternating Current
A/D	-	Analogue to Digital
AGA	-	American Gas Association
API	-	American Petroleum Institute
BS	-	British Standard Institution
CCR	-	Central Control Room
DC	-	Direct Current
DP	-	Differential Pressure
FAT	-	Factory Acceptance Test
GHV	-	Gross Heating Value
IP	-	The Institute of Petroleum

IEC	-	International Electrotechnical Commission
ISA	-	Instrument Society of America
ISO	-	International Organization of Standardization
LCR	-	Local Control Room
MPMS	-	Manual of Petroleum Measurement Standard
NBS	-	National Bureau of Standard
NEC	-	National Electricity Code
PID	-	Piping and Instrument Drawings
RTD	-	Resistance Thermal Detector
SI	-	International System of Unit
SIRIM	-	Standard Industrial Research Institute of Malaysia
STC	-	Site Testing and Commissioning

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 by this PTS are listed in [\(6\)](#).

1.6 ORDER OF PROCEDURES

In case of conflict between documents, the following priority of documents shall apply:

1. National or legal codes or regulations or binded contract between buyer and seller.
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.

2. GENERAL REQUIREMENT

2.1 UNIT OF MEASUREMENT

The base (reference of standard) conditions for metering system shall be in SI units in accordance with the ISO 1024 latest revision whose base conditions are defined as pressure of 101.325 kPa (abs) at temperature 15°C. Where imperial units such as barrel are required, it shall be converted from the base SI unit and referenced to 14.696 psia and 60°F.

Liquid hydrocarbon measurement shall be either in volumetric, mass or energy units. The units shall be SI units.

2.2 APPROVAL REQUIREMENT

Host country authority or the respective country petroleum resource manager's approval may be required for measurement and allocation concept and metering project implementation as per items [2.2.1](#) and [2.2.2](#), respectively for the oil and gas production facilities. Item [2.2.3](#) specifies the government approval that is required to be compiled by Contractors.

2.2.1 Measurement and Allocation Concept

2.2.1.1 Proposed Measurement and Allocation concept has to be submitted for the host country authority or their petroleum resource manager's evaluation and approval for the oil and gas production facilities. The concept shall be submitted and agreed during the field Development Plan Stage. Contractor shall carry out the financial exposure and cost benefit analysis during the evaluation of the concept and to determine the location for the installation of the metering system, metering system configuration and level of accuracy required. To facilitate the above approval, the preliminary submission to the host countries authority shall include but not limited to the following items:

- Measurement philosophy.
- Product allocation principles.
- Measurement methods and standards.
- Proposed system accuracy.
- Production accounting exposure analysis.
- Metering project cost estimates.
- Field area and installation layout with main pipelines.
- Proposed sizing of the metering system.
- Preliminary system configuration.

The metering system can either be used for Custody Transfer or Allocation purpose.

2.2.1.2 Two categories of metering system fall under the preview of these guidelines.

a) Custody Transfer Metering System

This type of system is shall be of high accuracy and designed with an uncertainty of +/- 0.25% of standard volume, used for custody transfer application i.e. transfer of ownership. The figure registered from this system is used for sales determination.

b) Allocation Metering System

This type of metering has slightly lower accuracy than Custody Transfer Metering and shall be designed with an uncertainty of $\pm 1\%$. This type of system is commonly used in oil and gas production facilities, used for allocation of liquid between fields of different ownership sharing a common facility or facilities. The allocation method normally used is by "full allocation" i.e. where metering systems are installed in all fields of different ownership involved in sharing the same facilities. However, the uncertainty of the metering system shall be designed to be of custody transfer quality standard e.g. $\pm 0.25\%$ if "measurement by difference" allocation concept being adopted.

Lowest level quality of Allocation Metering system can be of a well test system's standards ($\pm 10\%$). Factors such as oil reserve, investment cost and impact to the related parties are to be considered and agreed by those involved before this allocation concept is adopted. This is applicable for oil and gas production facilities only.

2.2.1.3 Generally two main measurement and allocation concept are currently acceptable for the above purpose namely,

- a) Measurement by different method
- b) Full allocation

Only upon the host country authority agreement or the respective country petroleum resource manager on the measurement and allocation concept, Contractor can proceed on procuring of the relevant metering systems in accordance to these guidelines. It is the responsibility of the Principal to obtain agreement from their equity partner and the interested party or parties that will be affected with the metering system installation, before the concept is submitted for host countries authority or the respective country petroleum resource manager's agreement.

2.2.2 **Metering Project Implementation**

2.2.2.1 Host country authority or the respective country petroleum resource manager may also request the following information to be submitted for approval for the oil and gas production facilities prior to the release of bid package:

- a) System specifications
- b) Design formula calculations
- c) Calculation of overall accuracy and uncertainty of the system
- d) Relevant drawings
- e) Other relevant information

They may also request the Project Definition Manual be submitted prior commencing fabrication of the metering system.

2.2.2.2 Prior to the official use of the metering system, Contractor shall submit an application together with all relevant data for the respective host country to review and data submitted or after visiting the installation site. Metering system installed shall be traceable to the national and international standards. For the case of the system in Malaysia, SIRIM Berhad's directive is applicable.

Contractor shall also submit to the respective host country authority or their petroleum resource manager for approval, the hydrocarbon and accounting procedure and as well as the validation procedure. The operation procedure will be requested on the need basis.

2.2.3 Government Regulatory Requirement

2.2.3.1 Custody Transfer Metering System that registered flow quantity that is also used to calculate the crude oil relevant tax needs to be agreed by the respective countries government authorities. For the system in Malaysia, it will be the Malaysian Authorities i.e. SIRIM Berhad and Customs and Excise Department. System to be installed shall be first agreed by the authorities and certification from them is necessary prior official use. See [Appendix 2](#) for typical flowchart of the application.

2.2.3.2 Contractor shall also ensure that the necessary safety approval is obtained by their Vendors from the Government Safety Department should the fabrication and testing of the metering system be carried out in the country that requires this approval. Approval may also need to be obtained if the system is to be installed and operate onshore in certain countries.

The government regulatory requirement may vary from country to country and Contractor shall ensure that the respective country regulatory requirements are being met.

2.2.3.3 Any deviations form these guidelines with respect to the measurement and allocation concept, design, operation and maintenance of the metering system requires Principal prior approval.

2.3 DOCUMENTATION

2.3.1 Contractor shall establish and maintain an up-to-date file containing all specifications, calculations and drawings (AS-BUILT). The file should also contain reports concerning verification revisions, design, fabrication, installation and commissioning including inspection and testing programs and operation manual for all fixed and temporary phases and other relevant documentation.

2.3.2 Contractor shall ensure that all documentation during the metering project implementation are timely available such as the project definition manual including the uncertainty analysis, factory and site acceptance test procedures and its result and as well as validation procedures.

2.3.3 The Contractor should maintain up-to-date lists of current documentation and documentation under preparation. Contractor's internal control system including the documentation should also be made available to ensure qualities of the metering systems are maintained.

3. DESIGN OF METERING SYSTEM

3.1 GENERAL REQUIREMENT

- 3.1.1 The metering and proving systems shall be designed, fabricated, inspected and tested in accordance with the latest agreed editions and addenda to the technical specifications, codes, standards and references mentioned in (6).
- 3.1.2 Contractor shall request the vendor to quote for the design, manufacture, testing, calibration and documentation of a fully integrated skid and associated control panel.

The metering system shall comprise the following major component parts:

- a) Field mounted skid, meter proving equipment and instrumentation.
- The minimum number of parallel meter runs required from the specified maximum and minimum flow rates at the specified accuracy with one complete spare meter run. For allocation metering system having less critical availability, the spare run may not be required. It is on case-to-case basis.
 - A meter proving equipment and its instrumentation for regular proving and calibration of the meter.
 - Flow proportional automatic sampling system. Refer to Section 3.7 for details.
 - All associated pipe works, valves and fittings, access stairs, walkways for operation, maintenance and validation, lifting pad eyes and drip pans.
 - All transducer and instrumentation necessary for automatic meter proving prover operation and continuous measurement of mass and volumetric quantities and flow rates of liquid together with its temperature, pressure, density and water content prior to delivery.
- b) Metering control panel and computing facilities in the Control Room
- The computer system consisting of the respective stream flow computing functions, meter proving computing functions, station computing functions and communication bus that will perform the calculation and computation of quantities, reporting and metering system control functions. Station computer and communication bus shall be provided with full redundancy. For allocation metering system will depends on the availability and criticality requirement of the system.
 - All other items not specifically mentioned but necessary for the functioning of the systems, including equipment for testing and calibration.
 - The control panel shall include all termination, computing devices, indicators and controls necessary for operation from the panel location.
- 3.1.3 All equipment within the skid shall be ergonomically arranged such that it is safe and easily accessible for operation, maintenance and validation. Facilities to ease the validation shall be included in the system. Platforms, gratings, stairs etc. be provided as required for easy movement within the skid area. For metering system that required heat tracing, all equipment and components that will be accessed periodically shall be provided with removable insulating covers fitted with quick release fasteners. All equipment and material supplied shall be brand new and suitable to be used for its intended operating conditions.
- 3.1.4 The system shall be designed to allow subsequent re-calibration of the displacement prover (either sphere or piston displacer) on site with a portable master displacement prover – master meter calibration equipment, tank prover-master meter or calibration can. The flange connection size for the tie ins of the prover system must be suitable with the respective parties facility providing such recalibration services. For allocation metering system where a master meter being used, a calibration facility for proving the master meter shall be made available. Suitable process and electrical equipment and connections shall be provided for the above purpose.

- 3.1.5 No bypassing of the metering system is allowed for normal operations after commissioning and start up. For the purpose of commissioning and start up, should a bypass line is required, it shall be provided with a blind or a positive shutoff double block and bleed valve with telltale bleed for verifying shutoff integrity. This valve shall always be sealed.
- 3.1.6 Other designs can be accepted provided that the Contractor can demonstrate and document equivalent or better accuracy and integrity of the above mentioned system.

A typical flow schematic diagram is shown in [Appendix 1](#) of this guideline.

3.2 METER RUN DESIGN AND PIPE WORK METERING SKID

- 3.2.1 The meter runs shall be designed in accordance to the ISO2714, ISO 2715 and API Manual of Petroleum Measurement Standards Chapter 5 - Metering and other chapters as specified in (6). Materials selected shall conform to applicable codes, pressures and temperature ratings, process conditions, corrosion resistance, ingress protection and electrical safety classification.
- 3.2.2 Each parallel meter run shall be provided with an inlet, outlet stream control and prover inlet valves, thermal relief valve, flow meter with required upstream and downstream straight length or flow straightening vane as required and a strainer with differential pressure indicator and draining facility. The strainer shall be able to handle the highest flow capacities of the meter with a minimum pressure drop. Temperature transmitter and thermowell, pressure transmitter and pressure gauge shall also be provided. The number of parallel meter runs shall be such that the metering system throughput with one meter runs on standby and the remaining meters still operating within their working range. For allocation metering system that is less critical, standby meter run may not be required.
- 3.2.3 A full bore through conduit or ball valve should be fitted upstream, downstream and prover inlets of each meter run.
- 3.2.4 Double block and bleed valves configuration with positive shut off for meter proving or meter calibration and prover system calibration shall be fitted at the following places:
- Meter runs outlets to prover inlet header
 - Meter run outlets to outlet header
 - Prover outlet to outlet header
 - Prover drains line.

These valves (with exception of the meter run inlet valve) shall have instrumentation for cavity pressure relief and shutoff integrity verification. Drain connections from double block and bleed valves configuration shall have an isolation valve and pressure gauge, for verification of tight shut-off. All drains and vents system downstream of the meter shall be of high integrity. For offshore metering systems, suitable arrangement for the valves to meet the safety standards is to be followed.

- 3.2.5 Flow control valves shall preferably be located at the following points:
- On each meter run outlet between the tee and the outlet double block and bleed valve.
 - On the prover outlet between the 4-way diverter valve and the outlet double block and bleed valve.