KLM Technology Group
#03-12 Block Aronia,
Jalan Sri Perkasa 2
Taman Tampoi Utama
81200 Johor Bahru
Malaysia

FISCAL MEASUREMENT SYSTEMS FOR HYDROCARBON LIQUIDS

(PROJECT STANDARDS AND SPECIFICATIONS)

TABLE OF CONTENT

SCOPE

This Project Standard and Specification describes the functional and technical requirements for fiscal measurement systems for liquid hydrocarbons based on dynamic methods. Further this Project Standard and Specification provides criteria for selection of such systems or main components thereof.

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. ANSI/ASME Performance Test Code 19.3
2. API MPMS, Chap. 4 Proving Systems
3. API MPMS, Chap. 4.3 Small volume provers
4. API MPMS, Chap. 4.8 Operation of proving systems
5. API MPMS, Chap. 5 Metering
6. API MPMS, Chap. 5.2 Measurement of Liquid Hydrocarbons by Displacement Meters
7. API MPMS, Chap. 5.3 Measurement of Liquid Hydrocarbons by Turbine Meters
8. API MPMS, Chap. 5.8 Measurement of Liquid Hydrocarbons by Ultrasonic Flow meters Using Transit Time Technology
9. API MPMS, Chap. 8.3 Standard Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
10. API MPMS, Chap. 10.9 Standard Test Methods for Water in Crude Oils by Coulometric Karl Fischer Titration (corresponds to IP 386/99)
11. API MPMS, Chap. 11 Volume Correction Factors
12. API MPMS, Chap. 11.2.2 Compressibility Factors for Hydrocarbons
13. API MPMS, Chap. 12 Calculation of Petroleum Quantities
14. API MPMS, Chap. 20 Allocation Measurement

15. BIPM, et.al.*)	OIML P17, Guide to the expression of Uncertainty in Measurements *) On behalf of BIPM, IEC, IFCC, ISO, IUPAC, IUPAP and OIML
16. IEC 60751	Industrial Platinum Resistance Thermometer sensors
17. IP 386/99	Determination of water content of crude oil - Coulometric Karl Fischer method Note: See also ASTM-D-4928-00 which corresponds to IP 386/99.
18. IP PMM Part VII	Density. Section 2. Continuous Density Measurement
19. ISO 1000	SI units and recommendations for use of their multiples and of certain other units
20. ISO 3171	Petroleum Liquids - Automatic pipeline sampling
21. ISO 5024	Measurement - Standard reference conditions
22. ISO 6551	Petroleum Liquids and Gases - Fidelity and Security of Dynamic Measurement - Cabled Transmissions of Electric and/or Electric Pulsed Data
23. ISO 7278-3	Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters - Part 3: Pulse Interpolation Techniques
24. ISO 9000-3	Guidelines for the application of the ISO 9001 to the development, supply and maintenance of software
25. ISO 10337	(corresponds to IP 386/99)
26. ISO 10790	Measurement of fluid flow in closed conduits — Guidance to the selection, installation and use of Coriolis meters (mass flow, density and volume flow measurements)
27. ISO/TR 9464	Guide to the use of ISO 5167
28. API MPMS, Chap. 8.2	Automatic sampling of petroleum and petroleum products
29. API MPMS Chap. 13	Statistical Aspects of Measuring and Sampling
30. IP PMP No. 2	Guidelines for users of the Petroleum Measurement Tables – Computer procedure for correcting density of crude and products at line conditions to standard conditions

31. IP PMM Part VI	Sampling. Section 2. Guide to Automatic Sampling of Liquid from Pipelines
32. IP PMM Part X	Meter Proving. Section 1. Field Guide to Proving Meters with a Pipe Prover
33. IP PMM Part X	Meter Proving. Section 3. Code of Practice for the Design, Installation and Calibration of Pipe Provers
34. IP PMM Part XV	Metering Systems. Section 1. A Guide to Liquid Metering Systems
35. ISO 8222	Petroleum Measurement systems - Calibration - Temperature corrections for use when calibrating volumetric proving tanks

DEFINITIONS AND TERMINOLOGY

Accreditation - official recognition to the effect that an organisation is operating in accordance with a documented quality assurance system and that it has demonstrated competence to carry out specified tasks.

Allocation - distribution of sold/produced quantities of hydrocarbons between licensees and owner companies.

Fiscal quantity - measured quantity of hydrocarbons used for sale, custody transfer, ownership allocation or calculation of royalty or tax.
Note: The term "fiscal " refers to the function of the measurement system, not its level of measurement uncertainty.

In-line - concept where the main pipe volumes flows through the in-line unit.

Prover unit - conventional pipe prover, compact prover, master meter or other applicable method to calibrate the flow element.

Quantity - measure of the hydrocarbon medium, by volume, mass or energy.

Standard gross volume - oil volume at standard conditions including water.

SYMBOLS AND ABBREVIATIONS

SYMBOL/ABBREVIATION	DESCRIPTION
A/D	analogue to digital
ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BIPM	International Bureau of Weight and Measure
CD-ROM	compact disc – read only memory
CEN	The European Committee for Standardization
CMR	Christian Michelsen Research
CPU	central processing unit
D/A	digital to analogue
EN	European Standard
FAT	factory acceptance test
GRP	glassfibre reinforced polyester
ID	internal pipe diameter
IEC	International Electrotechnical Commission
IFCC	International Federation of Clinical Chemistry
I/O	input/output
IP	Institute of Petroleum
IP PMP	Institute of Petroleum, Petroleum Measurement Paper
IP PMM	Institute of Petroleum, Petroleum Measurement Manual
ISO	International Organization for Standardization
IUPAC	International Union of Pure and Applied Chemistry
IUPAP	International Union of Pure and Applied Physics
LPG	liquified petroleum gas
MPMS	Manual of Petroleum Measurement Standard
OD	outer pipe diameter
OIML	International Organisation of Legal Metrology
PD meter	positive displacement meter
P&ID	piping and instrument diagram
Pt-100	platinum resistance thermometer
RAM	read access memory
RVP	reid vapour pressure
SAS	safety and automation system
SI	International System of Units
VDU	visual display unit

GENERAL REQUIREMENTS

General

The measurement system which fulfils the functional and technical requirements and has the lowest life cycle cost shall be selected.
Fiscal measurement systems for hydrocarbon liquid include all systems for:
- fiscal measurement of liquid,
- water in oil measurement,
- sampling.

All systems shall give readings and reporting in SI-units according to ISO 1000, except for pressure where the unit bar shall be used and for dynamic viscosity where the unit mPa shall be used.
The standard reference condition shall be 15C, 1,01325 bar absolute, see ISO 5024. LPG measurement could use other reference conditions in accordance with recognized standards.
For system concepts with no system specific requirements in this Project Standard and Specification, the design shall, when standards are available, be based on (in order of priority):
- international standards (preferably ISO or CEN),
- the manufacturer's recommendations.

Uncertainty

Uncertainty limit (expanded uncertainty with a coverage factor k=2) for the fiscal oil measurement system shall be 0,30 % of standard gross volume.
Any other uncertainty limit may be applicable for fiscal measurement systems if validated by a cost-benefit analysis performed and accepted by the operator, see Appendix C. In such cases, a deviation list including the relaxed requirements from this Project Standard and Specification should be defined. The uncertainty figures shall be calculated for each component and accumulated for the total system.

Sampling and Water Fraction Metering Equipment

Automatic sampling equipment shall be installed. For determination of water content in oil, a continuous water-in-oil monitor shall be considered as alternative to automatic sampling and subsequent laboratory analysis. Sampling systems, however, may be needed for other analyses such as density, salt, sediments,

composition analysis, and samples to be delivered to the customer etc. Such other use of the sampler shall be taken into consideration.
Manual sampling point shall also be installed.

Calibration

All instruments and field variables used for fiscal calculations or comparison with fiscal figures shall be traceable calibrated to international/national standards. Calibration by an accredited laboratory fulfils these requirements. Test requirements prior to start-up are given in Appendix B.
All geometrical dimensions used in fiscal calculations shall be traceably measured and certified to international/national standards. The material constants shall be documented. Implemented constants shall be available for verification.

Computer Design

The Vendor shall develop a functional specification for the computer part. This document shall clearly specify all functions and features, e.g. the applied algorithms, the sequences of the system, operator responses and error handling.

SALES AND ALLOCATION MEASUREMENT

Functional Requirements

1. General

   The measurement system shall measure crude oil, or other hydrocarbon liquids flow rates and accumulated quantities and control an automatic oil sampler system. Where applicable, approval by the national authorities is required.

2. Products/services

   Maximum pressure loss across the measurement station (including in- and outlet headers) shall be 2,0 bar, with no meter calibration in progress and 2,5 bar, with meter calibration in progress.
   Single liquid phase shall be maintained across the measurement station. The operating pressure in the metering run shall be maintained sufficiently above vapor pressure.

3. Equipment/schematic

   The measurement system shall consist of
   - a mechanical part including the flow meter and prover unit,
   - an instrument part,
   - a computer part performing calculation of quantities, reporting and system control functions.

   The computer part shall be dedicated computer(s). However, the supervisory computer part may be a dedicated part of the SAS.
   A compact design is encouraged to reduce space requirements and weight.

4. Performance

   a. Capacity

      The measurement system shall be capable of measuring the full range of planned quantities of hydrocarbon liquid through the measurement system. The flow rate in each meter run shall not exceed limits, which result in total uncertainty exceeding the uncertainty limits for the system.

   b. Uncertainty

      The uncertainty limit shall be 0,30 % (expanded uncertainty with a coverage factor k=2) of standard gross volume. For water content above 0,5 %, special attention shall be made to ensure compliance with the uncertainty limits and proper performance of the measurement system.

   c. Lifetime

      The lifetime is application specific.

   d. Availability

      The measurement system shall be designed for continuous measurement of all expected flow rates.

5. Process/ambient conditions

   Refer to process data sheet (project specific).

6. Operational requirements

   a. General

      The measurement system shall be operated from the computer part. It shall be possible to operate the measurement system from SAS.
      It shall be possible to measure the oil flow, operate the system and perform proving even if the supervisory computer fails completely.
      The system shall automatically perform all line/valve control for meter runs that are in service mode, as required during normal operation and during

the proving phase. There shall also be a manual mode for such operations.
The meter run inlet valves and the prover/master meter outlet valve shall as minimum be manually operated by electrical actuator.
It shall be possible to operate all valves locally.
The closing of the last open meter run shall only be possible in manual mode.
It shall be possible to automatically start and perform the proving sequence based on specified deviation criteria, e.g. flow rate deviation, density deviation, time since last proving. It shall be possible to start the proving sequence manually while in automatic mode and to disable the automatic mode. It shall also be possible to perform a proving sequence for one trial manually in a step-by-step manner.
Continuity in measurement of the oil flow shall be maintained during regular calibration of the field instruments and whenever a field instrument of any type fails.

b. Tanker loading measurement system

In automatic mode the different phases in a loading sequence such as start-up, loading, topping off and termination shall be pre-programmed in the computer. The computer shall automatically calculate and set the sampling rate when given the size of the oil batch.
The measurement system shall apply batch retroactive K-factor for the first meter calibration during the batch. Electronic batch totals shall be incremented or decremented immediately upon determination of the retroactive K-factor. Any non-reset-able counters that can not be decremented shall have separate decrement-registers (reset to zero at start of batch) to be incremented to zero before counting continues in non-reset-able counters.
When no batch is in progress, any flow passing through the measurement system shall be accumulated in non-reset-able non-batch totals.

7. Maintenance requirements

a. General

The field instrumentation shall be selected to reduce need for maintenance and calibration activities.
The maintenance requirements for automated condition based maintenance in Appendix A shall apply. In addition, there should be easy access to all instruments and flow elements for maintenance.

b. Calibration

Locations where checking and calibration take place shall be protected against environmental influences and vibrations so that the requirements given in this Project Standard and Specification can be fulfilled.
It shall be possible to calibrate all instruments and separate components in the electronic loop either without moving them from their permanent installations, without disconnecting any cables, or by using transmitters fitted with quick connectors (for removal for calibration/ maintenance). An exception to this will be a flow meter that requires off-line calibration.
If it is impossible to calibrate the meter at the relevant process conditions, the meter shall at least be calibrated for the specified flow velocity range.
Densitometer cables shall be equipped with quick connectors for easy retrofit.
There shall be connections for in-situ calibration of the prover unit.
The computer part shall be designed so that during calibration the amounts shall be registered separately and independently of measured amounts. In calibration mode, the flow time shall be registered and displayed by the flow computer/computer system.

c. Maintenance

There shall be easy access to any part requiring regular calibration and maintenance. Facilities to ease the calibration shall be included in the system or offered as an option.
The software shall provide means of calling up live transmitter values (one at a time) onto the operator workstation for purpose of calibration. The input shall be displayed in engineering units. Input shall be displayed on VDU with the same time period as read by the I/O system, i.e. no averaging.

d. Isolation and sectioning

It shall be possible to maintain the mechanical part of the system without dismantling the manifolds (or similar).
It shall be possible to isolate the prover unit for uninterrupted metering during calibration.

e. Thermal insulation

The insulation/heat tracing shall be removable for test and field calibration of instruments in the measurement system.

8. Layout requirements

Bypassing of the measurement system is not permitted.