

DEP SPECIFICATION

**CUSTODY TRANSFER MEASUREMENT SYSTEMS FOR
LIQUIDS AND GASES AND VAPOURS**

DEP 32.32.00.11-Gen.

February 2017

DESIGN AND ENGINEERING PRACTICE



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

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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design, fabrication, installation and commissioning of custody transfer measurement systems.

Liquids:

Application of this DEP is limited to single phase homogenous fluids which are liquids or super critical (dense phase) fluids at the measurement conditions such as LPGs, refined products (e.g., gasoline, diesel, kerosene), crude oils, ethane, CO₂, NGLs, LNG and chemicals (e.g., ethylene, benzene, styrene, glycols).

Custody transfer measurement systems associated with pipeline, marine vessel and truck (un)loading applications, with some exceptions as detailed below are included in the scope of this DEP.

Custody transfer measurement systems at the retail level of trade (e.g., gasoline dispensers), weight scales and metering requirements associated with allocation meters upstream of the sales meters (see DEP 32.00.00.12-Gen.) are outside the scope of this DEP.

Gases and Vapours:

Application of this DEP is limited to single phase homogenous fluids, which are gases or vapours at the measurement conditions such as natural gas, steam and hydrogen.

Custody transfer measurement systems associated with pipeline receipt or delivery applications are included in the scope of this DEP.

Custody transfer measurement systems at the retail level of trade (e.g., residential gas meters), and metering requirements associated with allocation meters upstream of the natural gas custody transfer meters are outside the scope of this DEP.

This revision of DEP 32.32.00.11-Gen dated September 2012 amended February 2013 also replaces DEP 32.32.00.12-Gen. dated February 2013, now covering the requirements for liquids, gases and vapours, see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP 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, the objective being to obtain agreement to follow this DEP 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 it. 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.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
Adjustment (API MPMS 1, 2004)	Adjustment (of meter registration): The operation of bringing a measuring instrument (meter) into a satisfactory state of performance and accuracy.
Adjustment (ISO-VIM, 3.11, 2012)	Set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured Types of adjustment of a measuring system include zero adjustment of a measuring system, offset adjustment, and span adjustment (sometimes called gain adjustment). Adjustment of a measuring system should not be confused with calibration, which is a prerequisite for adjustment. After an adjustment of a measuring system, the measuring system usually needs to be recalibrated.
API MPMS vs OIML/ISO	In jurisdictions where API MPMS terminology is utilised, measurement equipment performance assurance is denoted by the terms verification (i.e., assessment of the as-found state of the device relative to a reference standard) and calibration (i.e., device output adjustment to conform to reference standard value). In jurisdictions where OIML/ISO terminology is utilised, measurement equipment performance assurance is denoted by the terms calibration (i.e., verification in API MPMS) and adjustment (i.e., calibration as defined in API MPMS). In this DEP, the term "validation" is used to denote the process of verification followed by calibration if required.
Base Conditions	Synonymous with standard reference, base or standard conditions. Base conditions are the reference conditions of temperature and pressure to which measured volumes are to be corrected for reporting purposes. See (2.6) for details.

Term	Definition
Calibration (API MPMS 1, 2004)	Calibration (of an instrument): The process or procedure of adjusting an instrument, such as a meter, so that its indication or registration is in satisfactory close agreement with a reference standard. Meter proving data can be used either to calibrate the meter or to calculate a meter factor.
Calibration (ISO-VIM, 2.39, 2012)	Operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication. A calibration can be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it can consist of an additive or multiplicative correction of the indication with associated measurement uncertainty. Calibration should not be confused with adjustment of a measuring system, often mistakenly called "self-calibration", nor with verification of calibration.
Custody Transfer	Custody transfer measurement provides the highest accuracy quantity and quality information used for the physical and fiscal documentation of a change in ownership or a change in responsibility for products, feed stocks, fuel.
Fiscal Measurement	Measurement pertaining to government income and revenues such as taxation and royalties.
Master Meter	A meter of comparable or lower uncertainty used to verify/calibrate a custody transfer meter.
Meter Proving	On site validation of flow measurement equipment using a prover or master meter.
N+1	Number of required runs plus spare.
Pay and Check meter	Redundant flow meters in series for continuous verification whereby one system produces the fiscal data and the other checks the outcome of the previous.
Validation (ISO-VIM, 2.45, 2012)	Verification, where the specified requirements are adequate for an intended use Example: A measurement procedure, ordinarily used for the measurement of mass concentration of nitrogen in water, may be validated also for measurement of mass concentration of nitrogen in human serum.

Term	Definition
Verification (ISO-VIM, 2.44, 2012)	Provision of objective evidence that a given item fulfils specified requirements Example 1: Confirmation that a given reference material as claimed is homogeneous for the quantity value and measurement procedure concerned, down to a measurement portion having a mass of 10 mg. Example 2: Confirmation that performance properties or legal requirements of a measuring system are achieved. Example 3: Confirmation that a target measurement uncertainty can be met. When applicable, measurement uncertainty should be taken into consideration. The item could be a process, measurement procedure, material, compound, or measuring system. The specified requirements could be, e.g. that a Manufacturer's specifications are met. Verification in legal metrology, as defined in VIML[53], and in conformity assessment in general, pertains to the examination and marking and/or issuing of a verification certificate for a measuring system. Verification should not be confused with calibration. Not every verification is a validation. In chemistry, verification of the identity of the entity involved, or of activity, requires a description of the structure or properties of that entity or activity.

1.3.3 Abbreviations

Term	Definition
AGA	American Gas Association
AMS	Asset Management System
ATEX	European Union directives describing explosive atmosphere equipment requirements
BIPM	Bureau International des Poids et Mesures
BPCS	Basic Process Control System
CSA	Canadian Standards Association
CTM	Custody Transfer Measurement
D	Nominal Pipe Internal Diameter
DB&B	Double block and bleed
FAME	Fatty Acid Methyl Esters
FAT	Factory Acceptance Test

Term	Definition
FF	Foundation™ Fieldbus
FGS	Fire and Gas System
GC	gas chromatograph
GPA	Gas Processors Association
HPIMS	Hydrocarbon Production Information Management System
IAPWS	International Association for the Properties of Water and Steam
IPS	Instrument Protective System (the safeguarding system)
LACT	Lease Automatic Custody Transfer
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MESC	Materials and Equipment Standards and Codes
MID	European Measuring Instruments Directive
MPMS	API Manual of Petroleum Measurement Standards
NDI	Non-Destructive Inspection
NGL	Natural Gas Liquids
NIST	National Institute of Standards and Technology
NMI	National Metrology Institute
NPL	National Physical Laboratory
NPS	Nominal Pipe Size
NTEP	National Type Evaluation Program
OIML	Organisation Internationale de Métrologie Légale meaning International Organization of Legal Metrology
P&ID	Process and Instrumentation Diagram (see PEFS)
PD	Positive Displacement
PEFS	Process Engineering Flow Scheme (see P&ID)
PLC	Programmable Logic Controller
QMI	Quality Measurement Instruments
RTD	Resistance Temperature Detector



Term	Definition
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
TCoO	Total Cost of Ownership
UL	Underwriters Laboratories

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (15).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated September 2012, amended February 2013 now covering the requirements for liquids, gases and vapours. This revision combines the content of DEP 32.32.00.12-Gen. for gas and vapours with DEP 32.32.00.11-Gen. for liquids.

The revision process included a challenge of requirements to focus on clear, verifiable requirements and rationalise the content to essential elements. The changes are too numerous to list.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. COMMON SYSTEM REQUIREMENTS

2.1 INTRODUCTION

Custody transfer measurement systems are designed to provide accurate, equitable and reliable measurements. This is achieved by pre-establishing and meeting the regulatory, contractual and the Principal's requirements. This mitigates the risk of breach of contract, financial loss or regulatory non-compliance. The use of industry measurement standards lays the foundation for appropriate custody transfer measurement system design.

2.2 REQUIREMENT HIERARCHY

1. Prior to measurement system design, the requirements related to the following aspects shall be defined:
 - a. Uncertainty;
 - b. Regulatory;
 - c. Contractual;
 - d. The Principal's business process.
2. The following requirement hierarchy shall apply for custody transfer measurement systems (with a. being the highest priority):
 - a. Safety
 - b. Regulatory (i.e., local legal/metrology authorities)
 - c. Contractual
 - d. Principal's design practices and business process (e.g., HPIMS).
3. The following datasheets shall be used to specify critical design parameters including applicable regulations and industry standards:
 - a. DEP 32.32.00.94-Gen. for liquids
 - b. DEP 32.32.00.95-Gen. for gases and vapours.

2.3 MEASUREMENT STANDARD SELECTION

This DEP contains references to measurement standards typically utilised within the Americas (e.g., API MPMS, AGA) and those utilised typically outside of the Americas (e.g., ISO). However, subject to (2.2), there is no intent to prohibit use of API standards outside of the Americas and vice versa. In some instances where there is overlap of industry standards, a recommendation is made to use one standard rather than another (e.g., more up-to-date standard available).

1. The industry standards revision current at the time the agreement is executed shall apply to the measurement system at the time of design.

2.4 ENGINEERING UNITS

1. All calculated and measured values (e.g., temperature, pressure, mass, volume, density heating/calorific value) shall be expressed in units according to the International System of units (SI) or US Customary (USC) units. See (1.7)

2.5 BASE CONDITIONS

1. For volumetric measurements where the measured quantity is to be corrected from flowing conditions to base conditions (often the same as standard or normal conditions), the base conditions and nominal site barometric pressure shall be defined prior to design and itemised on the datasheet.

2.6 RESPONSIBILITIES

1. The Contractor's scope of work and responsibility shall include system design, documentation, equipment selection, acceptance testing and oversight of the Supplier's delivery of the measurement system.
2. The Manufacturer/Supplier's scope of work and responsibility shall include system design, documentation, fabrication, inspection, testing, delivery, and the initial calibration of the complete measurement system required to meet the system design.

3. SYSTEM DESIGN

3.1 INTRODUCTION

1. The measurement system shall be designed to meet the requirements of this DEP, all applicable agreements, codes, regulations and standards using proven methods and devices (i.e., no prototypes) to achieve the required uncertainty and availability in a safe and cost effective manner.

In this context, 'proven' means that it has been accepted by the Principal as being qualified for use and is supplied by a Manufacturer/Supplier that is approved by the Principal.

2. The total life cycle costs of ownership (TCoO) of the measurement system shall be optimised against the requirements stated in (3.1, Item 3).

A method for calculating the TCoO is given in DEP 32.31.09.31-Gen.

3. Prior to the design of custody transfer measurement systems, the following shall be defined and documented:
 - a. measurement basis (mass, volume or energy);
 - b. target uncertainty for the measurement system;
 - c. applicable codes, regulations, agreements and standards;
 - d. ownership of measurement equipment;
 - e. responsible party for measurement system;
 - f. acceptable flow meter types;
 - g. range of process conditions (e.g., fluid types, fluid contaminants, density, pressures, temperatures, flow rate range);
 - h. acceptable validation techniques (e.g., in-situ or remote);
 - i. base conditions for volumetric techniques;
 - j. target system availability;
 - k. third party data transfer connection requirements;
 - l. engineering units;
 - m. fluid quality specifications;
 - n. rangeability factor (3.6);
 - o. measurement system operational control philosophy (consistent with the facility operational control philosophy).

3.2 APPROVALS

Custody transfer metering installations are usually subject to approval by local authorities or other interested parties (e.g., JV partners, other producers or refiners, pipeline companies). These approvals typically extend from the design stage through to final installation and eventually to the operating stage.

1. The local authorities or other interested parties shall be consulted at the earliest possible stage and thereafter, in order to do the following:
 - a. gain acceptance of the metering philosophy,
 - b. get approval of the system design (where required)
 - c. to simplify final approval of the installation.

In some cases, local authorities require that devices (e.g., meters, flow computers, transmitters) have individual approvals (e.g., NMI, MID for liquids and NTEP or other Notified Bodies for gases and vapours). However, the fact that a device has such an approval does not negate the necessity to ensure the device's suitability for the application under consideration.

3.3 MEASUREMENT UNCERTAINTY

1. The overall uncertainty and data availability of the measurement system should initially be estimated from operational experience with other facilities of similar design and purpose.
2. To demonstrate that the system design meets the required contractual or regulatory uncertainty, ISO 5168 shall be used.
3. Stated uncertainty throughout this document shall be 2 sigma values (approximately 95 % confidence level).

3.4 GENERAL DESIGN

1. All measurement system equipment shall meet the following requirements:
 - a. be suitable for the operating envelope as detailed in Instrument data sheets,
 - b. be suitable for the electrical area classification in which it will be utilised,
 - c. meet the process safety requirements,
 - d. have the required uncertainty for the application for gases and vapours (e.g., contract, OIML),
 - e. have the required accuracy and precision for the application for liquids,
 - f. have the required approvals (e.g., CSA, ATEX, NMI, MID, materials),
 - g. have wetted components suitable for the process fluid.
2. The skid package shall be suitable for the location's prevailing environmental conditions, as specified on the datasheet.
3. The skid package shall include all pipe work, manifolds, metering streams, valves, electrical, instruments, fittings and be supplied as a fully piped, cabled, and instrumented package.
4. The number of parallel meter runs shall be determined by the required flow rate rangeability (3.6) and availability (3.5).
5. The maximum allowable pressure drop across the complete metering system should be less than 200 kPa (30 psi), or as specified in the datasheet.
6. Equipment layout shall provide for safe and sufficient access for device validation and maintenance.
7. For meters that are to be calibrated remotely, provision shall be made to permit removal of the meter run without disassembly.

For instance, transport meter, upstream and downstream straight pipe lengths including flow conditioner without unbolting.

- a. Local safety requirements regarding lifting of equipment shall be taken into account in the design (e.g., potential lifting above pressurized lines).
8. Where required, meter runs shall be thermally insulated in order to reduce heat transfer from ambient via the piping and so avoid hydrocarbon or water condensation and temperature stratification at low flow rates.
9. For volumetric measurements, the length of the insulated section shall at least satisfy the straight length requirements and include the temperature element and the primary device.
10. Designs intended to utilise a portable prover or master meter shall make provision for the following:
 - a. adequate and safe access;
 - b. appropriate drain connections;
 - c. spill containment.

3.5 SYSTEM AVAILABILITY

1. The required system availability shall be defined prior to design and specified in the datasheet.
2. The custody transfer measurement system shall have sufficient redundancy so that unavailability of a single component of the system due to failure or maintenance shall not result in any of the following:
 - a. the interruption of ongoing measurements;
 - b. the loss or invalidation of contractually required data.
3. Redundancy at meter run level, if required, should be a system of Pay and Check, each capable of producing independently the contractually required data.
4. Data from Pay and Check systems shall be continuously accrued and recorded thus creating two independent data sets of equal parity.
5. Orifice carriers should be considered for mitigating unavailability due to periodic inspection of the orifice plate or its replacement in the event of its failure.
6. Isolation practices that apply generally for the site or facility, such as requirements for double block and bleed valves, shall be implemented.

3.6 RANGEABILITY

The design capacity of the measurement system is determined by the maximum flow rate that can be measured at the required uncertainty (excluding any spare meter runs provided for reliability purposes).

The minimum design capacity is the minimum flow rate of the smallest single meter run at the required uncertainty.

1. The system design shall incorporate sufficient parallel meter runs to do the following:
 - a. permit the maximum and minimum system flow rates to be measured at the specified uncertainty;
 - b. achieve the specified availability including validation exercises when one of the meter runs is removed for validation.
2. Where required by agreement or regulation, provision shall be made to stop the flow at rates below a preset minimum value.

For example, for gases and vapours, the lowest flow calibration point of the flow meter as specified at the metrological certificate or where uncertainty cannot be met).

3.7 TRACEABILITY

1. The system shall be designed to permit traceability to the required national metrological standards.

At the design stage, this means:

- selecting equipment types that are traceable;
 - providing appropriate means (e.g., access, process taps, sample points) for the required field verifications and calibrations.
2. The equipment used for determining fluid and process properties shall be traceable to national and international standards using the following:
 - a. a system of analytical procedures,
 - b. reference materials,
 - c. sampling and calibration procedures (3.8.1).

3.8 DEVICE VALIDATION CAPABILITY

3.8.1 General

1. The requirement for factory calibrations shall be identified on the instrument data sheets.
2. Device performance validations should be conducted in-situ without instruments having to be removed.
3. Sufficient validation facilities shall be provided for each instrument (e.g., validation ports/manifolds, dual thermowells, manual sample valves).
 - a. For meters in gas and vapour service to be validated in-situ, master meter connections shall be provided (this excludes differential pressure measurement based devices).
4. If in-situ validation is not possible or not required, the instrument concerned shall be scheduled for regular factory recalibration, which might require a spare, calibrated instrument to be available.

Validations using a fluid different than the process fluid are only acceptable if this is accounted for in agreed uncertainty calculations, agreements or regulations and if approved in writing by the Principal.

5. Calibration equipment shall have a valid calibration certificate traceable to a national metrological standard and identify the 'as found' errors, the calibration uncertainty and expiry date.
6. Calibration equipment shall have an uncertainty no greater than one third of the uncertainty of the instruments to be calibrated under the conditions at which the tests take place.

3.8.2 Meter verification (gases) and meter proving (liquids)

1. As part of the preliminary design, the flow meter validation practice shall be selected and an assessment performed to determine which of the following meter validation options meet the application requirements:
 - a. Off-site calibrations (availability of suitable proving facilities in terms of geographic proximity, uncertainty and capacity),
 - b. On site calibration using a master meter (either permanently installed in series or periodically brought in-line),
 - c. For liquids, on site calibrations using a portable prover (local availability of suitable portable provers in terms of geographic proximity and capacity),

- d. For liquids, on site calibrations using a permanently installed prover.

3.9 OPERATING ENVELOPE

1. The measurement system shall be capable of meeting its uncertainty, rangeability and availability targets for the design operating envelope.
2. DEP 32.31.00.32-Gen. shall be followed for requirements related to instruments installation.

3.10 MATERIALS

1. All pressure retaining components such as piping, valves, strainers, and meter bodies shall comply with the piping classes and materials requirements specified in the datasheet.
2. Refer to the following as applicable for piping material requirements:
 - a. DEP 31.38.01.11-Gen.
 - b. DEP 31.38.01.12-Gen.
 - c. DEP 31.38.01.15-Gen.
 - d. DEP 39.01.10.11-Gen.
3. Refer to DEP 32.31.00.32-Gen. for instrument material requirements.

3.11 ELECTRICAL

3.11.1 General

1. All electrical devices shall be approved (e.g., ATEX, CSA, UL) and be marked for the area classification and jurisdiction in which they are to be installed.
2. See DEP 32.31.00.32-Gen. for electrical certification requirements.

3.11.2 Measurement device outputs

1. In addition to the primary element signals and secondary instrument signals, all measurement devices shall output a fault condition.
 - a. Measurement devices should, where available, provide device diagnostics.
2. With the exception of communications downstream of the flow computer, wireless shall not be utilised in custody transfer measurement systems.

3.11.3 Primary element outputs

1. The primary output of linear custody transfer meters shall be pulses where each pulse represents a discrete volume or mass.

That is, do not use analogue signals (e.g., 4-20 mA) or digital communications such as FoundationTM Fieldbus (FF) as the primary output for linear custody transfer meters.

3.11.4 Secondary device signals

1. Where compatibility has been proven through an interoperability testing between the transmitter and the flow computer, secondary instruments (e.g., static pressure, differential pressure, temperature, QMIs) should utilise a digital communications such as FF.
2. Where digital communications are not practical or provided for secondary instruments, analogue 4-20 mA outputs shall be used.
3. With the exception of gas chromatographs, Modbus shall not be used for secondary device signals.