

DEP SPECIFICATION

CUSTODY TRANSFER MEASUREMENT SYSTEMS FOR LIQUIDS

DEP 32.32.00.11-Gen.

September 2012

(Amendment A01 has been incorporated - February 2013)

ECCN EAR99

DESIGN AND ENGINEERING PRACTICE



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These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.

The objective is to set the standard for good design and engineering practice to be applied by Shell companies in oil and gas production, oil refining, gas handling, gasification, chemical processing, or any other such facility, and thereby to help achieve maximum technical and economic benefit from standardization.

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. Application of this DEP is limited to single phase homogenous Newtonian 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) are outside the scope of this DEP as are weight scales.

Metering requirements associated with allocation meters upstream of the sales meters are outside the scope of this DEP, see DEP 32.00.00.12-Gen.

This DEP encompasses mass, volumetric and energy measurement.

This DEP shall be used in conjunction with requisition sheet DEP 32.32.00.94-Gen.

This is a revision of the DEP of the same number dated September 2002; 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 authorized access to DEPs does not for that reason constitute an authorization 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. When existing facilities are being modified, a complete gap analysis shall be prepared between the existing facility and the latest DEP. The gap analysis shall be provided to the Principal for resolution.

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.

1.3.2 Specific definitions

Term	Definition
Custody Transfer	Custody transfer measurement provides highest accuracy quantity and quality information used for the physical and fiscal documentation of a change in ownership and/or a change in responsibility for feed stocks, fuel, products etc. Synonymous with fiscal measurement with the exclusion of government taxation and possible lack of change of ownership.
Fiscal Measurement	Measurement pertaining to income and revenues of parties concerned, including government taxation.
Validation	In jurisdictions where API MPMS terminology is utilized, 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 utilized, measurement equipment performance assurance is denoted by the terms calibration (i.e., verification as defined above) and adjustment (i.e., calibration as defined above). In this document the term "validation" shall be used to denote the process of verification followed by calibration if required. Meter validation is typically termed meter proving.

1.3.3 Abbreviations

Term	Definition
AMS	Asset Management System
API	American Petroleum Institute
ATEX	European Union directives describing explosive atmosphere equipment requirements
BPCS	Base Process Control System
CCR	Central Control Room
CTM	Custody Transfer Measurement
D	Nominal Pipe Internal Diameter
FF	FOUNDATION TM FIELDBUS
FGS	Fire and Gas System
GC	Gas Chromatograph
GPA	Gas Processors Association
HART®	Highway Addressable Remote Transducer
HPIMS	Hydrocarbon Production Information Management System
HFE	Human Factors Engineering
IPS	Instrument Protective System
ISO	International Organization for Standardization
IUPAC	International Union of Pure and Applied Chemistry
LACT	Lease Automatic Custody Transfer

Term	Definition
LCR	Local Control Room
LPG	Liquefied Petroleum Gas
MESC	Materials, Equipment, Standards and Code
MID	Measuring Instruments Directive
MPMS	Manual of Petroleum Measurement Standards
NGL	Natural Gas liquid
NIST	National Institute of Standards and Technology
OIML	International Organization of Legal Metrology or Organisation Internationale de Métrologie Légale
PD	Positive Displacement
PEFS	Process Engineering Flow Scheme
P&ID	Piping and Instrumentation Diagram
RTD	Resistance Temperature Detector
PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition
STP	IUPAC Standard Temperature and Pressure
TCOO	Total Cost of Ownership
UL	Underwriters Laboratories Inc.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section 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 2002. The following are the main, non-editorial changes.

Old section	New section	Change
All	All	Major DEP revision including name change to include other types of meters and North American measurement standards.

Amendment A01

1.6	1.6	Updated - new guidelines for submitting DEP feedback.
5.5	5.5	Corrected typo. In Section 5.5 it referred to ISO 2175 which should read ISO 2715.

1.6 COMMENTS ON THIS DEP

Amendment A01

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.

2. COMMON SYSTEM REQUIREMENTS

2.1 INTRODUCTION

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

2.2 REQUIREMENT HIERARCHY

Prior to system design, the uncertainty, regulatory, contractual and the Principal's business process requirements shall be defined. The requirement hierarchy for custody transfer measurements is as follows:

1. Safety
2. Regulatory (i.e., legal/metrology authorities)
3. Contractual
4. Principal's due diligence and business process (e.g., HPIMS)

The system shall be designed to meet the most stringent of these requirements. The CTM System Datasheet, DEP 32.32.00.94-Gen., shall be used to summarize critical design parameters including applicable regulations and Industry standards.

2.3 AGREEMENTS

The measurement sections of contracts (e.g., tariffs, connection agreements, sales and purchase agreements) should refer to general custody transfer measurement requirements. Measurement requirements should be expanded in an addendum (i.e., exhibit, attachment) to the contract thus avoiding undue revision of the contract if only technical requirements change. Measurement details such as procedures should be addressed in a Measurement Manual. The "Black and White List" (Appendix A) should be reviewed when preparing the contract.

2.4 MEASUREMENT STANDARD SELECTION

This DEP contains references to measurement standards typically utilized within the Americas (e.g., API MPMS) and those utilized 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).

The Industry standards revision current at the time the agreement is executed shall apply to the measurement system at the time of design. To avoid incurring cost without appropriate benefits, later editions of Industry standards shall only be implemented with the consent of the relevant parties.

2.5 ENGINEERING UNITS

All calculated and measured values (temperature, pressure, mass, volume, density heating/calorific value, etc.) shall be expressed in units according to the International System of units (SI). See DEP 00.00.20.10-Gen. Values in other units where required (e.g., barrels, cubic feet) shall be derived from the SI units. Use of non-SI engineering units requires the approval of the Principal.

The engineering units to be used for a specific facility shall be defined prior to design and detailed in DEP 32.32.00.94-Gen.

See (Appendix B) for common SI and US customary engineering units.

2.6 BASE CONDITIONS

For volumetric measurements where the measured quantity is to be corrected from flowing conditions to base conditions (also called standard or normal conditions), the base conditions and nominal site barometric pressure shall be defined prior to design and detailed in DEP 32.32.00.94-Gen.

See (Appendix C) for a discussion of base conditions.

2.7 RESPONSIBILITIES

The Contractor's scope of work shall include system design, equipment selection, and documentation of the measurement system and oversight of the Supplier. The Supplier's scope of work shall include fabrication, inspection, testing, delivery, and the initial calibration of the complete liquid metering system.

The Contractor shall assume full system responsibility. This means that the Contractor shall have, as a minimum, single point responsibility for the following:

- a) designing the custody transfer measurement system in accordance with this DEP and all applicable codes and standards,
- b) the operability, accuracy and quality of all components including those of sub-suppliers,
- c) obtaining written approvals from the Principal, regulatory authorities and all interested parties for the design prior to procurement and fabrication
- d) all performance based testing (e.g., water injection test for crude oil samplers)
- e) obtaining all permits, certifications and calibrations (e.g., prover water draw)
- f) demonstrating satisfactory system performance via a FAT, SAT and site commissioning
- g) timely notification of upcoming shop and field testing to permit witnessing (Principal, authorities, interested parties)
- h) providing appropriate documentation,
- i) fabrication, delivery and installation oversight.

The Supplier shall prepare a preliminary design with appropriate documentation (14.2) for approval by the Principal in writing prior to equipment procurement.

Where applicable, the Supplier 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 and control of the metering system.

The Supplier shall immediately inform the Contractor and the Principal if there is doubt regarding the specified requirements. The Supplier shall not proceed with any aspect of the work until the Principal gives the necessary written approval.

3. SYSTEM DESIGN

3.1 INTRODUCTION

The measurement system shall be designed to meet all applicable agreements, codes and standards using field proven methods and devices (i.e., no prototypes). Products shall be technically qualified to the satisfaction of the Principal and shall be sourced from Manufacturers acceptable to the Principal.

NOTE: For this purpose, Shell Companies may use the list of Technically Acceptable Manufacturers and Products (i.e., TAMAP) maintained by Shell.

The total life cycle costs of ownership (TCoO) of the measurement station shall be optimised against the requirements stated below. A method for calculating the TCoO is given in DEP 32.31.09.31-Gen.

Prior to the design of custody transfer measurement systems, the following shall be defined and documented (14):

- a) target uncertainty for measurement system,
- b) applicable codes, regulations, agreements and standards,
- c) ownership of measurement equipment,
- d) responsible party for measurement system,
- e) measurement basis (mass, volume or energy),
- f) acceptable meter types,
- g) range of process conditions (e.g., fluid types, fluid contaminants, density, pressures, temperatures, flow rate range, etc.),
- h) acceptable validation techniques (e.g., in-situ or remote),
- i) reference conditions for volumetric techniques, mass or weight (4.1),
- j) target system availability,
- k) third party data transfer connection requirements,
- l) engineering units,
- m) fluid quality specifications.
- n) load factor (3.6), and,
- o) measurement system operational control philosophy (consistent with the facility operational control philosophy).

It should be noted that selecting the industry measurement standards to be applied in combination with defining what validation techniques are to be applied will largely determine the potential measurement uncertainty (3.3).

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. Those authorities/interested parties shall be consulted at the earliest possible stage and thereafter, in order to gain acceptance of the metering philosophy, approval of the system design (where required) and 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). However, the fact that a device has such an approval does not negate the necessity to ensure the devices suitability for the application under consideration.

The preliminary design shall be submitted to the Principal for approval prior to detailed engineering (2.7).

3.3 MEASUREMENT UNCERTAINTY

The overall uncertainty and data availability of the metering station should initially be estimated from operational experience with other facilities of similar design and purpose, and may be quoted as target values in the contract.

At the design stage, the potential measurement uncertainty is largely determined by the prudent selection of which Industry standards apply and the selection of the device validation/calibration scheme to be applied. When required to demonstrate that the system design meets the required contractual or regulatory uncertainty, ISO 5168 shall be consulted. Stated uncertainty throughout this document shall be 2 sigma values (95 % confidence level).

3.4 GENERAL DESIGN REQUIREMENTS

All measurement equipment shall meet the following requirements:

- a) all applicable DEPs, regulations and codes (e.g., piping class, electrical, measurement, process isolation),
- b) be suitable for the operating envelope as detailed in Instrument data sheets.
- c) be suitable for the electrical area classification in which it will be utilized,
- d) have the required accuracy and precision for the application,
- e) have the required approvals (e.g., CSA, ATEX, NMI, MID),
- f) where required be traceable to a recognized national standards body (e.g., NIST),
- g) have wetted components suitable for the process fluid.

All designs shall meet the requirements of this DEP, applicable codes, regulations and standards and deliver the required uncertainty and availability in a safe and cost effective manner.

Where practical, the meter runs and prover subsystems of custody transfer metering systems should be designed as skid mounted packages. The control and computational devices should be located in the computing facility in the CCR, LCR or local equipment room.

The skid package shall be suitable for the location's prevailing environmental conditions as specified in DEP 32.32.00.94-Gen. The skid shall include all pipe work manifolds, metering streams, valves, electrical, instruments, fittings etc. It shall be supplied as a fully piped, cabled, and instrumented package.

The number of parallel meter runs shall be determined by the required flow rate rangeability and load factor (3.6) and availability (3.5).

The maximum allowable pressure drop across the complete metering system should be less than 200 kPa (30 psi) or as specified in DEP 32.32.00.94-Gen.

Equipment layout shall provide for safe access for device validation and maintenance.

For meters which are to be calibrated remotely, provision shall be made to permit removal of the meter run without disassembly (i.e., transport meter, upstream and downstream straight pipe lengths including flow conditioner without unbolting).

A typical meter run flow scheme for a custody transfer application is illustrated in (Appendix D) while a redundant custody transfer measurement system architecture is illustrated in (Appendix G) and (Appendix H). The examples presented in these two appendices detail a "highly" redundant system whereas typical designs need only meet the availability requirements detailed in (3.5).

The design shall meet the process control domain security requirements as detailed in DEP 32.01.20.12-Gen.

3.5 SYSTEM AVAILABILITY

The required system availability and load factor shall be defined prior to design and specified in DEP 32.32.00.94-Gen. The design shall incorporate the degree of redundancy to meet the defined system availability considering the documented reliability of the system components and subsystems based on the Principal's experience with similar devices or Manufacturer's reliability data. Local availability of spares and expertise to repair equipment failures in a timely manner shall be considered a part of the availability assessment.

When 100 % availability is required, the metering system shall be arranged in such a way that a single device failure does not result in a complete loss of measurement. This means that:

- a) 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.
- b) The pressure measurement and temperature measurements shall be redundant.
- c) In a multi-meter run design, at least the flow meter with the highest range shall be redundant. For equal range flow meters the design shall be N+1 (i.e., 2 x 100 %, 3 x 50 %, etc.).
- d) Redundant flow computers shall be provided.
- e) A spare instrument or an alternative method shall be available to determine physical properties of the liquid.
- f) The change out of failed equipment shall not interrupt measurements.
- g) Redundant meter provers are not required.

Although selection of components with a high inherent availability may reduce the level of redundancy required, such selections do not negate the requirement for redundant devices, adequate spares or repair expertise.

The Manufacturer shall with his proposal include a description of how the target availability is to be met.

3.6 RANGEABILITY

The design capacity of the metering 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.

Minimum and maximum flow rate design shall consider the limitations of all components such as the meter, static mixer, strainer, prover, etc. The system design shall incorporate sufficient parallel meter runs to:

- permit the maximum and minimum system flow rates to be measured at the specified uncertainty,
- achieve the specified availability including validation exercises when one of the meter runs is removed for remote validation.

Where required by agreement or regulation, provision shall be made to stop the flow at rates below a preset minimum value.

When determining the maximum flow rate required, peak as well as average flow rates shall be considered. For example, the average throughput of a jetty would not represent the average meter flow rate required because the product is typically unloaded or loaded as

quickly as possible to reduce vessel demurrage. To properly size meters a load factor would be determined by dividing the average quantity to be measured by the time it is to be measured in.

3.7 DYNAMIC VS. STATIC CUSTODY TRANSFER MEASUREMENTS

Where practical, custody transfer measurements shall be made utilizing flow meters (i.e., dynamic measurements).

Where dynamic measurements are not practical due to flow rate or fluid property limitations or the cost of a suitable dynamic measurement system cannot be justified, volumetric measurements using storage tank or marine vessel compartment level gauge, temperature and sampling/composition measurements (i.e., static measurement) are acceptable.

3.8 TRACEABILITY

The system shall be designed in a manner to permit traceability to the required national metrological standards. At the design stage this requires:

- selecting equipment types that are inherently traceable, and,
- providing appropriate means (e.g., access, provers, process taps) for the required field verifications and calibrations.

The equipment used for determining fluid and process properties shall be traceable to national and international standards through a system of analytical procedures, reference materials, sampling and calibration procedures.

3.9 DEVICE VALIDATION CAPABILITY

3.9.1 Introduction

Device verification procedures and frequency are outside the scope of this DEP; however, these items shall be considered in the design of the facility.

3.9.2 General

Device validation requirements shall be considered during design, procurement and installation. For example, the requirement for factory calibrations shall be identified on the instrument data sheets.

Device performance validations should be conducted in-situ without instruments having to be removed. Hence, sufficient validation facilities for each instrument shall be provided (e.g., validation ports/manifolds, dual thermowells, manual sample valves).

If in-situ validation is not possible or not required, the instrument concerned shall be scheduled for regular factory recalibration, which may 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. For example, Coriolis meters are often calibrated using water. Similarly ultrasonic meters may be calibrated using alternate fluids provided the operating Reynolds number range is matched during calibrations.

Calibration equipment shall have a valid calibration certificate traceable to a national metrological standard. Calibration certificates shall identify the 'as found' errors, the calibration uncertainty and expiry date. Wherever practical, 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. In cases where this is not practical (e.g., fully characterized differential pressure transmitter), the written approval of the Principal shall be obtained.

Some microprocessor based devices have the capability to perform self diagnostics. Provision shall be made in the design to incorporate such diagnostic functions into the field

devices and to provide suitable software to utilize such functions for performance monitoring and troubleshooting.

For the purposes of validation and troubleshooting, suitable electronic connections shall be provided for computational devices and field devices.

3.9.3 Meter proving

As part of the preliminary design, the flow meter validation practice shall be selected. Specifically, an assessment shall be 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 calibrations using a portable prover (local availability of suitable portable provers in terms of geographic proximity and capacity),
- c) on site calibrations using a permanently installed prover,
- d) on site calibration using a master meter (either permanently installed in series or periodically brought in-line).

Such assessments shall consider the total cost of ownership of the various meter validation options, meter performance characteristics, fluid properties and the risk associated with increased uncertainty or loss of use associated with master meter or off site calibrations.

3.10 OPERATING ENVELOPE

The measurement system shall be capable of meeting its uncertainty, rangeability and availability targets for the design operating envelope as follows:

- a) operating modes such as start-up, shutdown, off specification, continuous/batch operation, unidirectional or bi-directional flow and credible future operating modes.

NOTE: Deviations from the required uncertainty are permitted for operating modes such as start-up and shutdown provided the flow continues to be measured and the required uncertainty is achieved for the overall batch.

- b) fluid properties such as density, viscosity, pour point, corrosiveness, erosiveness, flashing, cavitation, toxicity and presence of solids or contaminants, mixed phase, special risks such as foaming, decomposition, fouling, plugging, depositing, solidification and chemical reaction,
- c) process limitations such as pressure, temperature, Reynolds number and flow rate,
- d) allowable pressure loss,
- e) operating environment including the following aspects:
 - weather related exposure (e.g., winterization, intense sunlight, tropical)
 - mechanical integrity (e.g., vibration, hydraulic noise, pulsating flow, radiation from hot process equipment, earthquake, wash-down area, vicinity to corrosive atmosphere such as cooling water towers, chlorides, seawater, etc.)
- f) plant organisation regarding maintenance, manned, unmanned, data collection and retrieval, self-diagnostic, AMS, and documenting features, expertise, installed base and training, stock keeping, spare parts, manufacturer's support etc:
- g) Human Factors Engineering (HFE) aspects such as accessibility for validation and maintenance, safety)
- h) Controlled access to third parties for data exchange.

If the measurement system operating envelope changes, the MOC process shall be used to reengage all disciplines to ensure the design is fit for purpose.

The relevant sections of this document cover specific aspects for the selection of instruments per function (temperature, flow, proving, sampling etc.).

All instruments shall be installed as per DEP 32.31.00.32-Gen.

3.11 MATERIALS

All pressure retaining components such as piping, valves, strainers, air eliminators and meter bodies shall comply with the piping classes specified in DEP 32.32.00.94-Gen. and with requirements of DEP 31.38.01.11-Gen., DEP 31.38.01.12-Gen., DEP 31.38.01.15-Gen. and DEP 39.01.10.11-Gen.

All instruments shall comply with the materials requirements as specified in DEP 32.32.00.94-Gen. and as specified in DEP 32.31.00.32-Gen.

3.12 ELECTRICAL

All electrical devices shall be approved (e.g., ATEX, CSA, UL) and so marked for the area classification and jurisdiction in which they are to be installed. See DEP 32.31.00.32-Gen., Section 2.5 for electrical certification requirements.

3.12.1 Measurement device outputs

In addition to the primary element signals (3.12.2) and secondary instrument signals (3.12.3), all measurement devices shall output a fault condition (3.12.4).

Where available, device diagnostics shall be provided (but not necessarily on a real-time basis).

With the exception of communications downstream of the flow computer, wireless shall not be utilized in custody transfer measurement systems.

Barriers to achieve intrinsically safe designs shall not be utilized for measurement devices analog outputs.

For custody transfer measurement devices, meter wiring design shall utilize a minimum number of connections (e.g., junction boxes). Continuous conductors shall be utilized between field devices and the skid junction box and between the skid junction box and the computational device. Other wiring practices are as per DEP 32.31.00.32-Gen.

3.12.2 Primary element outputs

Linear meters shall output pulses where each pulse represents a discrete volume or mass. Specifically, analog signals (e.g., 4-20 mA) or digital communications such as FOUNDATIONTM FIELDBUS (FF) shall not be utilized for linear custody transfer meters.

3.12.3 Secondary device signals

Where practical and provided compatibility has been proven through interoperability testing, secondary instruments such as static pressure, differential pressure, temperature and QMIs shall utilize a digital communications such as FF. With the exception of gas chromatographs, Modbus shall not be used for secondary device signals. Where digital communications are not practical, analogue outputs shall be 4-20 mA.

The square root function of differential pressure meters shall be applied in the computing device.

Temperature measurements may utilize one of the following:

- a fully characterized temperature transmitter combined with an RTD, or,
- a 4 wire RTDs interfaced directly to the computing device (i.e., avoid temperature transmitters).

3.12.4 Diagnostics/fault signals

In addition to the required measurement output, where practical measurement devices shall output common (i.e., grouped) warning and fault status signals to the BPCS or SCADA. Detailed diagnostic capability/screens shall be provided by equipment specific software and need not be programmed into the BPCS or SCADA.

The fault status may be transmitted utilizing a set of dry contacts, over/under range analog signals or via a digital protocol such as Modbus or digital communications such as FF.

Fault status via analog 4-20 mA type output signals shall comply with NAMUR NE-43 recommended values for abnormal signal levels. In such designs the computational device inputs shall also comply with NAMUR NE-43. The field device shall not drive the signal through the alarm condition to reach the fault condition value.

Contacts used for fault status shall be normally closed, open on fault detection and shall be self resetting.

Measurement systems shall be designed to provide the capability to connect to field and flow computation devices digitally (e.g., Modbus over Ethernet) for the purpose of performance validation and troubleshooting utilizing fit for purpose software.

Where asset management systems are employed, the analogue output devices shall be HART® or FF compatible to enable enhanced diagnostic data to be collected. The associated analogue input modules shall support HART® or FF without the need for additional hardware.

Subject to (2.2) the action upon fault detection shall be documented (e.g., measurement manual, control narrative).

3.13 ENVIRONMENTAL PROTECTION

Measurement equipment shall be capable of operating and measuring in the environment that they are installed, inclusive of atmospheric chemistry, local temperature ranges and humidity, EMI/RFI and vibration.

Environmental protection shall be as per Section 2.11 of DEP 32.31.00.32-Gen.

EMI/RFI compatibility shall be as per Section 2.12 of DEP 32.31.00.32-Gen.

3.14 SKID, STRUCTURAL AND BASEPLATE

The configuration of the metering skid shall meet the requirements and comply with the dimensional constraints of DEP 32.32.00.94-Gen. The Manufacturer shall propose a design within these constraints that combines compactness with compliance with quoted standards and codes, and ensures equipment maintainability.

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 System shall be designed and constructed to allow service and maintenance of measurement equipment in a safe manner.

The metering skid shall be of all-welded steel construction with a rigid base. The base plate 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. The manufacturer shall complete structural stress analysis of the skid base and piping supports inline with relevant standards prior to fabrication.

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

Where specified, 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 DN 50 (NPS 2) 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 base plate edge. Visual indication shall be provided at each drain so that liquid discharge can be observed.

For the specification of the painting, refer to DEP 30.48.00.31-Gen. The painting schedule shall be as specified in DEP 32.32.00.94-Gen. Colour schemes shall be as specified in DEP 32.32.00.94-Gen. and may be governed by local regulations and customs.

The metering system manufacturer shall provide foundation loading drawings/calculations for the metering skid prior to fabrication.

3.15 PIPING AND VALVING

3.15.1 General

Piping design shall comply with DEP 31.38.01.10-Gen., DEP 80.45.10.10-Gen. and DEP 31.38.01.11-Gen.

Piping shall be designed to minimize dead legs and trapped volumes of fluid for all anticipated modes of operation, including start-up and shutdown.

All in-line measurement system devices such as valves, strainers, air eliminators, meters, meter run upstream and downstream flow tubes, flow conditioners and meter provers shall have flanged connections to permit removal for inspection and maintenance.

Allowable pressure loss shall be determined considering the pressure drops through associated control valve as well the meter, strainer, prover, flow conditioner, etc. This system approach to pressure loss limitations/calculations improves meter selection and sizing.

Required back pressure to prevent flashing and or cavitation shall be calculated as follows:

$$P_b = 2\Delta p + 1.25 P_e$$

where:

P_b = minimum back pressure, kPag (psig),

Δp = pressure drop through the meter, flow conditioner, prover etc. at the maximum operating flow rate for the liquid being measured, kPad (psid),

P_e = equilibrium vapor pressure of the liquid at the maximum operating temperature, kPa (psia),

System shutdowns or product diversion to avoid mis-measurement or product contamination shall be agreed upon with the Principal, authorities and interested parties.

Spool pieces shall be provided to replace the meters during hydro-testing as per DEP 62.10.08.11-Gen. Where required, the spools shall be manufactured to the same piping standard as the skid piping and be provided complete with gaskets. Prover 4 way valves shall be removed or isolated (e.g., spectacle blinds) for hydrotesting.

Wherever practical, meters shall be installed in horizontal lines. Meter shall not be installed at the highest piping point where gases are likely to collect and are hard to remove. The flow line shall remain full under all operating conditions.

For unidirectional measurement applications, check valve(s) shall be provided to prevent back flow through meters. In single meter run applications, check valves shall be located downstream of the meter downstream straight run piping. For applications with a control valve, the check valve is located downstream of the control valve. For multi-meter run single product applications, a single check valve shall be provided downstream of the delivery header.

Remotely controlled meter run inlet and outlet and the prover inlet and outlet valves shall be fitted with open and closed position switches for remote indication. The position switches should be factory set and tamper resistant.

Parallel and redundant metering runs shall be symmetrical with, and of similar size to, the other meter runs. Special hydraulic consideration shall be given to achieving balanced flow. Such metering skids shall have a common inlet header and a common outlet header to ensure uniform flow conditions. For multi-meter run applications requiring in-situ meter proving, a prover inlet and outlet header shall be provided; see (Appendix E).

The inlet and outlet piping of parallel metering devices with common inlet and outlet headers shall have sufficient flexibility to cope with differences in thermal expansion when one device is not in operation and to facilitate component removal. The manufacturer shall complete piping stress analysis on the metering skid piping to ensure adequate strength during the various stream online configurations, varying process conditions and external termination point loads. Calculations shall be made available to Principal for review and approval prior to start of fabrication.

Verifiable isolation utilizing double block and bleed (DB&B) valves shall be provided as required to preclude the possibility of measurement error due to unmetered fluids (i.e., bypass around meters), undelivered fluids (i.e., diversion downstream of meters) or meter proving errors (i.e., inflow or outflow between meter and prover). This requires DB&B valves as follows:

- between parallel or redundant meter runs,
- on all permanently piped drain valves downstream of the meter including those between the meter and prover.

Single body type rotating plug valves are preferred for DB&B service.

The bleed port of DB&B valves shall allow visual or electronic means of seal verification.

Double block-and-bleed valve body relief valves shall not discharge into the line between the prover and the meter being proved.

Unless required for HSSE reasons, vent valve connections through which leakage is clearly visible do not require DB&B valves.

Facilities shall be designed to minimize hard-piped pressure relief and vent connections through which flow would cause measurement error. If hard piped relief, vent or DB&B bleed connections are necessary, the outlet of potential bypasses shall be routed to a continuously monitored sump or surge tank. Where such sumps or tanks are impractical, redundant, monitored electronic flow detection shall be provided.

If vents, drains, and relief valves that discharge to the downstream side of the flow meter absolutely cannot be avoided, associated discharge lines shall include a visual or electronic means of determining leakage.

3.15.2 Thermal relief

Thermal expansion relief valves are required in liquid-full systems if the system can be blocked in and subjected to heat input from atmosphere or process. For the application of thermal expansion relief valves, see DEP 80.45.10.11-Gen.

In no case shall a thermal relief valve be located between the meter and the prover or between the sampling system and meter.

3.15.3 Prover piping

Prover valving/manifolds shall be provided for applications requiring in-situ proving.

Prover valving/manifolds shall be:

- sized to allow meter proving over the full operating range expected for the meter.
- be located downstream of the flow meters.

Where in-situ meter proving is required, DB&B valves shall be provided as follows:

- as the meter run prover bypass (i.e., divert) valve to divert the flow through the prover for a single meter run application,
- as the meter run prover bypass (i.e., divert) valve to divert the flow to the prover supply header for a multi meter run application, and,
- to isolate individual meter runs from the prover supply header when meter proving other meters,

- to isolate individual meter runs the prover return header when meter proving other meters.

For multi-product, single meter run applications such as a pipeline transporting multiple products, a stationary prover or master meter may be shared between different products (e.g., gasoline and diesel).

For multi-meter run single product applications, a stationary prover or master meter should be shared between different products.

Sharing a prover between multi meter run, multi-product applications shall not be applied.

3.15.4 Flow control valves

Flow control valves shall be utilized where required to:

- control the flow rate through a meter to ensure the measured flow rate is within the calibrated portion of the meter range, and,
- create sufficient backpressure to preclude flashing.

With the exception of truck (un)loading applications, flow control valves are normally not required for single meter run applications. For multi-run flow measurement systems, one flow control valve shall be provided per meter run to balance flow rates during operation and when proving (where applicable).

Flow control valves associated with meter runs shall be installed outside the downstream straight length required by a meter (i.e., typically 5D downstream).

Flow control valves shall be selected, sized and installed as per the requirements of DEP 32.36.01.17-Gen.

3.16 FLOW CONDITIONING

Meter types such as ultrasonic, turbine, orifice and magnetic which are sensitive to flow profile disturbances such as those associated with bends, pipe reducers and partially open control valves shall be provided with sufficient upstream/downstream straight run piping (preferred) or an upstream perforated flow conditioner plate (acceptable).

Straight run lengths shall be as per the most stringent of the local authority or as per Industry standard. For CTM applications for which the straight length requirements are not defined by local authority or industry standard, the Manufacturer's straight length recommendations are acceptable provided the Manufacturer supplies supporting test data to substantiate the recommendations.

Meter applications without the provision for in-situ proving shall be provided with a perforated plate type flow conditioner installed according to the Manufacturer's recommendations.

Tube bundle style flow conditioners including those described in ISO 2715 or API MPMS 5.3 shall not be utilized.

For meters sensitive to flow profile disturbances, the upstream and downstream meter runs shall be free of protruding gaskets, weld beads, etc.

Eccentric pipe reducers shall not be utilized upstream or downstream of meters sensitive to flow profile disturbances.

The straight length/flow conditioner requirements stated above do not apply to meters insensitive to upstream flow disturbances (e.g., PD, Coriolis).

For bidirectional flow applications, flow conditioning should meet these requirements regardless of direction of flow.

3.17 STRAINERS

Strainers shall be provided for turbine meter, PD meter and displacement prover applications.

The strainers shall have the following characteristics:

- a) for meter protection applications, located upstream of the meter,
- b) for prover protection only applications, located downstream of the meter and upstream of the prover,
- c) for sampler only applications, located upstream of the sampling system
- d) pipeline vertical basket type with top entry
- e) In the clean condition, the strainer should have a pressure drop of not more than 20 kPa (2.9 psi), and in a dirty condition the strainer internals shall be capable of withstanding a pressure drop of at least 35 kPa (5 psi). This requirement is more stringent than that specified by most Suppliers, but is considered necessary to prevent the collapse of a dirty strainer.
- f) Strainers should have ports to accommodate the installation of a differential pressure indicator or transmitter across the strainer body.
- g) A differential pressure transmitter with alarm should be provided where frequent fouling of the strainer is expected.
- h) The strainer enclosure shall be of the quick-opening type with valved vent and drain connections.
- i) The strainer shall have replaceable stainless steel inserts.
- j) The strainer screen shall be supported by a strainer basket having much larger openings than those of the screen.
- k) The mesh size for the screen shall be as recommended by the meter Manufacturer or as per the following tables.

Meter Type	Meter Size (mm)	Basket (mm)	Liner
Displacement	50 mm – 200 mm	14 gauge or thicker with 3 mm holes 5 mm centre to centre	N/A
Displacement	250 mm to 400 mm	11 gauge or thicker with 5 mm holes 9 mm centre to centre	N/A
Turbine	50 mm	16 gauge or thicker with 12 mm flattened, expanded metal	30 mesh with 0.013 in diameter wire
Turbine	75 mm	16 gauge or thicker with 12 mm flattened, expanded metal	20 mesh with 0.016 in diameter wire
Turbine	100 mm to 200 mm	13 gauge or thicker with 19 mm flattened, expanded metal	10 mesh with 0.035 in diameter wire
Turbine	250 mm to 300 mm	14 gauge or thicker with 3 mm holes 5 mm centre to centre	N/A
Turbine	400 mm to 500 mm	11 gauge or thicker with 5 mm holes 9 mm centre to centre	N/A