

# SAUDI ARABIAN OIL COMPANY (Saudi Aramco)

## GENERAL INSTRUCTION MANUAL

GI NUMBER Approved

405.002

ISSUING ORG. PROCES &amp; CONTROL SYSTEMS DEPARTMENT

ISSUE DATE

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SUBJECT CUSTODY TRANSFER OF NATURAL GAS AND ETHANE

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## 1. PURPOSE AND SCOPE

This General Instruction sets policy guidelines and application requirements for the custody measurement of hydrocarbon gases, namely Natural gas or Sales gas and Ethane. This GI is not applicable to liquefied petroleum gases.

Custody Transfer Measurement is a specialized form of measurement that provides quantity and quality information used for the physical and fiscal documentation of a change in ownership and/or responsibility of hydrocarbon commodities. This includes measurement of hydrocarbon movements (deliveries or receipts) between Saudi Aramco and its customers excluding intra-company transfer.

## 2. RESPONSIBILITIES

### 2.1. Operating Organization

2.1.1. The Operating Organization that owns, maintains or operates the facility of custody transfer of hydrocarbon gases shall be responsible for the implementation of this General Instruction. The Operating Organization shall obtain approval from Custody Measurement Unit of Process & Control Systems Department (P&CSD/ CMU) for any deviation from this General Instruction. The Operating Organization shall designate trained personnel to maintain, monitor and assist in the implementation of this General Instruction. The assigned personal shall be responsible for the following:

- A. Interface with other departments on engineering/operation matters pertaining to custody metering.
- B. Ensure proper functionality of all metering installations.
- C. Respond to customers' technical/operational inquiries and investigate/resolve measurement dispute cases.
- D. Conduct weekly visits to every skid to conduct visual inspection of the meters, check proper valve status, collect the daily reports, verify instruments proper functionality, collect sample cylinders (where applicable), update the flow computers' gas composition with last-week's or latest available analysis results and verify that delivery ticket readings and flow computer displays are within normal limits.
- E. Monitor and keep records, as required for control, auditing and accounting purposes.

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F. Review daily tickets, compile weekly records and prepare data required for the monthly invoice statement for individual customers.

2.1.2. The Operating Organization shall

- A. Ensure that the operating instruction manuals are prepared, revised every three years to reflect current metering status, measurement accuracy, sound practices, and accountability in the transfer of gas. These new operating instructions shall be reviewed by P&CSD/CMU, for concurrence prior to their approval and implementation. If no modifications are made to the existing metering facility, the subsequent revision and approval of the operating instruction manuals shall be limited to the Operating Organization.
- B. Comply with the measurement requirements as specified in the supply or sales agreement. In case of disagreement between Aramco customer/supplier figures, then a thorough investigation should be initiated. Resolution of this disputed should be implemented by the Operating Organization. The investigation procedures should be covered in sales agreement and OIM.
- C. Comply with SAES-Y101, SAEP-21 and SAEP 50 for the design, construction, installation and execution of metering projects, equipment and partial upgrades.
- D. Comply with recommendations made by P&CSD/ CMU in order to maintain or enhance metering system accuracy, performance and to reduce potential gas losses.
- E. Respond to customers' technical/operational inquiries and investigate/resolve measurement dispute in timely manner. Also provide OSPAS with an estimate of the investigation duration once customer complaint is received from OSPAS
- F. Annual overall health check on the complete custody transfer measurement process is performed and records are maintained for verification. Operating Organization may request P&CSD/ CMU to provide a list of tasks for the annual health check for their measurement station. These tasks maybe different for each type of custody transfer station.
- G. Unless stated otherwise in sales gas or O&M agreements, ensure that spare parts critical for accurate measurement and control are stored appropriately.
- H. Correct and attend measurement problems as appropriate. Examples of deficiencies that shall be attended /corrected are as follows.
  - i. In case of GC failure or a composite sampler, manual samples shall be collected in accordance with API MPMS 14.1.
  - ii. In case of a leaking orifice dual chamber seal, a highest priority work order shall be issued.

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- iii. When differential pressure transmitter is found fixed at the maximum range value, investigation shall be triggered.
- iv. When an ultrasonic meter/transducer fails or when self diagnostic tools alert a deficiency, a highest priority work order shall be issued.

Any other malfunctioning/deficiency shall be reported as appropriate and acted-upon in a timely manner.

- I. Ensure that all calibration equipment (e.g., dead-Weigh tester, decade box, volt-ohm-ammeter, etc.) being used by Saudi Aramco (or outside contractors) are calibrated/verified and certified by a third party calibration agency accredited by an authoritative body like SASO or NIST every year. All calibration equipment that are out of calibration or overdue shall be taken out of service until recertification is completed.
- J. Ensure that sufficient numbers of calibrated and certified calibration equipment are available. The test equipment shall have calibration ranges suitable for the instruments to be verified/ calibrated.
- K. Perform Preventive Maintenance (PM) on the components of the gas custody transfer metering system. The frequency of the PM shall not exceed three months for major and primary gas customers. For secondary metering systems, this frequency may be relaxed to six months if historical PM records supports performance stability. Definition of the primary, major and secondary customers is stipulated in SAES-Y-101. The PM check shall include, but not limited to, the followings:
  - i. Visual inspection of the stations' components/premises.
  - ii. Verification/ calibration of the instrument loops from the field sensors to flow computer boards.
  - iii. Verifying the station's flow computer configuration parameters.
  - iv. Inspecting the meter.
  - v. Purging the instruments impulse lines to eliminate the impact of black powder/condensate accumulations.
  - vi. Verifying the flow computer's calculation against standard AGA-based software.
  - vii. Measuring the orifice bore and verifying it's recorded consistently in the flow computer.
  - viii. For ultrasonic meters, diagnostic checks shall be performed. Diagnostic limits shall be verified to be within the recommended range by the meter manufacturer.
  - ix. For major metering systems with 2 ultrasonic meters, perform meter verification to compare the readings of the pay and check meters and verify that the deviation is within +/- 0.5% or as specified by the meter manufacturer.

- L. Maintain records per section 7 below.

### 2.2. Custody Measurement Unit/PID/P&CSD

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Custody Measurement Unit/PID/P&CSD:

- A. Shall provide technical guidance to all concerned, to implement this instruction, and shall be the controlling entity for this GI.
- B. Provide engineering-level services as second line support to technical engineering services of each Operating Organization.
- C. Support Internal Auditing Team by answering their technical queries and providing interpretation to this GI.
- D. Can assist Operating Organization by:
  - I. Reviewing special training offered by vendors
  - II. Offering courses through PEDD
  - III. Offering special sessions as needed.
- E. Shall ensure consistent approach to the design of measurement systems.
- F. Will assist and/or guide the Operating Organizations in reviewing the operating instructions for new measurement facilities.
- G. Review and Propose needed modifications to operating instructions of existing metering facilities that are being modified.
- H. Offer training to company corporate entities that are involved with custody measurement process as needed.

### 2.3. Oil Supply, Planning and Scheduling Department (OSPAS)

Oil Supply, Planning and Scheduling Department shall:

- A. Notify Operating Organization in case of alarms or abnormal flow figurers
- B. Notify Operating Organization for any planned changes in consumption figures on the customer side
- C. Jointly with the Operating Organization, obtain Custody Measurement Unit/PID/P&CSD technical assistance to estimate or identify alternative measurement method for flow during planned or emergency outage of the meter.
- D. Obtain Custody Measurement Unit/PID/P&CSD and Operating Organization concurrence when resolving measurement claims with Saudi Aramco customers.
- E. Control the customers flow rate according to the gas allocated (Quota) using the control valves installed in Saudi Aramco custody meters, provided these FCVs are tested for reliability by Operating Organization.

### 2.4. Domestic Sales and Logistics Department (DSLDD)

Domestic Sales and Logistic Department shall:

- A. Ensure that sales agreement for each custody transfer measurement process with a customer is written and in place.
- B. Ensure that the sales agreement includes:
  1. Allowable claim tolerances between Saudi Aramco and its customers. These claim tolerances maybe extend to suppliers or transport contractors if applicable.

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2. The process, method and maximum time for resolving any measurement discrepancy in the custody transfer measurement process.
  3. The maximum grace period within which the customer can file a claim.
- C. Notify Operating Organization and OSPAS of any changes in sales agreement that will require an action from either organization.
  - D. Ensure that sales/ OIM agreement is reviewed by Operating Organization.
  - E. Ensure that technical clauses in sales/ service agreement related to measurement of quantity and quality is reviewed by Custody Measurement Unit/PID/P&CSD.

### **3. METERING EQUIPMENT**

The minimum mandatory requirements governing the design, construction, and installation of custody transfer metering stations are covered in SAES-Y-101.

#### **3.1. Meters**

Custody transfer measurement of natural gas and ethane shall be through orifice plates or ultrasonic meters. The orifice plate shall be removable concentric type with single or double chamber fittings. The ultrasonic meters shall be of the multi-path transit-time type. Metering station instruments shall be operated within the calibrated range. The span of the calibrated range shall be determined to reduce the uncertainty of device reading.

#### **3.2. Flow Computer**

On-line data gathering and flow calculation for net volume at standard conditions shall be done by the flow computers. Manual calculation using average or default values shall be used only on a temporary basis in case of failure of the flow computers.

The flow computer shall be used to calculate the total energy content using on-line gas composition data or manually entered values.

#### **3.3. Temperature Measurement**

Temperature shall be measured downstream of the meter using Resistance Temperature Detector (RTD) probe that is connected to Temperature transmitter.

#### **3.4. Low & High Differential Pressure & Static Pressure Measurement**

The static pressure shall be measured downstream of the meter. In orifice plates, static pressure tap shall connect to the downstream flange tap. For USM, the static pressure is measured from the tap on the meter's body.

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The range of differential pressure transmitters in orifice-based metering systems shall be between 0 and 100 inches of water. Exceeding this range up to 200 inches of water may be allowed on exceptional situations only and should be approved on a case-by-case basis. Such action must be reviewed and approved by P&CSD/ CMU.

### 3.5. Samplers

Heating value and relative density (specific gravity) shall be determined either by an on-line gas chromatograph, or by analysis of the gas sample obtained from the automatic sampler of the metering station. Samples shall be collected and analyzed on weekly basis or as contractually agreed.

Sample handling and analysis shall be performed in compliance with API MPMS 14.1.

## 4. INSPECTION, VERIFICATION & CALIBRATION

Inspection check, verification and calibration shall be as follows:

### 4.1. Calibration Frequency

The maximum duration between verifications/ calibrations shall not exceed the requirements of Section 2.1.2 K above. Verification is performed by comparing the output of the device under normal operating conditions against a certified calibrated device.

Verification of temperature, pressure, differential pressure instruments and other auxiliary ultrasonic metering components is recommended. If a difference is found when verifying the reading using the calibration equipment then a full range calibration is required.

### 4.2. Temperature Instruments

4.2.1. The complete loop (RTD, transmitter and the flow computer) shall be verified first against an ASTM glass thermometer certified by Saudi Aramco Laboratory placed in the test thermowell. No further action is required if the reading difference is less than 1 deg F.

4.2.2. If the reading differs by more than 1 deg F, then:

- a. The temperature transmitter shall be calibrated using a certified resistance decade box, where the off-set correction applied at three points covering full range.
- b. Then verification in 4.2.1 is repeated.
- c. If the meter reading still differs by more than 1 deg F, the RTD shall be replaced with a new certified one.

### 4.3. Pressure Instruments



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4.3.1. All pressure instruments shall be checked against a certified calibrated device traceable to NIST or its equivalent. Dead-weight testers, if used, shall have the NIST stamped on the weights, indicating the local gravity at which they were calibrated.

4.3.2. If verification at 4.3.1 shows a difference, a full range calibration is performed on the static pressure and the differential pressure instruments. The maximum allowable error shall not be more than 0.25% of span or 0.04 mA for a 4 to 20 mA output signal. All sensing lines shall be checked for leaks and blown to clear any blockage.

#### 4.4. Orifice Plates

Orifice plates shall be checked during instrument calibrations. The plate shall be free of rust, deposit and the edge shall have no nicks or roundness sufficient to reflect a beam of light when viewed without magnification. The orifice plate shall be inspected for flatness per AGA Report 3. In addition to checking the bore diameter, any damaged plate shall be rejected and a standard plate, identical to the original one, shall be installed. If the plate cannot be inspected for any reason, a highest priority corrective action shall be initiated to allow plate inspection.

#### 4.5. Ultrasonic Meters

##### 4.5.1. Verification and PM checks

Diagnostic verification test shall be conducted on monthly basis till confidence is established in the performance of the ultrasonic meter. Once historical data show stable performance of the meter then diagnostics results can be obtained during the quarterly PMs instead of monthly. Prior to changing frequency of obtaining diagnostic verification test results, the Operating Organization shall obtain P&CSD/CMU approval.

The key performance parameters of the USM diagnostic check shall not exceed the limits as specified by the meter's manufacturer. Diagnostics results obtained during the quarterly PMs shall be recorded for future reference and compared with the diagnostics results of the previous months to verify the meter's health trend.

Ultrasonic meters shall also undergo quarterly PM checks to assess its conditions. This will demonstrate that the meter is functioning within agreed tolerances. Records showing the performance of the station shall be maintained.

The PM check shall include:

- A. Report verification
- B. Meter/flow computer calculation validation check
- C. Ultrasonic meter performance assessment using meter diagnostic software
- D. Cleaning the meter's transducers.

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The requirements of the monthly and quarterly checks shall be clearly detailed in the station's Operations Instruction Manual (OIM).

#### 4.5.2. Calibration

For the first time and before the meter is used, the meter shall go through the following at the vendor site or at the calibration lab:

1. Zero flow verification
2. Flow calibration

These shall be done in accordance with 34-SAMSS-114 - Ultrasonic Flow Meter for Gas Custody Measurement.

For Primary systems, the Operating Organization shall troubleshoot if diagnostics indicate a potential malfunctioning of the USM. If Operating Organization could not fix the problem, they may collaborate with P&CSD and vendor to further assess. If recalibration is deemed necessary, the Operating Organization shall arrange for alternative measurement method in the interim based on P&CSD recommendation.

For Major systems:

- A. The check meter shall be re-calibrated after 5 years of operation for the first time provided no abnormal indications in its diagnostic tools and no customer claims.
- B. The next calibration frequency afterwards may be extended up to 10 years.
- C. The exact number of years following the first calibration will be decided following analysis provided by Operating Organizations showing diagnostic tools output, maintenance records and customer claims history.
- D. The pay meter shall be verified by the check meter on frequent basis.
- E. Major systems where single meter is installed, the Operating Organization is required to provide adequate alternative measurement to replace the pay meter during calibration.

#### 4.6. Gas Chromatograph

The gas chromatograph shall be inspected during the quarterly PM per vendor recommendations. The gas chromatograph shall be configured to weekly self-calibration.

#### 4.8. Auto sampler

The verification procedure for new spot or composite sample shall be in accordance with API MPMS 14.1 appendix E and F.



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## 5. SEALING REQUIREMENTS

- 5.1. All bypass piping shall be blinded. Bypass valves shall be sealed closed.
- 5.2. Flow computers and supervisory computers shall have a key lock and/or password protection to prevent unauthorized entry of meter configuration data or any calibration data which affect billing.
- 5.3. If the metering station is accessible to unauthorized personnel, all equipment which may affect the accuracy of measurement (e.g. temperature and pressure transmitters, etc.) shall be sealed to prevent unauthorized adjustment.

## 6. CALCULATION AND BILLING

### 6.1. Net Volume

Net volume shall be reported as Standard Cubic Feet (SCF) at 60 degree Fahrenheit and 14.73 psia.

### 6.2. Orifice Metering

The calculation for natural gas and ethane using orifice meters shall be based on the American Gas Association (AGA) Report 3, Part 3. The supercompressibility factor (Fpv) shall be calculated using AGA-8.

### 6.3. Ultrasonic Metering

The calculation for natural gas and ethane using ultrasonic meters shall be based on the American Gas Association (AGA) Report 9.

### 6.4. Heating Value and Total Energy content

Based on an on-line gas chromatograph or laboratory analysis of the gas and its component, the gross heating value of the gas mixture shall be calculated. The gross heating value of the gas mixture shall be converted to adjusted heating value by dividing the gross heating value by the compressibility factor. The heating value shall be reported in BTU/SCF on dry basis.

## 7. RECORD KEEPING

The following records shall be maintained by the Operating Organization for each metering station:

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- a. Records of physical data of all equipment, including instruments and flow computer for each custody metering station. Data shall be kept current by recording any changes made. (permanent)
- b. Copy of the flow computer program version loaded at each station. (permanent)
- c. Orifice/ultrasonic meters configuration data. (permanent)
- d. Weekly Gas record composing of volume, flow rate, temperature and pressure (minimum of one year)
- e. Maintenance record of all instruments including flow computer (minimum of one year)
- f. USM test/calibration data (permanent)
- g. PM findings and subsequent actions shall be documented and kept for a minimum of two years

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**RECOMMENDED BY:**

\_\_\_\_\_  
Manager, Process & Control Systems Dept.

Date: \_\_\_\_\_

**CONCURRED:**

\_\_\_\_\_  
Vice President, Gas Operations

Date: \_\_\_\_\_

\_\_\_\_\_  
Executive Director, Pipelines, Distribution & Terminals

Date: \_\_\_\_\_

\_\_\_\_\_  
Executive Director, Refining & NGL Fractionation

Date: \_\_\_\_\_

\_\_\_\_\_  
Manager, Oil Supply, Planning & Scheduling Dept.

Date: \_\_\_\_\_

**APPROVED BY:**

\_\_\_\_\_  
Vice President, Engineering Services

Date: \_\_\_\_\_

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