Engineering Standard

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Custody Metering of Hydrocarbon Gases

Document Responsibility: Custody Measurement Standards Committee

Saudi Aramco DeskTop Standards

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1 Scope

This standard defines the minimum mandatory requirements governing the design, construction, and installation of custody transfer metering stations used for the measurement of sales gas and ethane.

2 Conflicts and Deviations

2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Saudi Aramco Materials System Specifications (SAMSSs), Standard Drawings, (SASDs), industry standards, codes, and forms, shall be resolved in writing through the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.

2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer's Representative, who shall follow internal procedure SAEP-302 and forward such requests to the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.

2.3 Direct all requests for interpretation of this standard in writing to the Company or Buyer Representative who shall forward them to the Chairman, Custody Measurement Standards Committee for resolution. The Chairman, Custody Measurement Standards Committee shall be solely responsible for determining whether a proposed installation meets the requirements of this standard.

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

SAEP-21	*Project Execution Requirements for Saudi Aramco Royalty/Custody Metering Systems*
SAEP-50	*Project Execution Requirements for Third party Royalty/Custody Metering Systems*
SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-A-112	*Meteorological and Seismic Design Data*
SAES-B-054	*Access, Egress and Materials Handling for Plant Facilities*
SAES-B-068	*Electrical Area Classification*
SAES-H-001	*Coating Selection & Application Requirements for Industrial Plants & Equipment*
SAES-J-002	*Technically Acceptable Instrument Manufacturers*
SAES-J-003	*Instrumentation – Basic Design Criteria*
SAES-J-004	*Instrument Symbols and Identification*
SAES-J-005	*Instrumentation Drawings and Forms*
SAES-J-200	*Pressure*
SAES-J-400	*Temperature*
SAES-J-502	*Analyzer Shelters*
SAES-J-801	*Control Buildings*
SAES-J-902	*Electrical Systems for Instrumentation*
SAES-L-102	*Regulated Vendors List for Valves*
SAES-L-105	*Piping Material Specifications*
SAES-L-108	*Selection of Valves*
SAES-L-109	*Selection of Flanges, Stud Bolts and Gaskets*
SAES-P-101	*Regulated Vendors List for Electrical Equipment*
SAES-P-104	*Wiring Methods and Materials*
SAES-P-111	*Grounding*
SAES-Y-100	*Regulated Vendors List for Custody Measurement Equipment*

Saudi Aramco Materials System Specifications

01-SAMSS-010	*Fabricated Carbon Steel Piping*
01-SAMSS-017	*Auxiliary Piping for Mechanical Equipment*
04-SAMSS-041	*Expanding Plug Valve*
17-SAMSS-515	*Auxiliary Electrical Systems for Skid-Mounted Equipment*

34-SAMSS-112	*Orifice Meters for Gas Custody Measurement*
34-SAMSS-114	*Ultrasonic Flow Meters for Gas Custody Measurement*
34-SAMSS-511	*Chromatographs*
34-SAMSS-711	*Control Valves - General Services*
34-SAMSS-718	*Electric Motor Operated Valve Actuators*
34-SAMSS-820	*Instrument Control Cabinets – Indoor*
34-SAMSS-821	*Instrument Control Cabinets – Outdoor*
34-SAMSS-830	*Programmable Logic Controller*
34-SAMSS-831	*Instrumentation for Packaged Units*
34-SAMSS-846	*Flow Computers for Custody Transfer Measurement of Hydrocarbon Gases*
34-SAMSS-913	*Instrumentation and Thermocouple Cable*

Saudi Aramco Standard and Library Drawings

AB-036019	*Thermowell Assembly and Detail*
AC-036045	*Details Vent, Drain and Sample Connections*
AE-036046	*Detail of ½" Standard Sample Tube*
AB-036180	*Small Metering Skid (Gas) - Field - Mounted FC*
AB-036181	*Small Metering Skid (Gas) - Panel Mounted FC*
AB-036182	*Medium Metering Skid (Gas) - Orifice Based*
AB-036183	*Medium Metering Skid (Gas) - Ultrasonic Flow Meter Based*
AB-036184	*Large Metering Skid (Gas) - Ultrasonic Flow Meter Based*
DC-950040	*Pressure Indicators & Switches Locally Mounting Instrument Piping Details*
DC-950042	*Instruments Piping Details Pressure Instruments Blind and Indicating Type*
DC-950043	*Electrical Connections for Field-Mounted Instruments*
DD-950053	*Field Mounting Details for Instruments*
DC-950061	*Instrument Piping Details – Flow Meter Installation*

Saudi Aramco Product Specifications

A-120	*Dry Gas*
A-130	*Ethane – Chemical Grade*

3.2 Industry Codes and Standards

American Gas Association (AGA)

AGA Report 3	*Orifice Metering of Natural Gas*
AGA Report 5	*Fuel Gas Energy Metering*
AGA Report 8	*Compressibility and Supercompressibility for Natural Gas and Other Hydrocarbon Gases*
AGA Report 9	*Measurement of Gas by Multipath Ultrasonic Meters*
AGA Report 10	*Speed of Sound in natural Gas & other Gases*

American Petroleum Institute (API), Manual of Petroleum Measurement Standards (MPMS)

API MPMS 14.1	*Collecting and Handling of Natural Gas Samples for Custody Transfer*
API MPMS 14.3.1	*Natural Gas Fluids Measurement, Concentric Square-Edge Orifice Meters, General Equations and Uncertainty Guidelines*
API MPMS 14.3.2	*Natural Gas Fluids Measurement, Concentric Square Edge Orifice Meters, Specifications and Installation Requirements*
API MPMS 21.1	*Electronic Gas Measurement*

Commentary Note:

AGA-3 and API MPMS 14.3 are identical documents, so they can be used interchangeably.

3.3 Other Documents

ASME B31.3	*Process Piping*
Directive 2004/108/EC	*European Council Directive for Electromagnetic Compatibility (EMC)*
IEC 61000-4-3	*Electromagnetic Compatibility (EMC) - Testing and Measurement Techniques - Radiated, Radio Frequency Electromagnetic Field Immunity Test*

IEC 61000-6-2	*Electromagnetic Compatibility (EMC) -Generic Standards - Immunity for Industrial Environments*
NFPA 70	*National Electric Code (NEC)*

4 Definitions and Abbreviations

4.1 Definitions

Beta Ratio: Ratio between orifice bore size and pipe internal diameter.

Buyer: The Company (Saudi Aramco, Aramco Overseas Co., or Aramco Services Co.) actually placing the order for the material. The buyer can be a third party metering system customer.

Buyer's Representative: The person acting on behalf of the Buyer, who may be from the Engineering, Inspection, Purchasing, or User organization.

Custody Transfer Measurement: 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 liquid or gas movements (deliveries or receipts) between Saudi Aramco and its customers, suppliers, joint ventures and transport contractors including VELA ships.

Flow Computer: A dedicated off-the-shelf electronic device specifically designed for calculating and totaling metered volumes, and/or calculating meter factors during meter proving for one or more meters.

Meter Tubes: The straight upstream pipe and fittings between the flow meter and the upstream pipe flange and the similar downstream pipe and fittings between the flow meter and the downstream pipe flange.

Metering Station: A facility that is primarily dedicated to the measurement of the quantity and quality of a liquid or gas hydrocarbon. The facility may include, but not be limited to storage tanks, pipelines, piping, regulators, valves, strainers/filters, flow straightening and conditioning equipment, samplers, measurement elements, provers, Remote Terminal Units (RTU), pumps, communications (data and SA telephone), metering shelter, UPS, area fencing, area paving, area lighting, isolation valve systems and associated instrumentation, alarms, computers with software programs, peripheral equipment and associated control functions.

Metering Supervisory Computer (MSC): A computer that performs supervisory functions (data archiving, report generation, system integrity checks, alarm logging and operator interface) for a metering system.

Metering System: A complete assembly of equipment that is designed to measure the quantity and quality of hydrocarbon liquid or gas. The metering system includes, but is not limited to, the meter skid (meters, filters, analyzers, flow conditioning sections, valves), samplers, and control system (flow computers, metering supervisory computers, etc.).

Orifice Meter: A fluid flow measuring device that produces a differential pressure to infer flow rate. It consists of a thin, concentric, square-edge orifice plate, mounted in a single or double chamber orifice fitting and equipped with differential pressure sensing taps. Single chamber orifice fitting may be used only in multitube meter skids or where it is possible to shutdown the station to inspect the orifice plate.

Redundant Devices: Two identical devices that operate in an interchangeable primary/secondary arrangement in which the functions of the primary device are duplicated in the secondary and are automatically transferred to the secondary if the primary fails without the intervention of a third device.

Ultrasonic Meter: A fluid flow measuring device that utilizes transit-time ultrasonic signals to measure the flow rate.

Vendor: The party that supplies or sells integrated metering systems, metering equipment, or components.

4.2 Abbreviations

A/C:	Air Conditioner
BTU/SCF:	British Thermal Unit per Standard Cubic Feet
D:	Pipe Nominal Diameter
GC:	Gas Chromatograph
HMI:	Human Machine Interface
I.D.:	Internal Diameter
LCD:	Liquid Crystal Display
MF:	Meter Factor
MMBTU:	Million British Thermal Unit
MMSCF:	Million Standard Cubic Feet
MMSCFD:	Million Standard Cubic Feet per Day
MOV:	Motor Operated Valve
MSC:	Metering Supervisory Computer

MSCFH:	Thousand Standard Cubic Feet per Hour
OSPAS:	Oil Supply, Planning and Scheduling Dept.
PIB:	Process Interface Building
RTU:	Remote Terminal Unit
SAPMT:	Saudi Aramco Project Management Team
UFM:	Multi-Path Ultrasonic Transit-Time Flow Meter
UPS:	Uninterruptable Power Supply
WC:	Water Column

5 General Requirements

5.1 Approved Vendors

Meters, meter run instruments and control systems shall be purchased as an integrated system. A single vendor shall be responsible for the design, fabrication, assembly and proper functionality of the metering system.

Gas custody metering systems shall be fabricated by approved vendors. The list of approved vendors for gas custody metering systems & equipment shall be obtained from SAES-Y-100.

Instruments, valves and electrical equipment to be used in the gas custody metering system shall be furnished from approved vendors as specified in SAES-J-002, SAES-L-102 and SAES-P-101, respectively.

Gas custody metering projects shall be executed in accordance with the requirements of SAEP-21 or SAEP-50, as applicable. The construction agency (i.e., SAPMT) is responsible for ensuring the design and construction contractors provide a fully operational metering system that meets both the provisions of this standard and the approved project functional design specifications.

5.2 Classification of Gas Metering Systems

Gas Metering Systems are classified into three categories as defined below:

Small Gas Metering System: A metering system designed to handle gas flow rates of 20 MMSCFD or less.

Medium Gas Metering System: A metering system that is designed to measure gas flow rates more than 20 MMSCFD, but less than 200 MMSCFD.

Large Metering System: A metering system designed to handle gas flow rate of 200 MMSCFD or higher.

The specifications of each class of these metering systems shall comply with the application requirements in Section 6 of this standard.

5.3 Units of Measurement

All dimensions of the metering skid and associated equipment shall be in metric units unless otherwise specified in the project specifications.

The following US Customary units shall be used for the measurement signals, calculations and final reporting for billing purposes:

Quantity	Unit
Volume	MMSCF
Flow Rate	MSCFH, MMSCFD
Static Pressure	psig
Differential Pressure	Inch WC
Temperature	°F
Heating Value	BTU/SCF
Total Heating Value	MMBTU
Density	Lb/SCF

5.4 Reference Conditions

The gas volume shall be corrected to the following reference (base) temperature and pressure:

Quantity	US Customary Units	SI Units
Reference (Base) Pressure	14.73 psia	101.56 kPa
Reference (Base) Temperature	60°F	15.56°C

The local atmospheric pressure for different areas shall be as follows:

Location	Atmospheric Pressure (psia)
Dhahran	14.542
Jubail	14.679
Qasim	13.606
Ras Tanura	14.693
Riyadh	13.667
Shedgum	14.191
Yanbu	14.686

5.5 Environmental Conditions

Equipment shall be suitable for installation in the applicable environment specified in SAES-A-112 and shall meet the environmental conditions specified in SAES-J-003.

5.6 Gas Specifications

The gas specification is expected to vary depending on the source and season conditions. However, for the purpose of designing the metering system, these product specifications shall be used as applicable: A-120, Dry Gas and A-130, Ethane-Chemical Grade.

5.7 General Design

5.7.1 Layout

5.7.1.1 The gas custody metering system shall be skid-mounted, designed for unattended operation and measurement.

The metering system shall be designed to meet the 120% of the approved allocated customer demand. If this design changes the class of the metering system, the metering system shall be designed to meet the next class requirements.

Orifice-based metering system shall be sized that the Beta Ratio is between 0.20 and 0.6.

5.7.1.2 Equipment arrangement shall be in accordance with SAES-B-054 to ensure convenient access for operation,

maintenance and/or replacement. Equipment (transmitters, gauges, etc.) shall be located at convenient working heights from top of any platform/skid work surface (i.e., grating), and their access shall not be hampered by cross piping or other fixed structures. Where equipment is located above normal working heights, access steps or ladders and operating platforms shall be provided.

5.7.1.3 Pipe header stubs shall be provided in the original design to add additional meter runs in the future.

5.7.1.4 Blind flanges shall be provided at the end of each stub in case total shut down of the metering system is acceptable. However, for metering systems that cannot tolerate total shutdown to install future meter runs, a manually operated block valve with blinded outlet shall be provided at the end of each stub.

5.7.1.5 The proponent organization shall decide if the metering system requires filtration if black powder exists in the supply pipeline and will have an effect on the downstream equipment.

5.7.1.6 Two Flow Control Valves shall be installed in parallel downstream of the meter runs outlet header of the Medium and Large gas metering systems. Each Flow Control Valve shall handle 100% of the maximum flow rate. Upstream and downstream isolation valves shall be provided for each FCV. Whenever possible, instrument air shall be provided.

5.7.1.7 Medium and Large gas metering systems shall be equipped with a Remotely Operable Isolation Valve located outside the meter skid. This valve shall be installed upstream of the meter skid and shall be equipped with remote control capability. Unless otherwise specified, this valve is beyond the responsibility of the metering system vendor.

5.7.1.8 A sample probe and connection for manual sampling shall be installed downstream of the meter. If a GC is installed, the outlet of the sample probe shall have a suitable connection for manual sampling.

5.7.1.9 For Large gas metering systems, an online GC shall be installed. The sample probe shall be connected downstream of the meter runs. The location of the sample probe shall be

confirmed by the manufacturer to ensure the optimum performance.

5.7.1.10 For Medium gas metering systems, a dedicated online GC shall be installed unless a representative gas composition can be obtained from an online GC installed at a common and unique gas supply header, then an automatic composite sampling system can be installed, if requested by the Proponent, to collect and store representative gas sample over a period of one week.

5.7.2 Piping

5.7.2.1 All skid-mounted piping and pressure containing components shall be designed and constructed in accordance with ASME B31.3 or ASME B31.8, SAES-L-105, 01-SAMSS-010 and 01-SAMSS-017.

5.7.2.2 Metering system piping arrangement shall be designed with a minimum number of bends and fittings.

5.7.2.3 Piping design between the meter runs and the control valves shall minimize the propagation of acoustic noise to the flow meter(s) especially when ultrasonic meters are used.

5.7.2.4 The design pressure and temperature of the metering system piping shall match that of its interconnecting piping.

5.7.2.5 If a bypass line is installed, it shall include a double block-and-bleed valve or upstream and downstream isolation ball valves with a spectacle blind to prevent leakage during normal operation.

5.7.2.6 Gas metering systems shall be equipped with vent lines for depressurization. Vent lines shall extend at least 3 meters above the highest operating platform and shall be properly supported.

5.7.2.7 Pipe connections for vents, drains and samplers shall be in accordance with Standard Drawings AC-036045 and AE-036046.

5.7.2.8 Flanges and fittings welded to meter tubes shall have internal weld joints ground to a smooth finish, flush with the internal diameter of the pipe and free of sharp edges or abrupt changes in surface level or diameter.

5.7.2.9 Flanges and Gaskets shall be as per Saudi Aramco standard SAES-L-109. Gaskets shall be purchased or trimmed to have at least a 10 mm larger inside diameter (bore) than the meter tube for 12 inch tube size and above. For 10 inch and below, gasket internal diameter shall have at least 6 mm larger inside diameter (bore) than the meter tube.

Commentary Note:

This is required to preclude the gasket from protruding into the tube interior through misalignment or compression.

5.7.2.10 Protective coating shall be applied to the external surfaces of all piping and equipment and shall be in accordance with Saudi Aramco standard SAES-H-001.

5.7.3 Instrumentation

5.7.3.1 The mounting of field instruments shall be in accordance with Library Drawing DD-950053.

5.7.3.2 A temperature measurement is required for all metering systems. The installation of primary temperature measurement devices and test thermowells shall conform to Details 1 or 3 of Standard Drawing AB-036019 and SAES-J-400 as applicable.

5.7.3.3 For metering systems with orifice meters, two differential pressure transmitters shall be installed for each meter run. One DP transmitter for low range (20 inch of water column) and the other for high range (100 inch of water column).

Where a field mounted flow computer is used, only one DP is required.

Static Pressure transmitter shall also be provided for each meter run. The static pressure connection shall be derived from the orifice meter downstream pressure tap.

5.7.3.4 For metering systems with ultrasonic meters, a static Pressure transmitter shall be installed on each meter run. The static pressure tube shall be connected to the pressure tap on the meter body.

5.7.3.5 Pressure transmitters shall be installed in accordance with Library Drawings DC-950042 and DC-950043 and SAES-J-200 as applicable.

5.7.3.6 The gas metering skid shall have pressure gauges installed in the inlet and outlet headers. The installation of pressure indicators shall be in accordance with Detail 1 or 2 of Library Drawing DC-950040, as applicable.

5.7.3.7 For ease of calibration, all transmitters (differential pressure, static pressure and temperature) shall be grouped at a single point on the metering skid facing the same direction. A fixed calibration table shall be provided adjacent to the single point for setting calibration equipment and to provide convenient working location for the technicians. Adequate sunshade shall be provided to protect the transmitters.

5.7.3.8 Override values for pressure and temperature should be configured in the flow computer and should be used on transmitter failure.

5.7.3.9 The transmitter impulse lines shall be installed with a slope of not less than 1:12 toward the orifice fitting.

5.7.4 Electrical

5.7.4.1 Field instruments and electrical equipment shall be designed for the electrical area classification as determined by SAES-B-068 and as shown on the approved project drawings.

5.7.4.2 Design and installation of instruments and electrical equipment shall conform to the requirements of NFPA 70, SAES-J-902, SAES-P-104, and SAES-P-111. Instruments and electrical equipment furnished as part of vendor supplied metering systems shall also conform to 34-SAMSS-831 and 17-SAMSS-515, respectively.

5.7.4.3 Instrument cabling shall conform to 34-SAMSS-913.

5.7.4.4 Field junction boxes shall conform to the requirements specified in SAES-J-902 and shall be installed in accessible locations at the edge of the meter skid. Conduit and cable connections shall enter each junction box from the bottom. Each conduit shall be sealed with a weather-tight seal at the entrance to a field junction box.

5.7.4.5 All metering automation equipment, i.e., flow computers, system communications equipment and metering supervisory

computers and PLC's (if provided) shall be powered by a UPS system which conforms to the requirements of SAES-J-902.

5.7.4.6 Electrical and electronic equipment supplied as part of the metering systems shall carry the EC conformity mark ("CE") designating compliance with 2004/108/EC. An authorized agency shall also have tested and certified the equipment is immune to electromagnetic interference, electrostatic discharge, radio frequency interference, surge and fast transients, voltage dips and interruptions at Performance Level A in accordance with IEC 61000-6-2. Tests shall have been performed to confirm the equipment is immune to radiated, radio frequency and electromagnetic emissions in accordance with IEC 61000-4-3 using Test Level 3.

5.7.5 All components of the metering control system shall be for the sole use of the metering system and shall not be shared with any other systems, i.e., RTU.

6 Application Requirements

This section describes the minimum mandatory requirements for the three classes of gas custody metering systems.

6.1 Small Gas Metering Systems

6.1.1 General

The Small gas metering system shall be designed in accordance with Standard Drawing AB-036181. The Small gas metering system shall consist of at least one meter run. Each meter run shall have inlet and outlet manual isolation ball valves.

6.1.2 Meter Selection

Orifice meters shall be selected for the Small gas metering systems.

6.1.3 Meter Run Arrangement

The meter run of a Small gas metering system shall consist of the following as a minimum. However, additional equipment may be required as defined by the project design:

- Inlet isolation ball valve

- Upstream meter tubes with a minimum clear length of 20D and a flow straightening vane 13D upstream of orifice meter.
- Orifice meter
- Differential pressure and static pressure transmitters
- Downstream meter tube with a minimum clear length of 5D
- Two thermowells installed 5D downstream of the orifice meter one for an RTD connected to a temperature transmitter and one for checking purposes using a thermometer. The thermowells shall be separated by 300 mm, unless space restrictions dictate a reduced separation of the thermowells of no less than 150 mm with the approval of the Chairman of the Custody Measurement Standards Committee.
- Outlet isolation ball valve
- Sample Probe

6.1.4 Metering Control System

6.1.4.1 Metering Shelter

The metering control system of a Small gas metering system shall be installed in a field mounted cabinet suitable for the area classification and environmental condition. The cabinet shall include the flow computer, the printer, the power supply, the UPS and shall be equipped with adequate A/C.

6.1.4.2 Flow Computers

Measurement signals from the field instruments of each meter run in the Small gas metering system shall be connected to a flow computer mounted inside the field mounted cabinet. The flow computer shall read all field signals, perform volume and energy calculations and generate reports and alarms.

The flow computer shall read the following data (as a minimum):

- Static pressure and temperature
- Differential pressures across the orifice meter
- Differential pressure of the filter (if provided)

- Manually entered data

A printer shall be provided and shall be installed in the flow computer cabinet.

The reports shall be sent directly from the flow computer to the printer. Daily tickets shall be generated automatically and upon a manual request.

6.1.4.3 Alternative Control System Design

For Small gas metering systems, field mounted flow computers with multivariable transmitter capability may be used with the approval of the Chairman of the Custody Measurement Standards Committee. If approved, inputs from the multivariable transmitters can be connected directly to the field flow computer and the gas metering system shall be designed in accordance with Standard Drawing AB-036180.

Daily tickets shall be generated automatically and archived in the memory of the field mounted flow computer for a minimum period of 31 days (1 month).

Reports shall be retrieved using a laptop computer connected to the flow computer. The laptop and the connection shall be suitable for the area classification.

6.2 Medium Gas Metering Systems

6.2.1 General

The Medium gas metering system shall be designed in accordance with Standard Drawing AB-036183. The Medium gas metering system shall consist of at least one meter run. In case the metering system capacity cannot be handled by one meter, multiple meter runs shall be installed in parallel. Each meter run shall have inlet and outlet isolation ball valves.

6.2.2 Meter Selection

Ultrasonic meters shall be selected for the Medium gas metering system.

Selection of orifice meters for Medium gas metering systems is subject to the approval of the Chairman of Custody Measurement Standards Committee. Upon approval, the Medium gas metering system shall be designed in accordance with Standard Drawing AB-036182.

6.2.3 Meter Run Arrangement

The meter run of a Medium gas metering system shall consist of the following as a minimum. However, additional equipment may be required as defined by the project design:

- Inlet isolation ball valve
- Upstream meter tube consisting of two sections with a minimum clear length of 20D and a flow conditioning plate installed midway.
- Ultrasonic flow meter
- Pressure transmitter
- Downstream meter tube with a minimum clear length of 5D
- Two thermowells installed 5D downstream of the meter one for an RTD connected to a temperature transmitter and one for checking purposes using a thermometer. The thermowells shall be separated by 300 mm, unless space restrictions dictate a reduced separation of the thermowells of no less than150 mm with the approval of the Chairman of the Custody Measurement Standards Committee.
- 2" flanged inspection fitting downstream of the thermowells, the fitting shall be mounted at 45° facing the flow.
- Outlet isolation ball valve
- Sample Probe

6.2.4 Metering Control System

6.2.4.1 Metering Building

The metering control system of a Medium gas metering system shall be mounted in a process interface building (PIB) that complies with the requirements of SAES-J-801. The PIB shall include the flow computer cabinet, the metering supervisory computer (MSC), the printer, the communication equipment, the power supply, the UPS, telephone, and the A/C.

The design and construction of the PIB shall not be part of the scope of the metering system vendor. This shall be specified in the project documentation.

6.2.4.2 Flow Computer

Measurement signals from the field instruments of each meter run of the Medium gas metering system shall be connected to a flow computer mounted in a cabinet. The flow computer shall read all field signals, perform volume and energy calculations and generate reports and alarms.

The flow computer shall read the following data (as a minimum):

- Static pressure and temperature
- Dual pulses and serial communication from the UFM. Pulses to be configured as primary to calculate the flow rate
- Gas composition from an on-line GC (if provided)
- Differential pressure across the filter (if provided)
- Manually entered data or data from the MSC/OSPAS

6.2.4.3 Metering Supervisory Computer (MSC)

The flow computer shall have a single (Serial or Ethernet) communication link to a single metering supervisory computer (MSC) that is loaded with an HMI package designed for gas metering applications, a package for configuration and diagnosis of the UFM, and another for configuration of the flow computer.

The MSC shall have a direct serial link to the UFM.

The MSC shall be placed on an operator console suitable for the location.

A printer shall be provided along with the metering control system. The printer may be installed in the flow computer cabinet or on the MSC console. Reports shall be sent directly from the MSC to the printer. Daily tickets shall be generated automatically every midnight and up on a manual request. Provisions for printing reports directly from the flow computer upon a manual request shall be provided.

The Medium gas metering system shall communicate to OSPAS using a modem connected to the MSC to read/write data, close the remotely operable isolation valve or change

the settings of the flow control valves. The list of data for communication with OSPAS including alarms shall be specified in the project documentation.

6.3 Large Gas Metering Systems

6.3.1 General

Large gas metering system shall be designed in accordance with Standard Drawing AB-036184.

Large gas metering systems shall consist of at least one operational meter run and one standby/check meter run with piping and valves setup to permit series or parallel operation (known as "Z" configuration).

In case the metering system capacity cannot be handled by one operational meter, multiple meter runs shall be installed in parallel. The multiple operational meter runs shall all have the required piping and valves arrangement to be put in series with the standby/check meter one at a time for verification purposes.

6.3.2 Meter Selection

Ultrasonic meters shall be selected for the Large gas metering system. The operational meters and the standby check meter shall be equally sized and calibrated individually across their entire operational flow range.

6.3.3 Meter Run Arrangement

The meter run of a Large gas metering system shall consist of the following as a minimum. However, additional equipment may be required as defined by the project design:

- Inlet isolation MOV (double block and bleed valve)
- Upstream meter tube consisting of two sections with a total minimum clear length of 20D and a flow conditioning plate installed midway.
- Ultrasonic flow meter
- Pressure transmitter
- Downstream meter tube with a minimum clear length of 5D
- Two thermowells installed 5D downstream of the meter one for an RTD connected to a temperature transmitter and one for checking

purposes using a thermometer. The thermowells shall be separated by 300 mm, unless space restrictions dictate a reduced separation of the thermowells of no less than 150 mm with the approval of the Chairman of the Custody Measurement Standards Committee.

- 2" flanged inspection fitting downstream of the thermowells, the fitting shall be mounted at 45° facing the flow.
- Isolation MOV on the connection pipe to the check meter (double block and bleed valve)
- Outlet isolation MOV (double block and bleed valve)
- Sample probe

6.3.4 Metering Control System

6.3.4.1 Metering Building:

The metering control system of a Large gas metering system shall be mounted in a control room that complies with the requirements of SAES-J-801. The control room shall house the flow computers cabinet, the Metering Supervisory System (MSC), the PLC, the printer, the communication equipment, the power supply, the UPS, telephone and the A/C. If the control room is not part of the scope of the metering system vendor, it shall be specified in the project documentation.

6.3.4.2 Flow Computers

Measurement signals from the Large gas metering system field instruments shall be connected to redundant flow computers mounted in a cabinet. The flow computers shall read all field signals, perform volume and energy calculations and generate reports and alarms.

The flow computers shall read the following data (as a minimum):

- Static pressure and temperature
- Dual pulses and serial communication from the UFM. Pulses to be configured as primary to calculate the flow rate.
- Gas composition from an on-line GC
- Differential pressure of the filter (if provided)

- Manually entered data or data from the MSC/OSPAS

6.3.4.3 Metering Supervisory Computer

The flow computers shall have a single (Serial or Ethernet) communication link to a single metering supervisory computer (MSC) that is loaded with an HMI package designed for gas metering applications, a package for configuration and diagnosis of the UFM, a package to communicate with the PLC to display and edit its programming and another for configuration of the flow computer.

The MSC shall have a direct serial link to the UFM

The MSC shall be placed on an operator console suitable for the location.

A printer shall be provided along with the metering control system. The printer may be installed in the flow computer cabinet or on the MSC console. Reports shall be sent directly from the MSC to the printer. Daily tickets shall be generated automatically every midnight and upon a manual request. Provisions for printing reports directly from the flow computers upon a manual request shall be provided.

Large gas metering system shall communicate to OSPAS using a modem connected to the MSC to read/write data, or change the settings of the flow control valves. The list of data for communication with OSPAS including alarms shall be specified in the project documentation.

6.3.4.4 Programmable Logic Controller (PLC)

A PLC shall be provided for controlling MOV's opening and closing upon a command from the MSC. The PLC shall have dual communication links with the MSC.

The PLC shall automatically line-up the operating meter to be verified against the check meter. After completion of the verification (comparison) process and upon a command from the MSC, the PLC shall restore normal line-up so that the flow passes only through the normal operating meter.

7 Equipment Requirements

7.1 Meters and Meter Tubes

The meter type for each class of gas metering systems is identified in Section 6 of this standard.

Meter tubes are not allowed to be fabricated in the field. They shall be supplied by either the meter manufacturers or the metering system fabricator.

Orifice meters and meter tubes shall comply with the requirements of 34-SAMSS-112.

Ultrasonic flow meters and meter tubes shall comply with the requirements of 34-SAMSS-114.

7.2 Flow Conditioners

Flow conditioning devices shall comply with the pressure and temperature ratings of the adjacent piping. They shall be properly supported.

Flow conditioners shall be installed in a way that provides convenient access for ease of inspection, removal and maintenance.

For Orifice Meters, flange type straightening vanes or tube bundles shall be inserted in the upstream section of the orifice meter tube to minimize flow pattern disturbances. The installation of the straightening vane in the orifice meter tube shall comply with API MPMS 14.3.2. The material of the straightening vanes and their flanges shall be suitable for the application.

For Ultrasonic Flow Meters flow conditioning plates (perforated plates) made of stainless steel shall be used. The design of the flow conditioning plate shall be recommended by the meter's manufacturer. The flow conditioning plate shall be mounted between flanges in the middle of the upstream ultrasonic meter tube.

The flow conditioning plate shall have provisions (such as marking or pin) to ensure that it will be installed in the same orientation after dismantling the upstream meter tube at the conclusion of flow calibration or whenever the conditioning plate is taken out for inspection or cleaning.

7.3 Other Meter Skid Equipment

7.3.1 Temperature Instruments

7.3.1.1 Thermowells

Two thermowells made of 316 stainless steel shall be

installed in 1 inch NPT tap fittings located on the downstream meter tube. They shall be in accordance with Standard Drawing AB-036019.

7.3.1.2 RTD's and Temperature Transmitters

Platinum Resistance Temperature Detectors (RTD) with DIN curve shall be used. RTDs should be of the spring loaded type. They shall be connected to smart electronic transmitters utilizing ambient temperature drift compensation for output signal. The output signal from the transmitters shall be 4 to 20 mA DC with an accuracy of ± 0.2% of span or better. Normal range setting shall be 0°F to 150°F. Refer to Saudi Aramco Engineering Standard SAES-J-400.

7.3.2 Pressure Instruments

7.3.2.1 Differential Pressure Transmitters

Each Differential pressure transmitter shall be fitted with 5 way manifold valve in accordance to Library Drawing DC-950061. The transmitters shall be mounted as close to the orifice fitting as practical.

The transmitters impulse lines shall be ½ inch type 316 stainless steel tubing

Smart electronic type differential pressure transmitters with 4 to 20 mA DC output and with an overall accuracy of ± 0.25% of span or better shall be used. Refer to Saudi Aramco Engineering Standard SAES-J-200.

7.3.2.2 Static Pressure Transmitter

Smart electronic type pressure transmitters with 4 to 20 mA DC output with an overall accuracy of ± 0.25% of span or better shall be used. Refer to Saudi Aramco Engineering Standard SAES-J-200.

The static pressure transmitters shall be fitted with 3 way manifold valve in accordance to Library Drawing DC-950042. The transmitters should be mounted as close to the meter as practical.

7.3.2.3 Pressure Gauges

Pressure gauges shall be in accordance with SAES-J-200.

7.3.3 Gas Chromatographs

The GC shall comply with the specifications of 34-SAMSS-511 and shall be mounted in an analyzer shelter that complies with the specifications of SAES-J-502.

Field mounted GC may be installed with prior approval of the Chairman of the Custody Measurement Standards Committee.

Probe should be located on the top of the pipe and on the downstream side of the metering skid.

7.3.4 Automatic (Composite) Sampler

Automatic (composite) samplers shall comply with the requirements of API MPMS Chapter 14.1.

The sampler probe shall be as per Standard Drawing AE-036046. Probe tip length should be as indicated in drawing. For pipe larger than to 24 inches in size, the probe tip shall be 343 mm long. Probe shall be located on the top of the pipe and on the downstream side of the metering skid.

Sample collection control systems shall provide a flow-rate based sampling system with equally sized sample bites.

Spun cylinders (single chamber) can be used.

The Vendor shall provide two spare sample cylinders for the automatic composite sampler

7.3.5 Manual Sampling

Manual sampling connection shall comply with the requirements of API MPMS Chapter 14.1.

7.3.6 Filtration System

The filtration systems shall be skid mounted and shall be installed upstream of the meter skid. They shall be redundant and of a type and size suitable for the application and the maximum design pressure. Filtration systems shall be specified by the design contractor with advice from the metering vendor. They shall provide adequate cleaning of the

gas without causing significant pressure drop. As a minimum, filtration system shall be suitable for a minimum of 3 microns particle size with a filtration efficiency of 99%. Pressure drop shall be no more than 15 kPa (2 psi) when the filter is clean at the maximum design rate for the meter or group of meters.

The design of the filter shall allow for online inspection and cleaning without the need to remove it out of line (i.e., swing bolt, hinged-type closure).

The filters shall be equipped with a differential pressure transmitter

The details of the filter shall be indicated in the project detailed design and shall be approved by the Chairman of the Custody Measurement Standards Committee.

7.3.7 Valves

Block valves shall be selected per SAES-L-108.

Double block and bleed valves for the Large gas metering systems shall comply with the specification of 04-SAMSS-041.

7.3.8 Motor Operated Valve Actuators

Electric Actuators shall be provided for the Large gas metering systems and shall comply with the specifications of 34-SAMSS-718.

Limit switches shall be provided to permit local and remote indication of valve position.

7.3.9 Flow Control Valves

Flow control valves shall be provided in accordance with the specifications of 34-SAMSS-711.

7.4 Control System Equipment

7.4.1 Control Panels

Control panels for the Small industry gas metering system shall be in accordance to 34-SAMSS-821.

Control panels for the Large and Medium gas metering systems shall be in accordance to 34-SAMSS-820.

7.4.2 Flow Computers

The flow computer shall be provided to meet 34-SAMSS-846.

7.4.3 Metering Supervisory Computer

The metering supervisory computer (MSC) shall have single (Serial or Ethernet) communication links to each flow computer. It shall also be loaded with an HMI package designed for gas metering application to perform the following functions as a minimum:

- View live metering data on a graphical format similar to field arrangement. The live data for each stream includes (but not limited to): gross flow rate, net flow rate, temperature, pressure, heating value, gas composition and density.
- View totalized and average daily data in tabular format. The daily totalized data shall include (but not limited to): the total volume and energy. The daily averages shall include but not limited to: flow rate, temperature, pressure, specific gravity and gas composition.
- Indicate live and historical alarms
- Capture reports from the primary and secondary flow computers, archive and print reports (daily tickets, meter comparison report, etc.). Daily tickets shall be printed automatically at midnight and upon manual request and shall be based on the primary flow computer data.
- Trend critical values from the meter runs
- Initiate an automatically controlled comparison of the operational meter(s) using the check meter. As a result of the comparison of the gas volume reported by both the operational meter and the check meter during the comparison time, a report shall be generated to indicate the performance of the operational meter and the process condition during the comparison. The comparison report shall comply with the format described in Appendix C.
- Communicate to the GC processor to display the analysis, archive results and verify the performance or the configuration.

The MSC shall be loaded with a package for configuration and diagnosis of the UFM, a package to communicate with the PLC to display and edit its programming and another for configuration of the flow computer.

7.4.4 Programmable Logic Controller (PLC)

A PLC shall be provided to operate the MOV's in Large gas metering systems. The PLC shall meet the requirements of 34-SAMSS-830.

The PLC shall have dual communication links with the MSC.

The PLC shall provide logic functions and sequential control for the following operations upon a command from the MSC:

- Opening and closing meter runs
- Valve line-up in preparation for and after meter comparison

The PLC shall provide Open/Stop/Close logic with completion alarm timers, Remote/Local status, and the ability to reverse travel before completion of a command for each MOV.

The PLC shall include interlock logic for sequential control of the metering system MOV's. The logic provided shall include, but not be limited to provisions for preventing the following:

- Opening of the valve on the connection to the check meter from more than one meter run at a time (if the system has multiple meter runs)
- Closing of a meter run outlet valve prior to opening of the check meter outlet valve and the valve on the connection pipe to the check meter
- Closing of the check meter outlet valve prior to opening of the meter run outlet valve

The PLC shall set an alarm flag if an MOV is operated locally.

The PLC shall refuse a sequential operation and set an alarm flag if any of the affected valves is in the LOCAL position.

In response to a “Compare Meters” command from the MSC, the PLC shall sequence the valves for comparison as follows:

1. Ensure the inlet MOV of the check meter is closed
2. Open check meter outlet MOV
3. Open MOV on the connection pipe from the meter to be verified
4. Close the meter run outlet MOV

Upon receipt of a command from the MSC after completion of the ultrasonic meter comparison, the PLC shall reconfigure the metering system MOV's using the following sequence:

1. Open the meter run outlet MOV
2. Close the the MOV on the connection pipe from the meter to be verified to the check meter
3. Close the check meter outlet MOV

The PLC shall sequence the valves for an "Open Meter Run" command from the MSC as follows:

1. Ensure the MOV on the connection pipe from meter run to the check meter is closed.
2. Open the inlet MOV for the meter run.
3. Open the outlet MOV for the meter run.

The PLC shall sequence the valves for a "Close Meter Run" command from the MSC as follows:

1. Ensure the MOV on the connection pipe from meter run to the check meter is closed.
2. Close the meter run outlet MOV.
3. Close the meter run inlet MOV.

The PLC shall continuously run a self-diagnostic routine and shall set an alarm flag if it fails. The PLC's program and data memory shall have a battery backup with a minimum retention time of two weeks.

7.4.5 Printer

A panel or desk mounted laser type printer shall be provided according to the application as specified in this standard. The printer shall print a minimum 80 column with full 96 ASCII characters.

8 Testing and Inspection

8.1 General

The metering system components shall undergo tests as specified in the relevant Saudi Aramco Material Supply System specification.

Functional tests shall be witnessed and approved by the Buyer or the Buyer's Representative.

8.2 Hydrostatic Test

All piping and piping components shall be hydro-tested in accordance with 01-SAMSS-010 prior to the application of external paint and internal coating (if required). After the hydrostatic test, the pipes internal surfaces shall be dried and protected in accordance with the requirements of Section 9.2.1 of this standard.

8.3 Factory Acceptance Test (FAT)

Each complete metering system shall undergo a Factory Acceptance Test (FAT) at the Vendor's facility in accordance with SAEP-21 or SAEP-50, as applicable. This test shall ensure that the system meets all functional and operational requirements as described in the project specifications and the reference documents. The FAT shall consist of functional tests of all the components and checking the calculations using actual field or simulated signals. The FAT shall be witnessed by the buyer or the buyer's representative.

8.4 Site Acceptance Test (SAT)

A Site Acceptance Test (SAT) similar to the FAT shall be performed after the metering system is permanently installed at the field location. Refer to SAEP-21 or SAEP-50, as applicable.

9 Shipping Requirements

On completion of the FAT, all necessary repairs, replacements or modifications to hardware, firmware, and software, shall be completed and documented by the Vendor prior to shipment.

The Vendor shall be responsible for ensuring the equipment is properly prepared for shipment, including, but not limited to, the requirements specified hereafter.

9.1 General

All equipment and internals being shipped shall be braced and temporary supports shall be provided, if required, to prevent damage during shipment.

Equipment shall be marked with water-soluble materials that will not attack or damage the equipment at either ambient or operating temperatures. Marking materials shall be free of lead, sulfur, zinc, cadmium, mercury, chlorine and all other halogens.

Markings for export shall conform to the requirements specified on the purchase order.

9.2 Fabricated Equipment

9.2.1 Internal Protection

The internals of all piping, fabricated and assembled equipment shall be completely cleaned and dried to the satisfaction of the Saudi Aramco Inspector.

A non-toxic vapor phase corrosion inhibitor (CORTEC VCI-309 or VCI-307, or equivalent approved by Coordinator, CSD/Material Engineering & Corrosion Control Division) shall be applied to the internal surfaces of all piping, fabricated and assembled equipment.

Commentary Note:

Vendors are cautioned to allow sufficient lead-time for the purchase and delivery of the vapor phase corrosion inhibitor. Lack of planning by the Vendor will not constitute justification for a waiver of this requirement.

The application rate for the inhibitor shall be 1 kg/m³ of equipment.

The inhibitor shall be blown through the equipment using air with a dew-point that is the lower of the following: 1) -1°C or 2) 5°C below the lowest ambient temperature to be encountered in shipment from the point of manufacture to the final destination. Application of the inhibitor shall continue until the powder can be seen blowing out of the opposite end of the equipment.

Following application of the inhibitor, equipment openings shall be sealed vapor tight with steel covers in accordance with the requirements for external protection.

9.2.2 External Protection

All external surfaces shall be prepared and coated in the shop with the complete Saudi Aramco coating system (primer and final coats) as specified in SAES-H-001. If the specified Saudi Aramco approved coating is unavailable or unusable at the Vendor's site, an alternative coating system may be used with the concurrence of the Coordinator, CSD/Materials Engineering and Corrosion Control Division.

All bolts and nuts shall be coated with a temporary protective coating (MIL C16173, Grade IV, or Denso paste or equivalent).

Permanent blind flanges or covers shall be installed with the gaskets and bolts required for service.

The faces of open, flanged connections shall be coated with a temporary protective coating (MIL C16173, Grade IV, or equivalent) which can be easily removed prior to equipment installation. Following application of the protective coating, each connection shall be fitted with a neoprene gasket, and vapor tight steel cover. The cover shall be held in place by a minimum of four equally spaced bolts.

9.3 Electronic and Electrical Equipment

The Vendor shall determine if electronics and instruments are susceptible to damage from shock, weather or extremes of temperature during shipment. If required, such items shall be removed after the FAT and shipped separately.

Electronic equipment shall be prepared and protected for shipment in accordance with the manufacturer's recommendations. As a minimum, the equipment shall be fitted with a vapor phase inhibitor emitter (CORTEC VpCI -101, VpCI -105, VpCI-110 or equivalent).

Electrical boxes shall be fitted with vapor phase inhibitor emitters (CORTEC VpCI -101, VpCI -105, VpCI -110 or equivalent).

10 Documentation

10.1 The vendor shall produce system drawings in accordance with the requirements of SAES-J-004 and SAES-J-005.

10.2 Project documentation shall be developed, distributed, reviewed and approved in accordance with SAEP-21 or SAEP-50, as applicable.

10.3 Documentation for metering system equipment (including operation and maintenance manuals, product literature of all components, etc.) shall be furnished in accordance with the purchase order and relevant material specifications.

10.4 The vendor shall provide a list of recommended spare parts for start-up and two years of operation.

Revision Summary

31 May 2011	Major revision.
29 September 2013	Editorial revision to change the primary contact persons.

Appendix A – Daily Delivery Ticket Format for Ultrasonic Metering Systems

Saudi Arabian Oil Company (Saudi Aramco)

STATION: AAAAAAAAA DELIVERY DATE: MM/DD/YYYY
PRINT DATE/TIME: MM/DD/YYYY/HH:MM

TICKET NO.: XXXX FLOW COMPUTER TAG. NO.: AAA-XXX
SERVICE GAS: AAAAAAAAA
METER DATA:
TAG NO. AAA-XXX MODEL NO.: AAA-XXX SERIAL NO.: XXXXXX
MANUFACTURER: AAAAAAAAA METER K-FACTOR: XXXX PULSE/CF
PIPE ID (IN): XX.XXX USM ID (IN):XX.XXX

1.	METER CLOSING (DATE/TIME)		MM/DD/YYYY/HH:MM:SS
2.	METER OPENING (DATE/TIME)		MM/DD/YYYY/HH:MM:SS
3.	IDLE TIME		XX.XXX HRS
4.	NET DELIVERY TIME		XX.XXX HRS
5.	METER CLOSING READING	(MMSCF)	XXX.XXX
6.	METER OPENING READING	(MMSCF)	XXX.XXX
7.	TOTAL VOLUME	(MMSCF)	XXX.XXX
8.	METER CLOSING READING	(MMBTU)	XXXXXX
9.	METER OPENING READING	(MMBTU)	XXXXXX
10.	TOTAL HEATING VALUE (MMBTU)	XXXXXX	
11.	AVERAGE FLOW RATE	(MMSCFD)	XXX.XXX
12.	AVERAGE TEMPERATURE (°F)	XXX.X	
13.	AVERAGE PRESSURE	(PSIG)	XXX
14.	AVERAGE DENSITY	(LB/SCF)	XX.XX
15.	AVERAGE METER FACTOR		X.XXXX

16. DAILY AVERAGE GAS VELOCITIES:
CHORD A XX.XX M/S CHORD C XX.XX M/S
CHORD B XX.XX M/S CHORD D XX.XX M/S

METER AVERAGE GAS VELOCITY XX.XX M/S

17. GAS COMPOSITION:

	Mole %
C1	XX.XX
C2	XX.XX
C3	XX.XX
C4+	XX.XX
N2	XX.XX
CO2	XX.XX
Average Heating Value	XXXX BTU/SCF
Specific Gravity	X.XXXX

Non-Negotiable, Non-Transferable
Saudi Arabian Oil Company
Checked for Saudi Aramco by: _____ Date: _____

Explanation of Delivery Ticket for Systems with Ultrasonic Flow Meters

A new ticket shall be initiated upon delivery or receipt of a new batch; automatically at 12:00 midnight of each day; or when manually initiated by the operator.

STATION - Alpha-numeric value entered in the metering system computer during initialization
METER TICKET NUMBER – Computer generated number plus an alpha character if applicable. Numbers for each meter are consecutively assigned by the flow computer beginning with 12:00 midnight of the 1st day of each year
FLOW COMPUTER TAG. NO. – The tag number of the flow computer used to calculate the total volume and energy for the batch
DELIVERY DATE - Date of the delivery
PRINT DATE/TIME - Date and time when ticket is printed
SERVICE GAS – Alpha-numeric value entered in the metering flow computer during initialization (Natural Gas or Ethane)
METER DATA (METER TAG NO., MANUFACTURER, MODEL NO. AND SERIAL NO., PIPE INSIDE DIAMETER, ULTRASONIC METER DIAMETER AND METER K-FACTOR) - Alpha-numeric values entered in the metering system computer during initialization

1. METER CLOSING (DATE/TIME): Date and time delivery stops as determined by flow computer
2. METER OPENING (DATE/TIME): Date and time delivery starts as determined by flow computer
3. IDLE TIME: Calculated by the flow computer
4. NET DELIVERY TIME: Calculated by flow computer = Item 1-Item 2-Item 3
5. METER CLOSING READING: Total accumulated volume reading at the time the delivery stops (MMSCF).
6. METER OPENING READING: Total accumulated volume reading at the time the delivery starts (MMSCF).
7. TOTAL VOLUME: Item 5-Item 6 (MMSCF)
8. METER CLOSING READING: Total accumulated heating value reading at the time the delivery stops (MMBTU)
9. METER OPENING READING: Total accumulated heating value reading at the time the delivery starts (MMBTU)
10. TOTAL HEATING VALUE: Item 8-Item 9
11. AVERAGE FLOW RATE: Item 7*****24/Item 4
12. FLOW WEIGHTED AVERAGE TEMPERATURE: Calculated by flow computer
13. FLOW WEIGHTED AVERAGE PRESSURE: Calculated by flow computer
14. FLOW WEIGHTED AVERAGE DENSITY: Calculated by the flow computer
15. FLOW WEIGHTED AVERAGE METER FACTOR: Calculated by the flow computer
16. AVERAGE GAS VELOCITY – The average gas velocity calculated by the ultrasonic meter processor and the gas velocity for the individual paths
17. GAS COMPOSITION - Either data received from an on-line gas chromatograph at every scan or entered manually.

AVERAGE HEATING VALUE – Calculated by the flow computer based on the gas composition
SPECIFIC GRAVITY: Calculated by the flow computer based on the gas composition

Appendix B – Delivery Ticket Format for Orifice Metering System

Saudi Arabian Oil Company (Saudi Aramco)

STATION: AAAAAAAAA DELIVERY DATE: MM/DD/YYYY
TICKET NO.: XXXX FLOW COMPUTER TAG. NO.: AAA-XXX
PRINT DATE/TIME: MM/DD/YYYY/HH:MM
SERVICE GAS: AAAAAAAAA

METER DATA:
TAG NO. AAA-XXX MODEL NO.: AAA-XXX SERIAL NO.: XXXXXX
MANUFACTURER: AAAAAAAAA
PIPE ID (IN): XX.XXX ORIFICE PLATE BORE DIAMETER (IN): XX.XXX

1.	METER CLOSING (DATE/TIME)		MM/DD/YYYY/HH:MM:SS
2.	METER OPENING (DATE/TIME)		MM/DD/YYYY/HH:MM:SS
3.	IDLE TIME		XX.XXX HRS
4.	NET DELIVERY TIME		XX.XXX HRS
5.	METER CLOSING READING	(MMSCF)	XXX.XXX
6.	METER OPENING READING	(MMSCF)	XXX.XXX
7.	TOTAL VOLUME	(MMSCF)	XXX.XXX
8.	METER CLOSING READING	(MMBTU)	XXXXXX
9.	METER OPENING READING	(MMBTU)	XXXXXX
10.	TOTAL HEATING VALUE	(MMBTU)	XXXXXX
11.	AVERAGE FLOW RATE	(MMSCFD)	XXX.XXX
12.	AVERAGE DIFFERENTIAL PRESSURE	(INCH WC)	XX.XX
13.	AVERAGE TEMPERATURE	(°F)	XXX.X
14.	AVERAGE STATIC PRESSURE	(PSIG)	XXX
15.	AVERAGE DENSITY	(LB/SCF)	XX.XX

16. GAS COMPOSITION:

	MOLE %	
C1	XX.XX	
C2	XX.XX	
C3	XX.XX	
C4+	XX.XX	
N2	XX.XX	
CO2	XX.XX	
AVERAGE HEATING VALUE	XXXX	BTU/SCF
SPECIFIC GRAVITY	X.XXXX	

NON-NEGOTIABLE, NON-TRANSFERABLE
SAUDI ARABIAN OIL COMPANY
CHECKED FOR SAUDI ARAMCO BY: _____ DATE: _____

Explanation of Delivery Ticket for Systems with Orifice Meters

A new ticket shall be initiated upon delivery or receipt of a new batch; automatically at 12:00 midnight of each day; or when manually initiated by the operator.

STATION - Alpha-numeric value entered in the metering system computer during initialization.

METER TICKET NUMBER – Computer generated number plus an alpha character if applicable. Numbers for each meter are consecutively assigned by the flow computer beginning with 12:00 midnight of the 1st day of each year

DELIVERY DATE - Date of the delivery

PRINT DATE/TIME - Date and time when ticket is printed.

SERVICE GAS – Alpha-numeric value entered in the metering flow computer during initialization (Natural Gas or Ethane)

METER DATA (METER TAG NO, MANUFACTURER, MODEL NO. AND SERIAL NO, PIPE INSIDE DIAMETER AND ORIFICE PLATE DIAMETER) - Alpha-numeric values entered in the metering system computer during initialization

1. METER CLOSING (DATE/TIME): Date and time delivery stops as determined by flow computer
2. METER OPENING (DATE/TIME): Date and time delivery starts as determined by flow computer
3. IDLE TIME: Calculated by the flow computer
4. NET DELIVERY TIME: Calculated by flow computer = Item 1-Item 2-Item 3
5. METER CLOSING READING: Total accumulated volume reading at the time the delivery/receipt stops (MMSCF)
6. METER OPENING READING: Total accumulated volume reading at the time the delivery/receipt starts (MMSCF)
7. TOTAL VOLUME: Item 5-Item 6
8. METER CLOSING READING: Total accumulated Heating value reading at the time the delivery/receipt stops (MMBTU)
9. METER OPENING READING: Total accumulated Heating value reading at the time the delivery/receipt starts (MMBTU)
10. TOTAL Heating value: Item 8-Item 9
11. AVERAGE FLOW RATE: Item 7*24/Item 4
12. FLOW WEIGHTED AVERAGE DIFFERENTIAL PRESSURE: Calculated by flow computer
13. FLOW WEIGHTED AVERAGE DIFFERENTIAL PRESSURE: Calculated by flow computer
14. FLOW WEIGHTED AVERAGE TEMPERATURE: Calculated by flow computer
15. FLOW WEIGHTED AVERAGE STATIC PRESSURE: Calculated by flow computer
16. FLOW WEIGHTED AVERAGE DENSITY: Calculated by the flow computer
17. GAS COMPOSITION: Either data received from an on-line gas chromatograph at every scan or entered manually

AVERAGE HEATING VALUE: Calculated by the flow computer based on the gas composition

SPECIFIC GRAVITY: Calculated by the flow computer based on the gas composition

Appendix C – Comparison Report for Ultrasonic Meters

Saudi Arabian Oil Company (Saudi Aramco)

STATION: AAAAAAAAA PRINT DATE/TIME: MM/DD/YYYY/HH:MM
REPORT NO.: XXXX COMPARISON START DATE/TIME: MM/DD/YYYY/HH:MM
SERVICE GAS: AAAAAAAAA COMPARISON FINISH DATE/TIME: MM/DD/YYYY/HH:MM

FLOW COMPUTER TAG. NO.: AAA-XXX

OPERATIONAL METER DATA:		CHECK METER DATA:	
TAG NO.	AAA-XXX	TAG NO.	AAA-XXX
MODEL NO.:	AAA-XXX	MODEL NO.:	AAA-XXX
SERIAL NO.:	XXXXXX	SERIAL NO.:	XXXXXX
MANUFACTURER:	AAAAAAAAA	MANUFACTURER:	AAAAAAAAA
METER K-FACTOR:	XXXX PULSE/CF	METER K-FACTOR:	XXXX PULSE/CF
USM ID (IN):	X.XXX	USM ID (IN):	XX.XXX

CHECK METER READINGS

1.	ACTUAL VOLUME	MMACF	XXX
2.	AVERAGE TEMPERATURE	°F	XX.X
3.	AVERAGE PRESSURE	PSIG	XXX
4.	AVERAGE DENSITY	LB/SCF	X.XXX
5.	AVERAGE MF		X.XXXX
6.	AVERAGE GAS VELOCITY	M/S	XX.X
7.	FLOW RATE	MACFH	XXX
8.	STANDARD VOLUME	MMSCF	XXX

OPERATIONAL METER READINGS:

9.	ACTUAL VOLUME	MMACF	XXX
10.	AVERAGE TEMPERATURE	°F	XX.X
11.	AVERAGE PRESSURE	PSIG	XXX
12.	AVERAGE DENSITY	LB/SCF	X.XXX
13.	AVERAGE MF		X.XXXX
14.	AVERAGE GAS VELOCITY	M/S	XX.X
15.	FLOW RATE	MACFH	XXX
16.	STANDARD VOLUME	MMSCF	XXX

17.	VOL. DEVIATION	%	X.XX
18.	DURATION OF COMPARISON	HH:MM:SS	XX:XX:XX

HISTORICAL RECORDS:

DATE:	MM/DD/YY	MM/DD/Y	MM/DD/YY	MM/DD/YY	MM/DD/YY	MM/DD/YY	MM/DD/YY
FLOW RATE	X.XXXX	X.XXXX	X.XXXX	X.XXXX	X.XXXX	X.XXXX	X.XXXX
DEV. %	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX

CHECKED FOR SAUDI ARAMCO BY: _____ DATE: _____

Explanation of Comparison Report for Ultrasonic Meters

A new master meter comparison report shall be generated upon completion of the verification of the operational meter(s) against the check meter.

STATION - Alpha-numeric value entered in the metering system computer during initialization.

REPORT NUMBER – Computer generated number plus an alpha character if applicable. Numbers for each meter are consecutively assigned by the MSC every time a comparison is initiated

PRINT DATE/TIME - Date and time when comparison report is printed.

SERVICE GAS – Alpha-numeric value entered in the metering flow computer during initialization (Natural Gas or Ethane)

COMPARISON START AND FINISH DATE/TIME: The date & time when the comparison was actually started and completed

OPERATIONAL & CHECK METERS DATA (METER TAG NO, MANUFACTURER, MODEL NO. AND SERIAL NO, K FACTOR & UFM INSIDE DIAMETER) - Alpha-numeric values entered in the metering system computer during initialization

CHECK & OPERATIONAL METER READINGS: The following data are determined during each run of the comparison process based on measurement by the check & operational meters and their associated instruments

1 & 9. ACTUAL VOLUME – The volume at flowing conditions for operational and check meters

2 & 10. AVERAGE TEMPERATURE – Flow weighted average temperature for operational and check meters

3 & 11. AVERAGE PRESSURE – Flow weighted average pressure for operational and check meters

4 & 12. AVERAGE DENSITY – Flow weighted average density for operational and check meters

5. & 13AVERAGE MF – This applies only to the check meter and should reflect the average MF during the comparison

6 & 14. AVERAGE GAS VELOCITY – The average gas velocity for operational and check meters

7 & 15. FLOW RATE – The gas flow rate in the operational and check meters

8 & 16. STANDARD VOLUME – The volume at reference conditions for operational and check meters

17. VOLUME DEVIATION – (Line 16 – Line 8)/Line 8 x 100%

18. DURATION OF COMPARISON – Total difference between the comparison finish and start times. The comparison of gas volumes of the operational and check meters shall start after reasonable period of lineup defined the supervisory computer to establish check meter conditions similar to the operational meter.

HISTORICAL RECORDS – The Date, Flow Rate and Deviation % of the previous 10 comparisons. The Historical Record is updated each time a comparison is completed on the basis that oldest record will be deleted.