Engineering Standard

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Royalty Metering of Hydrocarbon Liquids

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Saudi Aramco DeskTop Standards

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1 Scope

This Standard prescribes the minimum mandatory requirements governing the design, construction and installation of all new, and modifications of, Saudi Aramco pipelines or marine type metering facilities for royalty measurement of crude oil, natural gasoline (A180/A305), natural gas liquid (NGL), butane and propane services.

Royalty Measurement: A specialized form of measurement which is the basis for paying royalty to the Saudi Arabian Government.

2 Conflicts, Deviations and Responsibilities

2.1 Any conflicts between this standard and other Saudi Aramco Engineering Standards (SAES's), related Saudi Aramco Materials System Specifications (SAMSS's), Codes, Forms, and Saudi Aramco Standard Drawings (SASD's) shall be resolved by the Manager of Process & Control Systems Department, Saudi Aramco, Dhahran, Saudi Arabia.

2.2 Any deviations providing less than the minimum requirements of this standard as determined by the Technical Director, Custody Measurement Unit (CMU), Process Instrumentation Division (PID), Process & Control Systems Department (P&CSD), Dhahran, Saudi Arabia, require prior written waiver approval from the Manager of Process & Control Systems Department, Saudi Aramco, Dhahran, Saudi Arabia.

2.3 The Project Management Team (PMT) and/or the design contractor involved is fully responsible for designing a fully-operable metering system that meets the provisions of this standard as well as the operating requirements.

2.4 Provisions of this standard take precedence over any others. Any topic or details not specifically covered by this standard may be supplemented by the applicable industry codes and standards as listed under paragraph 3.0 below.

3 Applicable Codes and Standards

References

References noted below shall be the latest revision (including all revisions, addenda, and supplements) unless stated otherwise.

Additional codes, practices, standards and bibliographies shall be listed as appropriate in the individual standards and specifications.

3.1 Saudi Aramco Documents

3.1.1 Saudi Aramco Engineering Standards (SAES)

SAES-B-054	*Access, Egress and Materials Handling for Plant Facilities*
SAES-B-068	*Electrical Area Classification*
SAES-H-002	*Internal and External Coatings for Steel Pipelines and Piping*
SAES-J-002	*Technically Acceptable Instruments*
SAES-J-003	*Basic Design Criteria*
SAES-J-200	*Pressure*
SAES-J-400	*Temperature*
SAES-J-600	*Pressure Relief Devices*
SAES-J-700	*Control Valves*
SAES-J-902	*Electrical Systems for Instrumentation*
SAES-L-008	*Selection of Valves*
SAES-L-130	*Material for Low Temperature Service*
SAES-L-140	*Thermal Expansion Relief in Piping*
SAES-N-001	*Basic Criteria, Industrial Insulation*
SAES-P-103	*Direct Current and UPS Systems*
SAES-P-104	*Wiring Methods and Materials*
SAES-P-111	*Grounding*
SAES-P-123	*Lighting*

3.1.2 Saudi Aramco Materials Systems Specifications (SAMSS)

02-SAMSS-001	*Piping Components for Low Temperature Service*
04-SAMSS-001	*Gate Valves*
04-SAMSS-041	*Expanding Plug Valve*
04-SAMSS-042	*Four-way Diverter Valve*
09-SAMSS-80	*Shop-Applied Baked Internal Coatings*
17-SAMSS-503	*Severe Duty Totally Enclosed Squirrel Cage Induction Motors to 250 HP*
34-SAMSS-117	*Turbine Flow Meters*

34-SAMSS-118	*Positive Displacement Meters*
34-SAMSS-119	*Bi-directional Meter Provers*
34-SAMSS-525	*Automatic Sampling Systems for Hydrocarbon Liquids*
34-SAMSS-711	*Control Valves - General Services*
34-SAMSS-718	*Electric Motor Operated Valve Actuator*
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-913	*Instrumentation and Thermocouple Cable*

3.1.3 Saudi Aramco Engineering Procedures (SAEP), as applicable.

SAEP-21	*Royalty/Custody Metering Facilities Execution Guide*
SAEP-50	*Project Execution Requirements for Third Party Royalty/Custody Metering Systems*

3.1.4 Saudi Aramco Drawings

AB-036019	*Thermowell Assembly and Detail*
AB-036646	*Royalty Metering and Proving Station (Liquid) Schematic*
DB-950040	*Instrument Piping Details - Pressure Indicators & Switches Locally Mounted*
DB-950042	*Instrument Piping Details - Pressure Instruments*
DB-950043	*Electrical Connection for Field Mounted Instruments*

3.2 Oil Industry and Other Standards

3.2.1 Major API Manual of Petroleum Measurements Standards (MPMS)

Chapter 1	*Vocabulary*
Chapter 4	*Proving Systems*
Chapter 5	*Liquid Metering*
Chapter 6	*Metering Assemblies*

Chapter 7	*Temperature Determination*
Chapter 8	*Sampling*
Chapter 9	*Density Determination*
Chapter 10	*Sediment & Water*
Chapter 11	*Physical Properties Data*
Chapter 12	*Calculation of Petroleum Quantities*
Chapter 14.8	*Liquefied Petroleum Gas Measurement*
Chapter 21.2	*Flow Measurement Using Electronic Meters*

3.2.2 Other Standards

ANSI/NFPA 70	*National Electrical Code (NEC)*
ASME/ANSI B31.3	*Chemical Plant and Petroleum Refinery Piping*
ASME SEC. VIII	*Boiler and Pressure Vessel Code*
ASTM D1250-52	*ASTM Petroleum Measurement Tables*
NEMA ICS 6-1983	*Enclosures for Industrial Controls and Systems*
GPA TP-15-6/88	*A Simplified Vapor Pressure Correlation for Commercial NGL's*

4 Design

The following design criteria shall be followed for all royalty metering stations:

4.1 Measurement Units

4.1.1 The units of measurement to be used shall be:

Parameters	**Units**
Area	square feet (ft^2)
Density	degrees API, relative density (sp. gr.)
Flow Rate	bbl/h, BPH, barrels per hour; bbl/d, BPD, barrels per day
Level/Distance	feet (ft); inch (in)
Mass	long ton (LT), metric ton (MT)
Pressure	pounds/square inch gauge (psig), absolute (psia)
Temperature	degrees F (°F)
Time	second (s), hour (hr)
Velocity	feet per second (fps); feet per minute (fpm)
Viscosity	Centipoise (Cp)
Volume	barrel (bbl), barrels (bbls); US gallon (US gal), US gallons (US gals); cubic metre (cu. m.), M^3

Equipment used to measure a commodity shall be consistent with the designated system of units.

4.1.2 Standard (Base) Conditions

Parameters	**Units**
Base Pressure	14.696 psia (0 psig)
Base Temperature	60°F

For liquid hydrocarbons having a vapor pressure greater than atmospheric pressure at base temperature, the base pressure shall be the equilibrium vapor pressure at base temperature.

4.2 Environmental Conditions

Environmental conditions for which this apparatus is to be designed shall conform to the requirements in SAES-J-003.

4.3 Metering System

An assembly of flow measurement equipment, computers, and associated control system necessary to measure the quantity of a flowing medium.

4.3.1 General Requirements

The packaged unit concept shall be used, with a single major vendor assigned total project responsibility for assembling and testing all the system equipment including any from sub-vendors. The single vendor shall provide Saudi Aramco with the complete metering system. Sub-vendors shall be subject to the approval of Saudi Aramco to ensure quality, technical support, standardization, and availability of spare parts.

<u>Redundancy</u>

A redundant, stand-alone, computerized metering and control system, separate and independent from any process-based control system, shall be provided. It shall provide three independent means of monitoring raw flow pulses from a flow meter.

For additional details, see Appendix 2-3, Basic System Architecture

4.3.2 Design Features for Metering Systems (For additional details, refer to Std. Dwg. AB-036646 and API MPMS Chapters 5 & 6)

For onshore service, a concrete foundation shall be provided. If a concrete floor is required, it shall be properly curbed at the periphery and be sloped towards a drain connection at the low point of the drip pan.

For onshore service using an open drain header system, a common header shall be installed underneath the skid to collect leakage from all bleed, vent, drain, and relief lines. It shall be provided with a downward slope toward a common collection point.

For offshore installations using an open drain header system, a drip pan, properly positioned beneath the skid where leakage is likely to occur, shall be provided. It shall slope downward toward a drain connection at the low point of the drip pan.

For an open drain header system, each bleed, drain, vent and relief line shall discharge to a drain funnel. The tip of each discharge line should allow ample visual observation of the discharged liquid.

For a closed drain header system, a DB&B (double block & bleed) valve, or arrangement, shall be installed at each vent and drain line located downstream of the flow meter. A pressure gauge with atmospheric vent shall be installed in the bleed line of each DB&B valve.

Catch basins or manholes shall be used to connect the drain lines to gravity sewers.

For offshore service, overhead davits shall be provided for lifting valves, meters, strainer baskets, etc.

Equipment layout design shall allow convenient access for operation, maintenance, and removal of equipment. (See SAES-B-054).

Adequate area lighting shall be provided. (See SAES-P-123).

Proper grounding of electrical equipment shall be provided. (See SAES-P-111).

The distance between the meter and its prover shall be kept as short as possible while providing convenient access between the meter and prover skids.

Each walkway shall have access/egress from at least two points. Modes of egress shall be remote from each other and so arranged to minimize any possibility that more than one may be blocked of by any one fire or emergency condition.

Piping from the meter to the prover shall be provided with plugged vent and drain valves to eliminate trapped liquid, air or vapor.

Coatings for pipe shall comply with SAES-H-002.

Where there is a possibility of flow reversal through the meter, a wafer check valve shall be provided directly upstream of the strainer on each meter run.

Flanged pipe header stub(s) for additional meter run(s) shall be provided in the original design when total station capacity expansion will occur in the future.

4.4 Meters (For additional details, refer to API MPMS Chapter 5.1, General Considerations for Measurement by Meters)

4.4.1 General Requirements

Selection shall be limited to turbine meters. (For additional details, refer to 34-SAMSS-117).

Turbine meters shall be provided with two coil pick-ups with integral preamplifiers. They shall be sized to operate between 40 to 100% of their normal maximum linear flow range. (For additional details, refer to API MPMS Chapter 5.2).

The meter shall be installed in a horizontal position.

The pick-up coil enclosures shall be oriented so that the possibility of water build-up inside is eliminated.

A complete, operational spare meter run in each metering skid shall be provided.

Temperature compensation shall be of electronic design. Mechanical temperature compensators shall not be used.

Frequency or pulse multiplier/combining amplifiers shall not be used.

Provisions shall be made to eliminate meter body distortion caused by piping contraction and expansion as well as thermal expansion of the liquid by proper alignment, incorporating proper supports, pressure relieving devices, insulation, etc.

Convenient maintenance access shall be provided for servicing the meter and its accessories.

4.4.2 Design Features for Meter Installations (For additional details, refer ASME/ANSI B31.3)

Piping supports shall be provided to hold the piping in place and to facilitate removal of the meter. Such supports shall not subject the meter to excessive forces, strain, or vibration. Pipe supports and restraints shall be such as to isolate the meter and prover runs from external forces such as thermal expansion and pipe movement due to pumping upsets and sudden valve closure.

Piping design shall permit the section in which the meter is mounted to be isolated and drained with minimum or no impact to nearby instrumentation, piping or other equipment.

Properly positioned piping support shall be provided underneath the upstream meter run to avoid the effect of cantilevering forces on the turbine meter when the straightening vane service spool is removed.

Meter flange sizes and ratings shall be the same as those for the meter run piping.

Gaskets shall not obstruct the free flow of liquid in the line.

Insulation of meter runs, provers and associated piping is required on refrigerated butane and propane services only. (For details, see SAES-N-001).

4.5 Meter Provers (For additional details, refer to 34-SAMSS-119, API MPMS Chapter 4, and ASME/ANSI B31.3).

4.5.1 Type of Installation

Permanently-installed provers shall be used.

4.5.2 Types of Provers

The types of prover shall be chosen to be either:

4.5.2.1 Conventional Provers

a) Ball/sphere type, bi-directional, with single plane, U-shaped calibrated piping shall be used. (For additional details, refer to 34-SAMSS-119).

Folded provers may be used only where there is severe limitation in space (e.g., off-shore services, retrofit installation, etc.), and is subject to the concurrence of the Technical Director, Custody Measurement Unit/PID/P&CSD.

b) Piston-type, bi-directional provers may be used for refrigerated propane service. (See SAES-L-130, SAES-N-001 and 02-SAMSS-001).

4.5.2.2 Small Volume Prover (SVP) (For additional details, refer to API MPMS Chapter 4.3)

This type of prover is not acceptable for crude oil service. It may be considered for clear products, including non-refrigerated butane or propane service, subject to the concurrence of the Technical Director, Custody Measurement Unit, PID/P&CSD.

4.5.3 Pipe Prover Size/Capacity

Prover size/capacity shall be based on the maximum normal linear flow range of the largest meter to be proved.

4.5.4 Design Features for Meter (Pipe) Provers (For additional details, refer to API MPMS Chapter 4.2).

Volume - The prover volume between detector switches shall be sufficient to provide at least 10,000 meter pulses in any one-way run.

Displacer Velocity - For bi-directional prover, the displacer velocity in the calibrated section shall never be less than 0.5 ft/sec. Maximum velocity shall not exceed 5 ft/sec for provers of nominal size of 24 inch or smaller, or 6 ft/sec for provers exceeding 24 inch nominal size.

The prover shall be installed downstream of the meter(s).

The prover shall be installed as close to the meter(s) as possible.

The diameter of the piping manifold between the meter(s) and prover shall not be smaller than the outlet diameter of the largest meter to be proved.

Launching chambers shall be sized at least one nominal pipe size larger than the calibrated section of the prover.

Pre-run length - Sufficient length of run shall be provided to ensure that the diverter valve has seated and is properly sealed before the displacer actuates any of the detector switches.

Internal Coating - A baked-on phenolic coating with a hard, smooth, and lasting finish shall be applied on the calibrated section of the prover. (Refer to 09-SAMSS-080).

Connections for Prover Calibration - Three 3-inch pipe flange connections shall be provided, one on each side of the diverter valve, and one on the upstream side of the DB&B prover take-off valve in the meter run nearest to the prover to facilitate calibration by the waterdraw or master meter method.

Adjacent flanges in the calibrated section of a bi-directional prover shall be match-bored and doweled and shall be die-stamped with unique identifiers. Flange O-ring material shall be compatible with the liquid to be measured.

Long radius elbows shall be used for all bends located between the detector switches.

The calibrated section of the prover shall be free of any obstruction such as valve and instrument connections.

Flanges shall be provided to permit disassembly and inspection of the calibrated section without disturbing the adjoining piping.

The prover shall be provided with at least one quick-opening closure for sphere inspection and servicing.

Non-adjustable sphere detector switches shall be provided.

Vent Valves - shall be provided at the highest point on the prover launchers to vent any trapped gas.

Drain Valves - shall be provided to drain the liquid in the prover during servicing.

4.6 Automatic Sampling Systems (For Crude Oil Service Only; refer to 34-SAMSS-525).

In compliance with the single responsibility approach specified in item 4.3.1 above, the main metering system contractor shall coordinate and/or be responsible for supplying a fully-operational and acceptable automatic oil sampling system for a given project. This applies whether the sampling system equipment is supplied or manufactured by the main contractor or a sub-vendor.

4.6.1 General Requirements (For additional details, refer to API MPMS Chapter 8.2)

A complete, operational, pre-packaged, skid-mounted sampling system is required.

The sampler probe shall be situated as close as possible to the final point of delivery.

A flow-proportional sampler with provision for time-proportioning as a back-up shall be used. In addition, it shall have an external digital trigger which can be used to force sampling from an external control system.

A static or power mixer shall be installed ahead of the sample probe to ensure collection of a representative sample of the main stream flow.

Final acceptance of the sampling system for official use shall be subject to passing the field water injection test per API MPMS Chapter 8.2 and formal MINPET approval.

4.6.2 Sample Receptacles

Two properly-sized, stainless steel sample receptacles shall be provided. Each shall have a quick-opening lid and O-ring seal to provide tight shutoff feature to prevent the light ends from escaping.

Each sample receptacle shall have provisions for over-pressure/vacuum protection, pressure indication, level indication, and high level alarm connection.

To facilitate draining, a single draw-off connection at the bottom of each receptacle shall be provided.

4.6.3 Collected Sample Mixing System

Fixed receptacles shall be equipped with an independent mixing circulation loop consisting of an electric motor-driven recirculation pump, static mixer and provisions for transferring sample from the mixing loop to the prescribed laboratory glassware and/or other sample containers.

Removable containers shall be provided with a mixer assembly which has the same features as the permanent circulation loop.

The system shall be designed to preclude the possibility of excessive mixing by use of an adjustable timer to automatically stop the mixing pump after a pre-set period of mixing time.

4.6.4 Piping

The lengths of piping, tubing, and hoses shall be kept to a minimum.

Low points or dead legs (where sediment and water can collect) shall be eliminated.

All piping installations up to ¾ inch size shall use 316 SS tubing and fittings.

Sample draw-off shall be located immediately downstream of the static mixer in the circulation piping. It shall be connected to a ¼-inch tube with quick-opening valve for collecting sample into a centrifuge tube.

4.6.5 Structural

The complete sampling system shall be skid-mounted and housed in a rigid, self-supporting enclosure, ready for direct mounting on a previously prepared field foundation. Segmented or multiple skid mounting is acceptable.

Lifting lugs shall be provided for handling the skid.

4.7 Instrumentation (For additional details, refer to the SAES-J series standards in paragraph 3.1.1, and 34-SAMSS-820, 821, 831 & 913).

4.7.1 General Requirements

Manufacturer's prescribed procedures for installing the instruments shall be followed.

Instruments shall be of the solid state, electronic type and meet the requirements of SAES-J-002 and SAES-J-003.

Equipment shall be suitable for the supply voltage shown in Table 1, SAES-J-902, Electrical System for Instrumentation.

Instruments shall not be adversely affected by any sources of electromagnetic interference thus ensuring the integrity of their readings.

Enclosures for use in hazardous (classified) locations shall meet the certification requirements of SAES-P-100.

Convenient and ample access for operation and maintenance purposes shall be provided.

4.7.2 Field-Mounted Instruments

Electronic components shall be suitable for operation under the environmental conditions described in SAES-J-003.

Instruments that absolutely rely upon or require a sunshade to meet the environmental requirements of SAES-J-003 for successful operation may be used, but only if the sunshade is permanent in nature, where there is no possibility for the sunshade to be removed during maintenance then inadvertently cast aside afterwards.

Instrument components shall be of materials that are compatible with the liquid being handled as well as with the environmental air pollutants present where the instruments are installed.

4.7.3 Design Details (For additional information, refer to Std. Dwg. AB-036019 and Lib. Dwgs. DB-950040, DB-950042, DB-950043, and DB-950044).

Temperature Instruments - Electronic smart-type temperature transmitters shall be provided, with an accuracy of ± 0.2% of span or better. (Refer to SAES-J-400 for additional details). However, where a suitable flow computer (FC) is involved and distance permits, RTD's may be directly wired to the FC's.

Static Pressure Transmitter - Electronic smart-type pressure transmitters shall be provided. They shall have a combined accuracy of ± 0.25% of span or better. Wetted parts shall be suitable for the liquid to be handled and shall have adequate overrange protection. Piping installation shall incorporate vent/drain/test features. (Refer to SAES-J-200 for details)

Insertion-type Flow Meter - If desired, this type of meter may independently be used to drive the automatic sampling system. It shall have a rangeability of at least 10 to 1, and an accuracy of better than ± 1.0%. The meter shall be removable from an active line through a properly-sized flanged valve.

Pressure Gauge - shall have an accuracy of ± 0.5% of span or better. Its range shall be selected so that the maximum operating pressure does not exceed 75% of the full scale range. Piping installations shall incorporate vent/drain/test features.

Piston or Diaphragm-type Differential Pressure Indicating Switch - shall have an accuracy of ± 2.0% of full scale range or better. A plain differential pressure gauge, without its own integral switch, is not an acceptable substitute and shall not be used.

Thermometers - For checking purposes, mercury-in-glass thermometers accurate to within ± 0.5°F or better shall be used.

Thermowells - shall be made of stainless steel, with 1-inch NPT connections, and provided with a chained plug. (See Standard Drawing AB-036019 for details).

4.7.4 Control Room Instruments

Instruments shall be installed in an environmentally-controlled building or enclosure.

Instruments shall be capable of operation during extended periods of air-conditioning equipment failure. Instruments shall function in an ambient temperature of 50°C (122°F) maximum.

4.8 Control System

The metering control system shall be arranged in functional blocks consisting mainly of flow computers (FC's), man-machine interfaces (MMI's), logic controllers (LC's and others) and system printers.

The system design is such that it shall permit easy addition of future flow meters, flow computers, logic controller input/output cards, etc.

The system shall be composed to the maximum extent possible of standard hardware, systems software, and firmware that can be configured to meet the stated requirements.

All software, exclusive of application software, shall be most recent, field-proven revision that is applicable to the system hardware at the time of the hardware freeze date, as defined in the contract or purchase order.

The system shall allow for upgrading of system operating software on all redundant modules of the system and without the necessity of shutting down the process and without losing the operator interface.

4.8.1 Basic System Architecture

Appendix 2-3, Basic System Architecture, describes the basic arrangement that meets the requirements of this standard for redundancy and measurement data security.

4.8.2 Design Details

The following terms are defined as follows:

Redundant - Two identical devices which operate in an interchangeable primary/secondary arrangement in which the functions of the designated primary device are duplicated in the secondary and are automatically transferred to the secondary if the primary fails.

Dual - Two devices which perform the same functions independently of each other.

4.8.2.1 Flow Computers (FC's)

All flow computers, auxiliary counters, indicating lights, etc., shall be panel-mounted. (For additional information, refer to 34-SAMSS-820 and 34-SAMSS-821).

At a minimum, flow computers shall provide the following functions or features:

a) Scanning all inputs, compute all correction factors, and perform all output control functions within one second.

b) Scanning and calculating a running flow-weighted average of the temperature (from 3 or 4 wire RTD's or temperature transmitters) and pressure readings that are needed for gross and net delivery volume calculations.

c) Displaying an 8-digit meter reading and batch volume totals in whole barrels in front of the panel.

d) The capability of readily modifying setpoints or other non-protected operating data.

e) Retaining the totalized, non-resettable meter reading for each flow meter in an internal register which can be read on the front panel and remotely by the MMI's via the communications link

f) Gross volume comparisons between the primary and secondary flow pulse signals. For each scan, each flow computer shall make calculations of its corresponding flow rate, interpolate the meter factor from the base curve, then calculate the scan and accumulated gross delivered volume. A running comparison of the respective gross deliveries shall be made by two independent computers, activating an alarm when a percent difference of 0.10% between them is detected.

g) Re-calculation of batch delivery totals based on manually-inputted composite API gravity or relative density (specific gravity) and Sediment & Water (S&W) values.

h) Re-calculation of batch delivery totals based on accepted new meter factor.

i) Control of 4 way-diverter valve, flow control of meter run and prover flow control valve (FCV's) using proportional and integral (PI) control with automatic bumpless transfer between automatic and manual modes.

j) At a minimum, a Level "C" Pulse Security System shall be provided. The secondary (B) pulse signal shall be used automatically as the main source of flow signal upon failure of the primary (A) pulse signal, which shall be alarmed. (Refer to API MPMS Chapter 5.5, Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems).

k) Set a 5-digit (minimum) nominal K-factor which will scale the input pulses from the flow meters so that each count in the flow meter is equal to the desired unit of measurement.

l) Retention of a base meter curve and historical meter factors for each meter in accordance with the requirements of Appendices 1-1, 1-2, & 1-3.

m) Providing the following information for Man-Machine Interface (MMI) computer functions via redundant digital communications channels:

1) One proving report for each meter, per Appendix 1-1.

2) One batch measurement ticket for each meter, per Appendix 1-4.

3) Dynamic temperature, pressure and flow rate readings

4) Providing up to 50 configuration and alarm point changes (e.g., flow computer system alarms & status, transmitter out of range alarms, etc.).

n) Accepting supervisory commands pertaining to meter proving and normal operation from the MMI's via redundant digital communications channels.

o) The flow computers shall be capable of digitally setting the "Zero & Span" input values from the field microprocessor-based smart transmitters. This provides complete loop calibration rather than requiring individual instrument and analog/digital (a/d) card calibration.

p) In the event of failure of the metering skid primary outlet header temperature instrument, all of its functions shall be taken over by the secondary (backup) inlet header temperature instrument.

4.8.2.2 Man-Machine Interfaces (MMI's)

Dual MMI's through multi-tasking operating softwares (e.g., QNX, NT, or VMS) shall be provided, consisting of video displays and accessories, operator control selections, report printing, trending and alarm capabilities. They shall have no direct interface with field devices.

At a minimum, redundant MMI's shall provide the following functions or features:

a) Be capable of reading and collecting all metering and process data and valve status from the flow computers and the Logic Controllers (LC), (e.g., PLC's or others), as applicable, via the serial communication links at individual user configurable scan intervals from 5-30 seconds.

b) Each MMI shall have two serial communication ports capable of MODBUS RTU protocol for connection of the MMI to FC's and LC's. The MMI shall be the master on its communications link.

c) The communications drivers of each MMI shall be capable of reading and writing floating point numbers. Single and double precision floating-point values shall conform to the IEEE floating-decimals.

d) Overall system control

1. Source, meter run and destination loading line-up.
2. Inhibit loading operation due to improper or unacceptable line-up.
3. Sending flow rate set points to the flow computers.
4. Automatic selection of flow meters and flow balancing between active meter runs based on total station flow rate.

e) Start or Stop batches

f) The proving system (excluding recirculation system) shall be designed so that a meter can be proved without disrupting normal plant or loading operations.

g) The MMI's shall automatically initiate all the valve sequencing operations and associated activities after a meter is selected for proving by the operator. However, the operator shall retain the capability to operate individual valves where required.

h) An interlock circuit to prevent the operation of the prover diverter valve when the following conditions exist:

1) When any of the block valves belonging to a meter run about to undergo a proof are not properly positioned.

2) When any of the block valves belonging to a meter run that is not to undergo a proof are not completely closed.

3) When the flow rate passing through the meter being proved exceeds its normal maximum linear flow rate.

i) Incorporate a configuration editor for defining and changing all display and display information with a retention time of at least 2 weeks.

j) Redundant, configurable color video displays with accessories (e.g., keyboards, mice, trackball, or other pointing device, etc.) shall provide the required graphics for display of the meter runs, automatic sampling system and, when required, additional process piping and valves. The system flow rate temperatures, pressures and other relevant process parameters shall be displayed in a P&ID-type graphical format or other easily understood format that is acceptable to Operations.

k) Calculate the percentage difference between the running gross standard batch total volumes determined by each primary and associated backup flow computer for each flow meter, then set off an alarm anytime the percentage difference between each other exceeds a configurable, maximum allowable limit of 0.1%.

l) Communications with other systems.

m) Trending capability shall be provided for pressure, temperature, and flow rate readings for a period of 7 days, with a resolution of 1 minute per meter.

n) One MMI shall be designated to generate the following reports from data available across the serial link:

1) Active Alarm Summary

2) Meter Calibration Curve

3) Hourly Summary

4) Meter Proving, per Appendices 1-1, 1-2, & 1-3.

5) Measurement Ticket, per Appendices 1-4, & 1-5,

6) Batch Summary Report, per Appendices 1-6 & 1-7.

4.8.2.3 Logic Controllers (LC's) (Where a PLC is used, refer to 34-SAMSS-830)

At a minimum, redundant LC's shall provide the following functions or features:

a) Data monitoring and scaling of the secondary (B) flow pulse signals from all flow meters.

b) Operation of all the meter system's electric MOV's.

c) Various functions pertaining to interlocks, line-up logic, valve sequencing control, and monitoring alarm points.

d) Continuously perform self-diagnostics and set off an alarm if it fails.

e) Data retention time of at least two weeks through sufficient battery backup.

f) Redundant I/O and devices that execute control logic and interlocks.

4.8.2.4 System Printers and Printing Functions

A set of redundant printers (laser-type for metering reports and dot-matrix type for alarms) shall be provided. Printouts shall be obtained:

a) On demand, via a manual push-button.

b) Automatically, at fixed intervals, as controlled by a digital system time clock.

c) After each proving, whether successful or not.

d) On each completed delivery.

e) If used with individual ticket printers, digital system time clock shall be accurate and independent of the main power supply frequency. Where a system has multiple clocks, one must be designated as the system master and all others shall be synchronized against it. It shall provide the following:

1) Accurate, Gregorian calendar-based time of day, day of the month, month and year, for visual readout and time of printout for the ticket printer.

2) Provisions for time setting or correction.

4.8.2.5 Alarms

At a minimum, alarms shall be activated at the occurrence of the following:

a) Flow pulse signal failure.

b) Primary & secondary flow pulse signal mismatch.

c) primary power supply failure.

d) high/low flow rates.

e) high strainer differential pressure.

f) four-way diverter valve seal leakage.

g) actuation of first detector switch before the diverter valve is seated, which also automatically aborts a proof.

h) exceeding pre-arranged limits of historical records.

i) when the difference between the meter skid inlet and outlet header temperature readings exceed 2°F.

j) watchdog timer time-out.

k) memory error (RAM or ROM).

l) program errors.

m) input/output (I/O) errors.

4.8.2.6 Instrument Control Panels (For additional details, refer to 34-SAMSS-820 and 821).

Control panel shall accommodate all the panel-mounted instruments and accessories listed above. Extra space for future meter run equipment and accessories shall be considered.

4.8.2.7 Signal Transmission (Refer also to API MPMS Chapter 5.4) - shall be designed to protect the integrity of instrument signals from electrical noise caused by electromagnetic interference. The necessary features shall be incorporated to render the installed system immune to interference from operation of standard commercial UHF and VHF hand-held personal radio equipment held within 3 feet of fully open cabinet doors. The following basic precautions shall be taken in transmission system design:

a) Shielded, twisted pair of signal cables shall be used. (For details, refer to 34-SAMSS-820 and 34-SAMSS-913).

b) The cable shield shall be grounded at the readout end only, to prevent ground loop effects. The grounding of parallel readout devices and other panel-mounted instruments shall follow the manufacturer's recommendations and be grounded at one common point.

c) Conduits for transmission cables shall be made of rigid galvanized steel to provide shielding against unwanted electromagnetic radiation, and shall be grounded.

d) Control, measurement and power cables shall not be run in the same conduit or raceway.

4.8.2.8 Communication

Dual communication links shall be provided between the flow computers and the MMI's with either link selectable at each MMI. A similar arrangement of dual communication links shall be provided between the pair of LC's and the MMI's. Where a master/slave protocol is used, the MMI's shall be masters, while FC's and LC's shall be slaves on their respective communication ports.

All communication links in the system shall support error correction and multiple retries.

Single and double precision floating-point values shall conform to the IEEE floating-point formats.

It shall not be possible to modify any flow computer-generated ticket or proving data (e.g., volumes, meter factors, average process data, etc.) through any of the communication links.

As a minimum, flow computers shall:

a) support peer-to-peer (master/slave) communication with other flow computers. Non-process data shall be passed from primary to secondary through this link.

b) have two serial ports capable of MODBUS RTU protocol. The flow computer shall be slave on each port.

c) have an RS-232 port which is suitable for uploading and downloading its entire operating configuration using a portable computer or local programming terminal.

d) accept the download of information from the MMI.

e) be capable of accepting input of floating point, digital and alphanumeric data to its memory via the front panel or via the RS-232 communications link.

4.8.2.9 Data Security

Normal access to metering data that are critical to the integrity of the metering results shall be protected by a combination of password, keylock and MINPET (Ministry of Petroleum and Mineral Resources) wire sealing arrangement.

Normal access to operational and other non-critical metering data shall be protected by a password and keylock arrangement.

Local and remotely-initiated changes to the flow computer configuration shall be logged internally.

Each flow computer's program, data memory and time clock shall have battery backup with minimum retention time of two weeks.

4.8.2.10 Diagnostics and Testing

Each flow computer shall allow the manual input of data (e.g., pressure, temperature, density) in a test mode for verification of calculated correction factors.

4.9 Electrical (For additional details, refer to SAES-B-068, SAES-J-003, SAES-P-103, 104, 111 & 123, and 34-SAMSS-718).

4.9.1 General Requirements

Electrical supplies shall comply with SAES-J-902.

Electrical portions of the metering system shall meet the requirements of SAES-J-902, Saudi Aramco electrical standards (see SAES-P-100) and NFPA 70 (NEC). In case of conflicts, the order of preference for these standards is as listed.

4.9.2 Equipment and Accessories

Terminal/junction boxes on skid-mounted or packaged units shall be mounted at an accessible location on the edge of the skid.

Separate and independent junction boxes shall be provided for analog, digital and MOV control signals.

Conduit connections shall be bottom entry only.

High barrier terminal blocks with solid cap screw-type terminals shall be provided.

Terminal identifications shall be made by heat-shrinkable, permanently marked, slip-on type wire markers, which must carry "To/From" information.

Terminals shall be tagged to correspond to their associated connection diagrams.

Terminal blocks and cables shall be provided with 20% spares.

Spare conduit holes shall be plugged and epoxy-coated.

Electric motors for hydraulic and/or sampling applications shall comply with the provisions of 17-SAMSS-503, Severe Duty Totally Enclosed Squirrel Cage Induction Motors to 250 HP.

All equipment and accessory housings shall comply with applicable NEC requirements and be a minimum of NEMA Type 4X.

Pushbuttons and manual stations installed in corrosive atmospheres shall have operator shaft assemblies made of corrosion resistant materials to prevent the shaft from binding. Mounting accessories such as screws and hinges shall be stainless steel.

4.9.3 Redundant Uninterruptible Power Supplies (UPS) - (For additional details, refer to SAES-P-103)

Redundant UPS with a minimum 2-hour battery capacity shall be provided for the metering and control system to avoid affecting the metering results during periods of power failures. A failure of a single UPS shall not cause the metering system to stop reading process data and computing volumes. Field instruments (pressure, temperature, and pulse preamplifiers) required for accurate flow measurement shall be powered from the control system and/or UPS.

"No-break" transfer switching between the main A.C. supply and inverter output shall be installed to avoid instrument shutdown due to inverter failure.

4.10 Valves (Refer to SAES-L-008, 34-SAMSS-711, 04-SAMSS-001, 041, and 042)

4.10.1 General Requirements

Flow limiting valves or restriction orifices, if required, shall be installed downstream of the meter. They shall be selected or adjusted to maintain sufficient pressure to prevent vaporization or flashing of the pipeline liquid.

4.10.2 Control Valves

General requirements for control valves are covered in SAES-J-700.

Control valves and their controllers for meter run and prover services shall be able to:

a) Maintain the minimum back pressure required downstream of the meters to prevent flashing;

b) Balance the pressure drops in multiple meter systems when one of the meters is switched to the prover;

c) Control the flow rate through a meter during blending operations;

d) Control loading rates through a meter during normal operation by compensating for changes in system pressure;

e) Overcome the full pumping head of the system during closing or opening.

f) For controlling intermittent flow, valves shall be of the fast acting, shock-free type to avoid damaging the metering equipment and/or impacting accuracy of measurements.

g) Flow control valves shall be provided with position indicators.

4.10.3 Block Valves

A double block and bleed plug valve per 04-SAMSS-041 shall be used where valve leakage can affect the integrity of metering or proving (e.g., meter run outlet isolation valves, prover take-off valves). It shall be provided with a thermal relief valve discharging back to its upstream side, to the drain system, or manual bleed system.

4.10.4 Manually-operated Valves

Applications for this valve type, as specified in 04-SAMSS-001, shall:

a) generally be limited to 4" and smaller sizes only or where effort on the part of the field operator shall not be excessive and rapid closing or opening is not mandatory;

b) be provided with a vertical hand wheel when the size of the valve prevents convenient operation of a horizontal handwheel.

4.10.5 Motor-operated Valves (MOV) (For additional details, refer to 34-SAMSS-718)

Requirements for this valve type are that they shall:

a) Be capable of rapid and smooth closing and opening throughout the travel range;

b) Incorporate emergency manual operation capability for use in the event of power outage, actuator failure, or maintenance;

c) Have each gate valve be provided with a stainless steel valve position indicating rod.

4.10.6 Four-way Diverter Valves

Diverter valves as specified in 04-SAMSS-042 shall provide a positive, bubble tight shutoff during proving and shall incorporate the following:

a) Either an indicating pressure differential switch or differential pressure switch with separate local pressure gauges and alarm for monitoring valve sealing during proving;

b) A thermal relief valve discharging to the drain, manual bleed system, or to the upstream side of the 4-way valve.

4.10.7 Thermal Relief Valves (For additional details, refer to SAES-J-600 and SAES-L-140)

Thermal relief valves shall be used for the control of thermal expansion of the liquid in the prover and meter runs while they are completely isolated from the main stream. They shall not discharge directly to the atmosphere but through a properly-sized discharge line to an oily water sewer or blowdown system.

They shall be installed between the strainer and the upstream side of the flow conditioning device on each meter run and between the downstream side of the 4-way diverter valve and prover return valve.

4.11 Fluid Conditioning Devices (For additional details, refer to API MPMS Chapter 5.3)

4.11.1 General Requirements

Common guidelines that apply to all fluid conditioning devices (e.g., strainers, straightening elements) are:

a) They shall comply with the pressure/temperature rating of the pipeline;

b) All process wetted materials shall be compatible with the liquid being handled;

c) They shall be located so as to provide convenient access for ease of inspection, removal, and maintenance;

d) No bypass valves or lines around these devices shall be allowed;

4.11.2 Design Details

4.11.2.1 Strainers (For additional details, refer to API MPMS Chapter 5.4)

Strainers shall meet the following requirements:

a) They shall be used in all meter runs regardless of the type and condition of the liquid being metered to protect the meters against intrusion of foreign materials.

b) They shall be sized at least one size larger than the meter size and be installed upstream of the straightening vane.

c) They shall be supplied with a stainless steel element of a mesh size that will not cause an unacceptable pressure drop to the system while providing adequate protection to the meter.

d) They shall be supplied with vent, drain, upstream and downstream differential pressure connections.

e) They shall be provided with a differential pressure indicator switch or a differential pressure switch with separate pressure gauges.

f) They shall be provided with a quick-opening lid for ease of servicing.

4.11.2.2 Straightening Elements (For additional details, refer to API MPMS Chapter 5.3).

Straightening vanes shall be installed to eliminate liquid swirls and crosscurrents set up by pipe fittings and valves preceding turbine meters.

The two types that shall be used are:

a) Flange-type, for:

  1. use in a 3-section meter tube;
  2. pipe sizes below 20-inch.

b) Line-type, for:

  1. use in a 2-section meter tube;
  2. pipe sizes 20-inch and above.

  Straightening vane installations require the following:

  a) They shall be aligned parallel to the pipe axis;

  b) Gaskets shall be internally aligned and shall not protrude inside the pipe;

  c) There shall be no other intervening devices (e.g., thermowells, temperature & pressure instruments, drains, vents, etc.) between the straightening element and meter.

d) They shall be fastened securely in place to prevent their being dislodged toward the meter.

5 Metering, Proving and Automatic Sampling Equipment Lay-Out

The basic piping and installation shall be in accordance with Standard Drawing AB-036646, Royalty Metering and Proving Station (Liquid) Schematic.

6 Report Formats

6.1 Meter Proving Report

The minimum requirements and format for the meter proving report shall comply with Meter Proving Report as shown in Appendix 1-1. An explanation of each of the specific items required in the meter proving report is presented in Appendix 1-2.

Each step in the meter factor calculation is discussed per the specified API MPMS Chapter.

6.2 Meter Factor Control Procedure

Meter factor control procedure defines how the historical data are corrected to base conditions. The tolerances are defined and an explanation of procedures and events are given if the deviations are outside of the limits. The specific meter factor control procedures shall, as a minimum, conform to Appendix 1-3.

6.3 Measurement Ticket

The minimum requirements and formats for the measurement tickets shall comply with Measurement Ticket as shown in Appendix 1-4. An explanation of each of the specific items specified in the measurement ticket is also presented in Appendix 1-5.

A measurement ticket shall be generated for each meter used for each cargo or delivery.

A single summary batch report showing the total volumes handled by the metering skid as well as each meter used in the batch shall be provided (See Appendix 1-6).

7 Testing and Inspection

(For additional details, refer to SAEP-21 and SAEP-50, as applicable).

The complete metering system shall undergo a Functional Acceptance Test (FAT) in the Vendor's shop using simulators to demonstrate the performance and reliability of the complete system as well as the performance and reliability of the individual components. This includes simulation tests of all field and control equipment as well as data processing, calculations and control.

FAT plan shall be submitted at least 60 days prior to the scheduled start of the testing. The plan shall include a detailed schedule for the FAT; a description of each phase of the FAT; an outline of the FAT procedure; and the criterion for acceptance of each FAT activity. After approval of the FAT plan, the FAT procedure shall be prepared and approved at least 30 days prior to the scheduled start of the FAT.

After successful completion of the FAT, transport, installation and pre-commissioning of the system, a Site Acceptance Test (SAT) will be conducted. The SAT procedure shall be submitted 60 days prior to the beginning of the test. The SAT will consist basically of a repeat of the FAT, but conducted under actual operating conditions using the process fluid. Prior to the actual beginning of the SAT, a waterdraw calibration of the proved shall be completed.

Whenever feasible, control room cables connecting the control panel and marshaling cabinets in the control room and used during the overall functional and operational tests should also be the ones that will be permanently installed in the field. The cables shall be:

a) of single, continuous lengths sufficient to cover the actual distance between the control panel and marshaling cabinets located in the control building;

b) carefully wound on shipping spools, properly protected from weather and mechanical damage, and tagged before shipment to the field.

Flow meters shall be calibrated per the manufacturer's standard calibration procedure.

Automatic sampling system for crude oil shall meet the field test requirements as specified in API MPMS Chapter 8.2.

The volumes of the meter provers shall be certified using either the waterdraw or master meter method at the vendor shop and in the field, prior to its commissioning.

All necessary repairs, replacements and modifications to the system's hardware, reports and software programs, etc., shall be completed at the vendor shop before shipment to the field.

FAT's shall be witnessed and approved by Saudi Aramco representatives.

8 Documentation

The vendor responsible for the whole metering system shall coordinate timely supply of all the necessary engineering drawings and specifications; completed and signed off QA/QC (quality assurance/quality control) documents; FAT and SAT plans and procedures; installation instructions; operating & maintenance manuals, special tools and equipment, etc., pertaining to the project.

A certificate of calibration shall be provided for each flow meter and prover.

9 Nomenclature

Different terms used in all the appendices listed under section 10.0 are described below:

AMF	Average meter factor.
AVGMF	Average meter factor for PERIOD 1.
BATCH	Terminal Operation: A complete ship loading of commodities from a terminal. Pipeline Operation: Delivery of commodities based on a 24-hour period.
BMFCP	Base meter factor for current proving at base flow rate.
BMFPP	Base meter factor for previous proving at base flow rate.
BPV	Base prover volume
CCF	Combined correction factor for prover (CCFp), or meter (CCFm).
CF	Conversion factor from US barrels at 60°F and 0 psig to cubic meters at 15°C.
CPL	Correction factor for the effect of pressure on density of liquid in prover (CPLp), or meter (CPLm).
CSW	Fiscal correction factor for sediment & water.
CTL	Correction factor for the effect of temperature on the density of liquid in the prover (CTLp), or meter (CTLm).
DV	Indicated volume from this calculation cycle only.
F	Compressibility factor of liquid in meter (Fm) or prover (Fp).
FGV	Factored gross volume
FGVx	Factored gross volume at any time "x".
FR	Average flow rate, delivered volume divided by the actual time (excluding idle time) involved.
FRUADJ	Unadjusted flow rate.
GSV	Gross standard volume
GSVp	Gross Standard Volume for proving operations.
GV	Gross volume for any scan.
ISVm	Indicated Standard Volume of Meter.
IV	Indicated volume.
IVm	Indicated Volume of Meter.

LT	Long tons.
MFCL	Meter factor for current loading.
MFCL1, 2	Meter factor at current loading for Period 1 or 2 (adjusted for flow rate).
MFCLB	Meter factor at current unadjusted loading flow rate, interpolated from base curve.
MFCP	Meter factor at current proving, at proving condition.
MFCPB	Meter factor at current proving rate, interpolated from base curve.
MFPP	Meter factor from previous proving, at proving conditions.
MFPPB	Meter factor from previous proving from base calibration curve, at base flow rate.
MINPET	Saudi Ministry of Petroleum and Mineral Resources
MRc	Meter closing reading.
MRo	Meter opening reading.
MT	Metric tons
NKF	Nominal K Factor, in pulses/barrel - Stamped on the meter's nameplate as established by the meter manufacturer in the test laboratory. When used as the system factor (SF) or scaling factor (divisor/multiplier, as the case may be), it generates a meter factor equal to or closest to unity (1.0000).
NSV	Net standard volume delivered at standard conditions (60°F and 0 psig), excluding S&W.
Pc	Current value of pressure, psig.
PERIOD1	Time of accumulation of flow pulses, from start of batch to time X1.
PERIOD2	Time of accumulation of flow pulses, from X1 to end of batch at X2.
PULSES	The flow pulses received by the computer and accumulated in a counter for each scan period.
PWAc	Current flow-weighted average pressure
PWAp	Flow-weighted average pressure from previous calculation cycle.
RD	Relative Density
RHOb	Base density at 60°F
SF	System factor (See Nominal K Factor)
TCFGV1	Total corrected factored gross volume for PERIOD 1
TCL	Temperature of the meter at current loading.
TCP	Temperature of the meter at current proving.
TFGV	Total Factored gross volume for a batch.
TFGV1, 2	Total factored gross volume for PERIOD 1, or 2.
TGV	Sum of total gross volume at total time "X2".
TGVx	Total gross volume at any time "X".
TPP	Temperature of the meter at previous proving.
UV	Total indicated volume from previous calculation cycle.
x	Any time, where factored gross volume is determined.
X1	Time when a new meter factor is accepted for current delivery (end of PERIOD1).

X2	Time of completion of batch (end of PERIOD 2).
Xs	Scan period (in seconds) of flow computer. (Should be less than 60 seconds).
Yc	Current value of temperature, °F
YWAc	Current flow-weighted average temperature

10 Appendices

The following Appendices are part of this Standard and as such the requirements presented therein are also Mandatory Engineering Requirements.

Any deviation from the report formats shall require prior written approval from the Technical Director, Custody Measurement Unit, Process Instrumentation Division, Process & Control Systems Department.

10.1 Crude Oil, Natural Gasoline (A180/A305), Natural Gas Liquid (NGL), Butane and Propane Services

Appendix 1-1	*Meter Proving Report Format*
Appendix 1-2	*General Information Concerning Meter Proving Reports*
Appendix 1-3	*Meter Factor Control Procedure*
Appendix 1-4	*Measurement Ticket Format*
Appendix 1-5	*General Information Concerning Measurement Tickets*
Appendix 1-6	*Batch Summary Report Format (Common to all Services)*
Appendix 1-7	*General Information Concerning Batch Summary Reports*

10.2 Miscellaneous

Appendix 2-1	*Rounding Convention and Discrimination Levels*
Appendix 2-2	*Principal Correction Factors*
Appendix 2-3	*Basic System Architecture*

Revision Summary

29 December 2004 Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with editorial changes.

Appendix 1-1

METER PROVING REPORT FORMAT FOR ROYALTY MEASUREMENT OF CRUDE OIL, NATURAL GASOLINE (A180/A305), NATURAL GAS LIQUID (NGL), BUTANE & PROPANE SERVICES

==

SAUDI ARABIAN OIL COMPANY (Saudi Aramco)
METER PROVING REPORT

( ) OFFICIAL ( ) UNOFFICIAL ( ) ABORTED

LOCATION: AAAAAAAAAAAAAAAAAAAAA DATE/TIME: MM/DD/YY/HH:MM
LIQUID: AAAAAAAAAAAA API/RD @ 60°F: XX.X/X.XXXX

METER DATA		PROVER DATA	
TAG NO.	AAAAAA-XXXXXX	TAG NO.:	AAAAAA-XXXXXX
MANUFACTURER::	AAAAAAAAAAAAA	MANUFACTURER	AAAAAAAAAAAAA
TYPE	AAAAAAA	TYPE/MODEL NO.:	AAAAAAA/XXXXX
MODEL NO.:	XXXXXXX	SERIAL NO.:	XXXXXXXXXXXXX
SERIAL NO.:	XXXXXXXXXXXXX	OD/WT (in):	XXX.XXX/X.XXX
SIZE(in):	XX	COEF. CU. EXP. Gc)	0.0000XXX/°F
NOM. K FACTOR (NKF)	XXXX.XXX (p/bbl)	MOD. OF ELAST. (Em)	XX,XXX,XXX psi

RUN	L-R	R-L	TOTAL		PRESS (psig)		* TEMP(°F)		TMF
NO.	PULSES	PULSES	PULSES	SECS	PROVER	METER	PROVER	METER	
1	XXXXX	XXXXX	XXXXX	XXX.X	XXX	XXX	XXX.X	XXX.X	X.XXXX
2	XXXXX	XXXXX	XXXXX	XXX.X	XXX	XXX	XXX.X	XXX.X	X.XXXX
3	XXXXX	XXXXX	XXXXX	XXX.X	XXX	XXX	XXX.X	XXX.X	X.XXXX
4-10	XXXXX	XXXXX	XXXXX	XXX.X	XXX	XXX	XXX.X	XXX.X	X.XXXX
AVG. OF LAST 4 RUNS			XXXXX	XXX.X	XXX	XXX	XXX.X	XXX.X	X.XXXX

REPEATABILITY: (TMFmax - TMFmin) x 100 / TMFavg ≤ 0.05%

METER FACTOR CALCULATION		
A. BASE PROVER VOLUME AT 60°F & 0 psig	(BPV)	5 DIGITS (bbls)
B. TEMP. CORR. FACTOR FOR STEEL OF PROVER	(CTSp)	X.XXXXX
C. PRESS. CORR. FACTOR FOR STEEL OF PROVER	(CPSp)	X.XXXXX
D. TEMP. CORR. FACTOR FOR LIQUID IN PROVER	(CTLp)	X.XXXX
E. PRESS. CORR. FACTOR FOR LIQUID IN PROVER	(CPLp)	X.XXXXX
F. COMBINED. CORR. F. PROVER (B * C * D * E)	(CCFp)	X.XXXXX
G. GROSS STD. VOL. OF PROVER (GSVp), (A * F)		5 DIGITS (bbls)
H. INDICATED VOL. OF METER (IVm),(AVG. TTL. P/NKF)		5 DIGITS (bbls)
I. TEMP. CORR. FACTOR FOR LIQUID IN METER	(CTLm)	X.XXXX
J. PRESS. CORR. FACTOR FOR LIQUID IN METER	(CPLm)	X.XXXXX
K. COMBINED CORR. FACTOR FOR METER (I * J)	(CCFm)	X.XXXXX
L. INDICATED STD.VOL. OF METER (ISVm) (H x K)		5 DIGITS (bbls)
M. AVG. METER FLOW RATE (A * B * C * 3600/AVG TIME)		XXXXX (BPH)
N. METER FACTOR @ PROV. FLOW RATE. (G/L)		X.XXXX
O. METER FACTOR @ BASE FLOW RATE OF XXXXX BPH		X.XXXX

EXCEEDS TEST NO./(%): 1)/X.XX; 2)/X.XX

HISTORICAL DATA OF BASE METER FACTORS @ XXXXX BPH
INITIAL BASE METER FACTOR (DATE: MM/DD/YY) X.XXXX

DATE:	MM/DD/YY	MM/DD/YY	MM/DD/YY	MM/DD/YY	MM/DD/YY
FACTOR:	X.XXXX	X.XXXX	X.XXXX	X.XXXX	X.XXXX
DEVIATION (±)	X.XX%	X.XX%	X.XX%	X.XX%	X.XX%
DATE:	MM/DD/YY	MM/DD/YY	MM/DD/YY	MM/DD/YY	MM/DD/YY
FACTOR:	X.XXXX	X.XXXX	X.XXXX	X.XXXX	X.XXXX
DEVIATION(±):	X.XX%	X.XX%	X.XX%	X.XX%	X.XX%

PROVED FOR SAUDI ARAMCO BY: ____________________________ DATE: ___________________

VERIFIED FOR MINPET BY: ___________________________________ DATE: ___________________

===

NOTE: UP TO TWO DECIMALS FOR BUTANE AND PROPANE SERVICES, PER APPENDIX 2-1.

Appendix 1-2

GENERAL INFORMATION CONCERNING METER PROVING REPORTS FOR ROYALTY MEASUREMENT OF CRUDE OIL, NATURAL GASOLINE (A180/A305), NATURAL GAS LIQUID (NGL), BUTANE & PROPANE SERVICES

1.0 GENERAL (See Appendix 1-1).

1.1 OFFICIAL - Operator Entry. These reports are marked "(X) OFFICIAL" when proving is done officially and witnessed by MINPET representative(s). If the results of the reports are accepted by MINPET, they shall be automatically incorporated into the computer data base.

1.2 UNOFFICIAL - Operator Entry. These reports are marked "(X) Unofficial" during unofficial runs such as for checking purposes, troubleshooting, etc., the results of which are not incorporated in the computer data base nor used in any delivery calculations.

1.3 ABORTED - Computer Generated. These reports are automatically marked "(X) ABORTED" after any unsuccessful official or unofficial provings.

1.4 LOCATION, DATE/TIME - Initially entered by authorized systems administrator.

1.5 "AAAAAA" - Computer Generated. Denotes alpha values. "XXX.XX" - Computer Generated. Denotes numeric values.

1.6 LIQUID, API GRAVITY OR RELATIVE DENSITY (RD) AT 60°F. - Operator Entry.

1.7 METER DATA - TAG NO., ENTERED BY OPERATOR; MANUFACTURER, TYPE, MODEL NO., SERIAL NO., SIZE AND NOMINAL K FACTOR - Initially Entered By Authorized Systems Administrator; Computer-Generated Afterwards, Based On Meter Tag No.;

1.8 PROVER DATA: - TAG NO, MANUFACTURER, TYPE/MODEL NO., SERIAL NO., OUTSIDE DIAMETER.(OD)(In)/WALL THICKNESS (WT) (In), COEFFICIENT OF CUBICAL EXPANSION (Gc)/°F, MODULUS OF ELASTICITIY (E)/psi - computer-generated, based on meter tag no.; initially entered by authorized systems administrator, computer-generated afterwards, based on meter tag no.

2.0 PROVING DATA

2.1 Pulses, Time, Pressure, Temperature (**Note:** For temperature, up to two decimals for butane and propane services, per Appendix 2-1) Readings - Logged During Proving.

2.2 Trial Meter Factor - Calculated by computer, steps "A" through "N" per run, as shown in item 3, METER FACTOR CALCULATION, below.

2.3 Proving trials to continue up to 10 trials, until 4 successful, consecutive runs meet the percent repeatability tolerance limits per the following equation:

$$\frac{(\text{TMF max.} - \text{TMF min.})}{(\text{TMF avg.})} \text{ x } 100 \leq 0.05\% \qquad (1)$$

2.4 Proving program shall abort after 10 unsuccessful trials or when initiated by the operator. An aborted proving report shall automatically be generated showing all the unsuccessful proving data used in calculating the trial meter factors.

3.0 METER FACTOR CALCULATION

(For rounding of figures on different parameters, see Appendix 2-1).

a. Base Prover Volume (BPV) at 60°F & 0 psig (Bbl) - Five significant digits minimum. Stored in computer database. Must be field-changeable and secured by keylock, password and/or MINPET wire seal combination.

b. CTSp - Correction factor for the effect of temperature on the steel of the prover. (See Appendix 2-2).

c. CPSp - Correction factor for the effect of internal pressure on the steel of the prover. (See Appendix 2-2).

d. CTLp - Correction factor for the effect of temperature on the density of liquid inside the prover. Based on table look up of either Table 6 or 24, as applicable, ASTM D1250/API-2540/IP-200, issue of 1952, using prover temperature, rounded to 4 decimals.

e. CPLp - Correction factor for the effect of pressure on the density of liquid inside the prover. (See Appendix 2-2).

f. Combined Correction Factor for Prover (CCFp) - Obtained by serial multiplication of the individual correction factors for the prover - CTSp, CPSp, CTLp and CPLp, (Items B * C * D * E).

g. Gross Standard Volume of Prover (GSVp) - Items A * F, serial multiplication of prover volume at 60°F, rounded to 5 significant digits minimum.

h. Indicated Volume of Meter (IVm) - Calculated by computer:- Total average pulse count/nominal K factor (NKF); rounded to 5 significant digits minimum.

i. CTLm - Same as item D above, but using the temperature of the liquid inside the meter.

j. CPLm - Same as item E above, but using the pressure of the liquid inside the meter.

k. Combined Correction Factor of Meter (CCFm) - Obtained by serial multiplication of the individual correction factors for the meter - CTLm and CPLm, (Items I * J).

l. Indicated Standard Volume of Meter (ISVm) - Calculated by computer, items H * K, rounded to 5 significant digits minimum.

m. Average Meter Flow Rate - Calculated by computer;
items A * B * C * 3600/Total Average time (secs).

n. Meter Factor at Proving Flow Rate - Calculated by computer; Items (G/L).

o. Meter Factor at Base Flow Rate of XXXXX BPH - Computer-calculated for meter factor control chart function. Base flow rate chosen must be representative of the normal meter proving flow rate at the station and where all historical meter factors calculated at the same base flow rate are compared. See also item 3, Appendix 1-3.

4.0 HISTORICAL DATA - Refer to Meter Factor Control Procedure, Appendix 1-3.

Appendix 1-3

METER FACTOR CONTROL PROCEDURE FOR ROYALTY MEASUREMENT OF CRUDE OIL, NATURAL GASOLINE (A180/A305), NATURAL GAS LIQUID (NGL), BUTANE & PROPANE SERVICES

1.0 The latest meter factor obtained at the base flow rate (Item "O" on the proving report) shall be incorporated automatically into the historical data provided it is within the tolerance test limits of both Test 1 and Test 2 as described below:

2.0 Test Limits

2.1 Test No. 1

a) For all types of Saudi Aramco crude oils, except for Arab Heavy (AH) and products:

$$\%\text{ Dev.} = \frac{(\text{Current MF, line "O" - Initial MF})}{(\text{Initial MF})} \text{ x } 100 \leq +/- 0.25\%$$

b) For Arab Heavy crude oil:

$$\%\text{ Dev.} = \frac{(\text{Current MF - Initial MF})}{(\text{Initial MF})} \text{ x } 100 \leq +/- 0.35\%$$

The initial meter factor is based on a pre-selected flow rate from the meter calibration curve, which is determined and entered in the computer by authorized personnel only, using a password, MINPET wire seal and/or keylock combination.

2.2 Test No. 2

a) For continuous operations (e.g., Pipeline or Refinery)

$$\%\text{ Dev.} = \frac{(\text{Current MF}) - (\text{Avg. of Last Two MF})}{(\text{Avg. of Last 2 MF's})} \text{ x } 100 \leq \pm 0.1\%$$

b) For batch operations (e.g., Terminal)

$$\%\text{ Dev.} = \frac{(\text{Current MF - Avg. of Last 10 MF})}{(\text{Avg. of Last 10 MF's})} \text{ x } 100 \leq 0.1\%$$

Only one of the two choices in test no. 2 is required in a given metering facility, to be determined on a case-by-case basis.

Only when the percentage deviation of the current meter factor from either (or both) tests 1 or 2 is exceeded shall it be listed, immediately below line "O". Deviation values are calculated as follows:

$$\% \text{ Dev.} = \frac{(\text{Line "N" - Test 1, or 2, value})}{(\text{Test 1, or 2, value})} \text{ x } 100$$

Only valid meter factors obtained during official proving that meet the requirements of Tests 1 and 2 above shall automatically be incorporated into the meter factor historical data file.

The proving report shall print out the last 10 meter factors at the selected base flow rate, along with the date of proof and deviation values per test no. 1. Rolling factors to be handled on a FIFO (First In, First Out) basis, i.e., oldest data is No. 1, newest is No. 10.

3.0 The current meter factor at base flow rate of XXXXX BPH is determined by:

MFB MFC + Flow Adj.

where:

MFB Current meter factor at base flow rate, item "O".

MFC Meter Factor at proving flow rate of XXXXX BPH**,** Item "N".

Flow Adj. MFbfr - Mfpfr;

where:

MFbfr Meter factor at base flow rate, interpolated from the meter's base curve.

MFpfr Meter factor at proving flow rate, interpolated from the meter's base curve.

4.0 The minimum number of calibration points required to develop a multipoint meter calibration curve (meter factor vs. flow rate) shall be as follows:

Meter Nominal Size, Inch	Minimum No. of Points
4 and smaller	5
6 to 12, inclusive	8
16 and larger	12

Appendix 1-4

MEASUREMENT TICKET FORMAT FOR ROYALTY MEASUREMENT OF CRUDE OIL, NATURAL GASOLINE (A180/A305), NATURAL GAS LIQUID (NGL), BUTANE & PROPANE SERVICES

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SAUDI ARABIAN OIL COMPANY (Saudi Aramco)
MEASUREMENT TICKET

( )OFFICIAL ( )UNOFFICIAL ( )RECALCULATED TICKET NO./YR: XXXX/XX

DELIVERED TO: AAAAAAAAAA DELIVERY DATE: MM/DD/YY
LOCATION: AAAAAAAAA PRINT DATE/TIME: MM/DD/YY/HH:MM

METER DATA:
TAG NO.: AAA-XXX SIZE (in): XX
MANUFACTURER: AAAAAAAAAAAAAA SERIAL NO.: XXXXXX
MODEL NO.: AAA-XXX NOMINAL K FACTOR: XXXX.XXX

	1. TYPE OF LIQUID		AAAAAAAAAAA	
	2. METER CLOSING (DATE/TIME)	MM/DD/YY/HH:MM:SS	XX/XX/XX/XX:XX:XX	
	3. METER OPENING (DATE/TIME)	MM/DD/YY/HH:MM:SS	XX/XX/XX/XX:XX:XX	
	4. IDLE TIME	XX.XXXX		
	5. NET DELIVERY TIME		XX.XXXX	(hrs)
	6. METER CLOSING READING (MRc)		XXXXXX	(bbls)
	7. METER OPENING READING (MRo)		XXXXXX	(bbls)
	8. INDICATED VOLUME (IV)		XXXXXX	(bbls)
	9. AVERAGE FLOW RATE		XXXXX	(BPH)
	10. TOTAL FACTORED GROSS VOLUME (TFGV)		XXXXXX.	(bbls)
	11. AVERAGE METER FACTOR (AMF)		X.XXXX	
	12. BASE DENSITY (RHOb) @ 60°F (API/RD)		XXX.X/(X.XXXX)	
	13. FLOW WEIGHTED AVERAGE TEMP. (YWAc)		XXX.X	(°F)
	14. VOLUME CORRECTION FACTOR	(CTLm)	X.XXXX	
	15. FLOW WEIGHTED AVERAGE PRESS.	(PWAc)	XXX	(psig)
	16. PRESSURE CORRECTION FACTOR	(CPLm)	X.XXXXX	
	17. COMB. CORR. FACTOR FOR METER	(CCFm)	X.XXXXX	
	18. GROSS STANDARD VOLUME (GSV)		XXXXXX	(bbls)
*	19. PERCENTAGE OF SEDIMENT & WATER (%S&W)		XX.XXX	(%)
*	20. S&W CORRECTION FACTOR	(CSW)	X.XXXXX	
	21. NET STD. VOL. DEL. @ 60°F & 0 psig (NSV)		XXXXXX	(bbls)
	22. NET STD. VOL. @ 15°C & 101.325 kPaa (NSV)		XXXXXX.XXX	(M^3)
	23. NET WEIGHT DELIVERED		XXXXXX.XX	(LT)
	24. NET WEIGHT DELIVERED		XXXXXX.XX	(MT)

NON-NEGOTIABLE, NON-TRANSFERABLE
SAUDI ARABIAN OIL COMPANY

CHECKED FOR SAUDI ARAMCO BY: ___________________________ DATE: ____________

VERIFIED FOR MINPET BY: ___________________________________ DATE: ____________

==

NOTE: APPLIES TO CRUDE OIL SERVICE ONLY.

Appendix 1-5

GENERAL INFORMATION CONCERNING MEASUREMENT TICKETS FOR ROYALTY MEASUREMENT OF CRUDE OIL, NATURAL GASOLINE (A180/A305), NATURAL GAS LIQUID (NGL), BUTANE & PROPANE SERVICES

1.0 DESIGN BASIS

1.1 The method and sequence of calculations involved in processing the delivery ticket shall follow the real-time approach.

1.2 The computers store a table of Flow Rate vs. Meter Factor (Base Curve) curve for each grade or type of hydrocarbon liquid being handled. Incorporation of said base curves into the computers is subject to the approval of the Saudi Arabian Ministry of Petroleum and Mineral Resources (MINPET).

1.3 The adjusted base curve after each official proving shall be the basis for obtaining the loading meter factor for the corresponding flow rate in each scan. The pulses are scanned at intervals of "N" seconds by the flow computer, where "N" is the scan period (less than 5 seconds).

1.4 Flow pulse signals from the flow meter's two pick-up coils (primary A and secondary B) are hardwired and compared at their individual (meter run) or system flow computer(s). For each scan, the applicable computers make simultaneous calculations of the flow rate, interpolate the meter factor from the base curve, then calculate the accumulated factored gross delivered volume. The primary system computer shall make a running comparison of the corresponding gross deliveries between the secondary system computer and itself, activating an alarm whenever the difference exceeds by 0.1% from each other.

(For additional details, refer to Appendix 2-3, System Architecture).

1.5 The computers also scan and calculate a running flow-weighted average of the temperature and pressure readings being used in the calculations

1.6 The computers shall use their full floating decimal capability in all intermediate calculations. Rounding of figures shall be per Appendix 2-1.

2.0 EXPLANATION OF MEASUREMENT TICKET TERMS (See Appendix 1-4).

2.1 GENERAL

2.1.1 OFFICIAL - Operator Entry. These reports are marked "(X) OFFICIAL" when loading or delivery is done officially and witnessed by MINPET representative(s). If the results of the reports are accepted by MINPET, they shall be automatically incorporated into the computer database.

2.1.2 UNOFFICIAL - Operator Entry. These reports are marked "(X) UNOFFICIAL" during unofficial delivery such as for checking purposes, troubleshooting, maintenance, etc., the results of which shall not be incorporated in the computer data base nor used for billing purposes.

2.1.3 TICKET NO./YEAR - Automatically generated for each meter and numbered consecutively, beginning with the first number, for the corresponding year.

2.1.4 DELIVERED TO - Operator Entry. Usually selected from a prepared list of offtaker ships, or destination. Applies to marine terminal, or pipeline operations, respectively.

2.1.5 DELIVERY DATE, LOCATION, PRINT DATE/TIME - Computer generated; indicates the starting date of the delivery. (See notes 1 & 2 below)

2.1.6 METER DATA - Tag No., entered by operator; SIZE (In), MANUFACTURER, SERIAL NO., MODEL NO., NOMINAL K FACTOR: - Computer-generated, based on meter tag no.; initially entered by the systems administrator; computer-generated afterwards, based on meter tag no.

2.2 MEASUREMENT TICKET TERMS

2.2.1 TYPE OF LIQUID - Operator Entry (e.g., Arab Light, Arab Medium, etc.), via selection from a computerized list of hydrocarbon liquids being handled at the facility.

2.2.2 METER CLOSING (DATE/TIME) - By computer; date & time (hours/ minutes/seconds) flow signals stop at the end of batch).

2.2.3 METER OPENING (DATE/TIME) - By computer; date & time (hours/ minutes/seconds) flow signals start at the beginning of batch).

2.2.4 IDLE TIME - Determined by computer; time with no flow through the flow computer, in hours:

2.2.5 NET DELIVERY TIME - By computer; actual time of flow through meter, excluding idle time, in hours:

= Meter Closing time -(Meter Opening time + Idle Time); [i.e., Item 2.2.2 - (Item 2.2.3 + Item 2.2.4)]

2.2.6 METER CLOSING READING (MRc) - By computer; total accumulated meter pulses at the time of meter's closing, divided by the meter's nominal K factor (NKF), in bbls.

2.2.7 METER OPENING READING (MRo) - By computer; total accumulated meter pulses at the time of meter's opening, divided by the meter's nominal K factor, in bbls.

2.2.8 INDICATED VOLUME (IV) - By computer; Total accumulated gross delivered volume, Item 2.2.6 - Item 2.2.7 above, in bbls.

2.2.9 AVERAGE FLOW RATE - By computer; indicated volume (IV) divided by net delivery time. (Item 2.2.8/Item 2.2.5), in BPH.

2.2.10 TOTAL FACTORED GROSS VOLUME (TFGV) - By computer; (See SEQUENCE OF CALCULATIONS BELOW, ITEM 4.3.2), in bbls.

2.2.11 AVERAGE METER FACTOR (AMF) - By computer; TFGV/IV (i.e., Item 2.2.10/Item 2.2.8).

2.2.12 BASE DENSITY (RHO_b), in °API or Relative Density (RD), as applicable, at 60°F (based on ASTM D1250/API 2540/IP 200, issue of 1952), - Operator entry; to be done within 24 hours of end of batch/loading.

2.2.13 CURRENT FLOW WEIGHTED AVERAGE TEMPERATURE (YWAc) - Running calculation by computer, in °F; (**Note:** Up to two decimals for butane and propane services, per Appendix 2-1):

$$\text{YWAc} = \frac{(\text{YWAp x UV})}{(\text{UV} + \text{DV})} + \frac{(\text{Yc x DV})}{(\text{UV} + \text{DV})}$$

where:

YWAc Current flow-weighted average temperature value.

YWAp Flow-weighted average temperature from previous calculation cycle.

UV Total indicated volume from previous calculation cycle.

DV Indicated volume from this calculation cycle only.

Yc Current value of temperature, °F.

2.2.14 VOLUME CORRECTION FACTOR (CTLm) - Correction factor for the effect of temperature on density of liquid in the meter. Based on actual table look-up of Table 6 or 24, as applicable, ASTM D1250/API 2540/IP 200 - issue of 1952, using the API Gravity or Relative Density (RD) input (item 2.2.12) and flow-weighted average meter temperature (YWAc), item 2.2.13.

2.2.15 CURRENT FLOW WEIGHTED AVERAGE PRESSURE (PWAc) - Running calculation by computer, in psig.

$$\text{PWAc} = \frac{(\text{PWAp x UV})}{(\text{UV} + \text{DV})} + \frac{(\text{Pc x DV})}{(\text{UV} + \text{DV})}$$

where:

PWAc Current flow-weighted average pressure value

PWAp Flow weighted average pressure from previous calculation cycle.

UV Total indicated volume from previous calculation cycle.

DV Indicated volume from this calculation cycle only.

Pc Current value of pressure, psig.

2.2.16 PRESSURE CORRECTION FACTOR (CPLm) - Correction factor for the effect of pressure on density of liquid in the meter. (See Appendix 2-2).

2.2.17 COMBINED CORRECTION FACTOR FOR METER (CCFm) - Obtained by serial multiplication of the individual correction factors CTLm and CPLm, (items 2.2.14 * 2.2.16).

2.2.18 GROSS STANDARD VOLUME (GSV) - (For non-crude-oil service only); By computer; (Item 2.2.10, TFGV * Item 2.2.17, CCFm) **Note:** String calculation to be applied (no rounding in intermediate steps), in bbl.

2.2.19 PERCENTAGE OF SEDIMENT & WATER (%S&W) - For crude oil service only (does not apply to other services); Operator entry; to be done within 24 hours from the end of this batch/loading. (See Note 1 below).

2.2.20 S&W CORRECTION FACTOR (CSW) - For crude oil service only, (does not apply to other services); By computer; CSW = 1.00 - (Item 2.2.19/100).

2.2.21 NET STANDARD VOLUME DELIVERED - (For non-crude oil service, same as GSV, item 2.2.18, above); calculated: (Item 2.2.18 * Item 2.2.20); in barrels, at 60°F & 0 psig (equilibrium pressure for butane & propane services).

2.2.22 NET STANDARD VOLUME DELIVERED - (For non-crude oil service, same as GSV, item 2.2.18, above); calculated: (Item 2.2.21 * CF); in cubic meters, at 15°C and 101.325 kPa_a (equilibrium pressure for butane & propane services).

1) Where API Gravity is used as base density ($RHO_{b)}$, CF is taken from Table 4, ASTM D1250/API 2540/IP200 - 1952:

API G @ 60°F	CF	API G @ 60°F	CF
< = 12.0	0.15893	60.0 - 68.7	0.15888
12.1 - 31.4	0.15892	68.8 - 78.2	0.15887
31.5 - 44.2	0.15891	78.3 - 87.0	0.15886
44.3 - 52.4	0.15890	87.1 - 94 3	0.15885
52.5 - 59.9	0.15889	94.4 - 100	0.15884

2) Where relative density (RD) is used as base density ($RHOb_{)}$, CF is taken from Table 22, ASTM D1250-/API 2540/IP 200 - 1952:

REL. DEN. @ 60°F	CF	REL. DEN. @ 60°F	CF
0.985 - 1.100	0.15893	0.582 - 0.593	0.15882
0.863 - 0.984	0.15892	0.570 - 0.581	0.15881
0.808 - 0.862	0.15891	0.560 - 0.569	0.15880
0.770 - 0.807	0.15890	0.551 - 0.559	0.15879
0.737 - 0.769	0.15889	0.542 - 0.550	0.15878
0.705 - 0.736	0.15888	0.534 - 0.541	0.15877
0.675 - 0.704	0.15887	0.526 - 0.533	0.15876
0.648 - 0.674	0.15886	0.519 - 0.525	0.15875
0.627 - 0.647	0.15885	0.512 - 0.518	0.15874
0.608 - 0.626	0.15884	0.505 - 0.511	0.15873
0.594 - 0.607	0.15883	0.500 - 0.504	0.15872

2.2.23 NET WEIGHT DELIVERED, (IN LONG TONS) - By computer;

When using API Gravity as base density:

$$= \left(\text{Item 2.2.21 x 0.0375}\right) \text{ x } \left[\frac{(589.9438)}{(\text{Item 2.2.12 } + \text{ 131.5})} - 0.0050789\right]$$

When using relative density as base density:

$$= \left(\text{Item 2.2.21 x 0.0375}\right) \text{ x } \left[\left(4.169214 \text{ x Item 2.2.12}\right) - 0.0050789\right]$$

2.2.24 NET WEIGHT DELIVERED, (IN METRIC TONS) - By computer; (Item 2.2.23 * 1.01605).

2.2.25 GENERATION OF MEASUREMENT TICKETS

1) Computer to store previous data of at least 2 last batches while logging the current one.

2) For crude oil service: Official ticket shall be generated only after manually entering the API Gravity or relative density (as applicable), and S&W figures corresponding to the delivered batch.

3) Unofficial tickets (for crude oil service) and

Official tickets (for A-180/A-305 natural gasoline, NGL, butane & propane) shall be generated under the following circumstances:

a) For Terminal Operations: after each batch (loading one ship).

b) For Pipelines Operations: Automatically at 12 midnight, after a 24-hour batch.

c) On demand.

d) When the inlet isolation valve of the meter run involved is closed and generation of meter pulses completely stops.

e) On a preprogrammed basis, as required.

4) As a precaution against metering data (e.g., API/RD, %S&W, temperature, pressure, etc.) that were found and verified later to be incorrect, the system shall be able to generate a recalculated ticket after manually inputting the correct values of said parameters. The notations "OFFICIAL" and "RECALCULATED" as shown on the ticket apply under such situation. This feature shall be under a password, keylock and MINPET seal protection.

4.0 SEQUENCE OF CALCULATIONS

The calculation sequence to obtain the final delivered volume involves three major steps:

4.1 PERIOD 1 (SCANS FROM TIME 0 TO X1):

The period from the first scan at the start of the batch/loading (00:00 hours for Pipeline Operations) to the last scan immediately before the acceptance of a new meter factor by the computer.

If a new meter factor is not generated or the factor is not within the acceptable tolerance as defined in Appendix 1-1, then PERIOD 1 is up to the end of the batch.

4.1.1 FLOW RATE (FR):

$$\text{FR (UNADJ)} = \frac{\text{SUM (PULSES)}}{\text{NKF x (N / 3600)}} \text{ (BPH)}$$

FR FR (UNADJ) x ADJ. MF

Where:

ADJ. MF MFPP + FLOW ADJ.

MFPP	Meter Factor from previous proving, at proving condition.
FLOW ADJ	MFCLB - MFPPB
MFCLB	Meter Factor at current unadjusted loading flow rate, interpolated from the base curve.
MFPPB	Meter Factor at the previous proving flow rate, interpolated from the base curve.

4.1.2 METER FACTOR FOR PERIOD 1, DURING CURRENT LOADING, (MFCL1):

MFCL1 MFPP + FLOW ADJ.

4.1.3 GROSS VOLUME FOR ANY SCAN (GV)

GV SUM PULSES/NKF

4.1.4 TOTAL GROSS VOLUME AT ANY TIME "X", (TGVX):

TGVx SUM (from 0 to x) of GV

4.1.5 TOTAL GROSS VOLUME FOR PERIOD 1 (TGV1):

TGV1 SUM (from 0 to X1) of GV

4.1.6 FACTORED GROSS VOLUME (FGV):

FGV (SUM PULSES * MFCL1)/NKF

4.1.7 FACTORED GROSS VOLUME AT ANY TIME "X", (FGVx):

FGVx SUM (from 0 to x) of FGV

4.1.8 TOTAL FACTORED GROSS VOLUME FOR PERIOD 1, (TFGV1):

TFGV1 SUM (from 0 to X1) of FGV

4.1.9 A NEW METER FACTOR (MFCL2) IS GENERATED BY PROVING THE METER.

1) For facilities using fully-automated and computerized proving system, a new and official meter factor meeting the acceptability criteria specified in Appendix 1-3 is accepted automatically into the computer.

2) If the new meter factor is not acceptable, the computer will ask if another proof will be run. If the meter factor obtained after the "nth" run (per operator's discretion) is still unacceptable, the operator will stop further proving. In this case, the previous official meter factor will be used for delivery calculations.

4.1.10 AVERAGE METER FACTOR (AVGMF):

AVGMF TFGV1 /TGV1 (i.e., Item 4.1.8/Item 4.1.5)

4.1.11 BASE METER FACTOR FOR PREVIOUS PROVING (BMFPP):

BMFPP Meter Factor for previous proving at base flow rate calculated per Appendix 1-3.

4.1.12 BASE METER FACTOR FOR CURRENT PROVING (BMFCP):

BMFCP Meter factor for current proving at base flow rate, obtained similarly per Appendix 1-3.

4.1.13 SHIFT IN METER FACTOR (SHIFT) - This determines the correction necessary for the meter factor for Period 1 due to the new meter proving:

SHIFT BMFCP - BMFPP (i.e., Item 4.1.12 - Item 4.1.11)

4.1.14 ADJUSTED METER FACTOR (AMF) - This determines a new average meter factor for Period 1.

AMF AVGMF + SHIFT (i.e., Item 4.1.10 + Item 4.1.13)

4.1.15 TOTAL CORRECTED FACTORED GROSS VOLUME FOR PERIOD 1 (TCFGV1):

TCFGV1 TGV1 * AMF (i.e., Item 4.1.5 * Item 4.1.14)

4.2 PERIOD 2 (SCANS FROM TIME X1 TO X2):

Steps 4.1.1 through 4.1.18 are repeated to calculate the flow rate, gross volume and factored gross volume using the new meter factor (MFCL2), corrected for flow and temperature, using the new proving temperature and proving flow rate.

4.2.1 FLOW RATE (FR):

$$FR\ (UNADJ) = \frac{SUM\ (PULSES)}{SF \times (N / 3600)}$$

FR   FR (UNADJ) * ADJ. MF

where:

ADJ. MF   MFCP + FLOW ADJ.

MFCP   Meter factor from current proving at proving condition.

FLOW ADJ.   MFCLB - MFCPB

where:

MFCLB   Meter factor at current unadjusted loading flow rate, interpolated from the base curve.

MFCPB   Meter factor at current proving flow rate interpolated from the base curve.

4.2.2 METER FACTOR FOR PERIOD 2 FOR CURRENT LOADING (MFCL2):

MFCL2   MFCP + FLOW ADJ.

4.2.3 GROSS VOLUME FOR ANY SCAN (GV):

4.2.4 TOTAL GROSS VOLUME AT ANY TIME "X" (TGVx):

TGVt   SUM (from X1 to x) of GV

4.2.5 TOTAL GROSS VOLUME (TGV2):

TGV2   SUM (from X1 to X2) of GV

4.2.6 FACTORED GROSS VOLUME (FGV):

$$FGV = \frac{SUM\ (PULSES \times MFCL2)}{NKF}$$

4.2.7 FACTORED GROSS VOLUME AT ANY TIME "x" (FGVx):

FGVx = SUM (from X1 to x) of FGV

4.2.8 TOTAL FACTORED GROSS VOLUME (TFGV2):

TFGV2 SUM (from X1 to X2) of FGV

4.3 NET VOLUME CALCULATION AT THE END OF BATCH

4.3.1 TOTAL GROSS VOLUME (TGV)

TGV TGV1 + TGV2 (i.e., Item 4.1.5 + Item 4.2.5)

4.3.2 TOTAL FACTORED GROSS VOLUME AT THE END OF BATCH (TFGV):

TFGV TCFGV1 + TFGV2 (i.e., Item 4.1.18 + Item 4.2.8)

Appendix 1-6

BATCH SUMMARY REPORT FORMAT FOR ROYALTY MEASUREMENT OF CRUDE OIL, NATURAL GASOLINE (A180/A305), NATURAL GAS LIQUID (NGL), BUTANE, AND PROPANE SERVICES

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SAUDI ARABIAN OIL COMPANY (Saudi Aramco)
BATCH SUMMARY REPORT

( )OFFICIAL ( )UNOFFICIAL

REPORT NO.: XXXX/XX
PRINT DATE/TIME: MM/DD/YY/HH:MM

NOMINATION: XXXXXXX (Bbls)
SHIP NAME/LOCATION: AAAAAAAAAAAAAAAAA
DESTINATION: AAAAAAAAAAAAAAAAA

LIQUID: AAAAAAAAAAAAAAAAAAAAAA
API/RD: XX.X/X.XXXX

METER TAG NO.	START TIME	STOP TIME	AVG FLOW RATE	*****AVG TEMP (°F)	AVG PRESS (psig)	AVG METER FACTOR	IND. VOLUME (BBL)	NET STD VOLUME (BBL)
FM-XXX	MM/DD/YY HH:MM:SS	MM/DD/YY HH:MM:SS	XXXXX	XXX.X	XXX	X.XXXX	XXXXXX	XXXXXX
FM-XXX	MM/DD/YY HH:MM:SS	MM/DD/YY HH:MM:SS	XXXXX	XXX.X	XXX	X.XXXX	XXXXXX	XXXXXX
FM-XXX	MM/DD/YY HH:MM:SS	MM/DD/YY HH:MM:SS	XXXXX	XXX.X	XXX	X.XXXX	XXXXXX	XXXXXX
FM-XXX	MM/DD/YY HH:MM:SS	MM/DD/YY HH:MM:SS	XXXXX	XXX.X	XXX	X.XXXX	XXXXXX	XXXXXX
FM-XXX	MM/DD/YY HH:MM:SS	MM/DD/YY HH:MM:SS	XXXXX	XXX.X	XXX	X.XXXX	XXXXXX	XXXXXX
FM-NNN	MM/DD/YY HH:MM:SS	MM/DD/YY HH:MM:SS	XXXXX	XXX.X	XXX	X.XXXX	XXXXXX	XXXXXX

TOTAL NET VOL (BBL): XXXXXX

NON-NEGOTIABLE, NON-TRANSFERABLE
SAUDI ARABIAN OIL COMPANY

CHECKED FOR Saudi Aramco BY: ________________________ DATE: _________________

VERIFIED FOR MINPET BY: _____________________________ DATE: _________________

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NOTE: UP TO TWO DECIMALS FOR BUTANE AND PROPANE SERVICES, PER APPENDIX 2-1.

Appendix 1-7

GENERAL INFORMATION CONCERNING BATCH SUMMARY REPORTS FOR ROYALTY MEASUREMENT OF CRUDE OIL, NATURAL GASOLINE (A180/A305), NATURAL GAS LIQUID (NGL), BUTANE, AND PROPANE SERVICES

1.0 GENERAL (See Appendix 1-6)

1.1 OFFICIAL - Operator entry. These reports are marked "(X) OFFICIAL" when loading or delivery is done officially and witnessed by MINPET representative(s). If the results of the reports are accepted by MINPET, they shall be automatically incorporated into the computer data base and used for billing purposes.

1.2 UNOFFICIAL - Operator entry. These reports are marked "(X) UNOFFICIAL" during unofficial runs such as for checking purposes, troubleshooting, etc., the results of which are neither incorporated in the computer data base nor used for billing purposes.

1.3 REPORT NO. - Automatically generated for each batch and numbered consecutively, beginning with the first number for the corresponding year.

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

2.0 REPORT TERMS

2.1 NOMINATION - Operator entry. The nominal volume in barrels requested by the offtaker ship, or any receiving pipeline station.

2.2 LIQUID - Operator entry, either manually or via selection from a computerized list of hydrocarbon liquids being handled at the facility.

2.3 SHIP NAME/LOCATION - Operator entry, either manually or via selection from a computerized list of offtaker ships, or metering facility location, as applicable.

2.4 API/RD: Operator entry, prior to loading operation.

2.5 DESTINATION - Operator entry, either manually or via selection from a computerized list of offtaker ship, or pipeline delivery destination, as applicable.

2.6 METER TAG NO. - Computer generated, automatically taken off from the delivery tickets of flow meters in the metering skid involved.

2.7 START TIME - Computer generated, indicating the exact date and time the delivery started, automatically taken off the delivery ticket (item 3, METER OPENING, Appendix 1-4), of the particular meter used during the delivery. For meters not used in the delivery, this should show a value of zero.

2.8 STOP TIME - Computer generated, indicating the exact date and time the delivery ended, automatically taken off the delivery ticket (item 2, Meter Closing, Appendices 1-4), of the particular meter used during the delivery. For meters not used in the delivery, this should show a value of zero.

2.9 AVERAGE FLOW RATE - Computer generated, taken automatically off the delivery ticket (item 9, Appendix 1-4), corresponding to the flow meter(s) used during the delivery. For meters not used in the delivery, this should show a value of zero.

2.9 FLOW WEIGHTED AVERAGE TEMPERATURE. (YWAc), in °F - Computer generated, taken automatically off the measurement ticket (item 13, Appendix 1-4), corresponding to the flow meter(s) used during the delivery, rounded to 1 decimal for crude oil, natural gasoline and natural gas liquids; rounded to 2 decimals for butane and propane services. For meters not used in the delivery, this should show a value of zero.

2.10 FLOW WEIGHTED AVERAGE PRESSURE (PWAc), in psig - Computer generated, taken automatically off the delivery ticket (item 15, Appendix 1-4), corresponding to the flow meter(s) used during the delivery. For meters not used in the delivery, this should show a value of zero.

2.11 AVG. METER FACTOR (AMF) - Computer generated, taken automatically off the delivery ticket (item 11, Appendix 1-4), corresponding to the flow meter(s) used during the delivery. For meters not used in the delivery, this should show a value of zero.

2.12 INDICATED VOLUME (IV), in bbls - Computer generated, taken automatically off the delivery ticket (item 8, Appendix 1-4), corresponding to the flow meter(s) used during the delivery. For meters not used in the delivery, this should show a value of zero.

2.13 NET STANDARD VOLUME (NSV) in bbls - Computer generated, taken automatically off the measurement ticket (item 21, Appendix 1-4), corresponding to the flow meter(s) used during the delivery. For meters not used in the delivery, this should show a value of zero.

2.14 TOTAL NET STANDARD VOLUME (bbls) - By computer, adding all the delivered net volumes of all meters used in the delivery.

Appendix 2-1

ROUNDING CONVENTION AND DISCRIMINATION LEVEL

1.0 ROUNDING CONVENTION

1.1 When the figure to the right of the last place to be retained is 5 or greater, the figure in the last place to be retained should be increased by 1.

1.2 When the figure to the right of the last place to be retained is less than 5, the figure in the last place to be retained should be unchanged.

2.0 DISCRIMINATION LEVELS

2.1 PROVING REPORTS

VARIABLES	NO. OF DECIMALS/DIGITS
Base Density (RHOb) at 60°F	
API Gravity (°API)	1
Relative Density (RD)	4
Temperature (°F)	
Crude oil, Natural Gasoline, NGL	1
Butane & Propane	2
Pressure (psig)	0
Compressibility Factor F	8
Modulus of Elasticity (Em)	8 digits minimum
Correction Factors	
CTS, CPS, CPL, & CCF	5
CTL	4
Combined Correction Factor	
CCFp and CCFm	5
Flow Rate (BPH)	0
Meter Factor (MF)	4
Volume	
Prover Base	5 digits minimum
Gross Metered	5 digits minimum
Pulse Applications	
Whole	0
Double Chronometry	3
Time (secs)	1
Coeff. of Cubical Expansion (Gc)	7

2.2 MEASUREMENT TICKETS

VARIABLES	NO. OF DECIMALS/DIGITS
Base Density (RHOb)at 60°F	
API Gravity (°API)	1
Relative Density (RD)	4
Time (Hours)	4
Temperature (°F)	
Crude oil, Nat. Gasoline, NGL	1
Butane & Propane	2
Pressure (psig)	0
Compressibility Factor F	8
Correction Factors	
CTS, CPS, CPL, & CCF	5
CTL	4 (or 5, as needed)
Percent S&W	3
Correction Factor CSW	5
Volume	
Barrels (bbls)	0
Cubic Metres (cu. metres, M^3)	3
Mass	
Long Tons (LT)	2
Metric Tons (MT)	2

Appendix 2-2

PRINCIPAL CORRECTION FACTORS

Correction factors are provided to adjust the metered volume and the volume of prover to base conditions. The principal correction factors used in the proving and delivery ticket reports are the following:

1.0 CTSp - Correction factor for thermal expansion and/or contraction of the steel in the prover shell due to the average prover liquid temperature. Calculated from formula from API MPMS Chapter 12.2, Part 1 issue of 5/95, paragraph 1.11.2.1:

$$CTSp = 1 + [(T-Tb) * Gc]$$

where:

T mean liquid temperature in the prover/meter (°F)

Tb base temperature, (60°F)

Gc mean coefficient of cubical expansion per °F of the material of the prover/meter.

= 1.86E-05/°F for mild carbon steel

= 2.88E-05/°F for 304 stainless steel

= 2.65E-05/°F for series 316 stainless steel

= 1.80E-05/°F for 17-4 PH stainless steel

2.0 CTSm - Correction factor for thermal expansion and/or contraction of the steel in the meter housing and rotor due to the average meter liquid temperature:

$$CTSM = \{1 + (EH) * (TM - 60)\}^2 * \{1 + (ER) * (TM - 60)\}$$

where:

EH The coefficient of linear expansion of the steel of the meter housing, derived from the table below.

ER The coefficient of linear expansion of the steel of the meter rotor, derived from the table below.

Where the material of the meter housing and rotor is the same, EH = ER.

TM The temperature of the meter in °F.

60 Reference temperature, in °F.

TABLE OF COEFFICIENT OF LINEAR EXPANSION

TEMP. (°F)	EH) STNL STL
-75	0.00000883
-50	0.00000890
-25	0.00000894
0	0.00000898
+25	0.00000903
+50	0.00000907
+75	0.00000911
+100	0.00000916
+125	0.00000920
+150	0.00000925

2.1 Applicability of CTSm

1 CTSm applies *only* to refrigerated propane service, where the proving liquid and its temperature are *not* identical to that of the process liquid.

2 For natural gasoline, butane and propane services where the proving liquid is identical to the process liquid, this factor may be eliminated, or be assigned a factor of 1.0000.

3.0 CPSp - Correction factor for the effect of internal pressure on the steel of the prover (CPSp). Calculated per API MPMS, Chapter 12.2, Part 1, issue of 5/95, paragraph 1.11.2.2:

$$CPSp = 1 + \left(\frac{[(P - Pb) \times ID)]}{(E \times WT)} \right)$$

Assuming Pb is 0 gauge pressure, the equation simplifies to:

$$CPSp = 1 + \left(\frac{[(P \times ID)]}{(E \times WT)} \right), \text{ and}$$

ID = OD - (2 * WT)

where:

P internal operating pressure of prover (psig).

Pb base pressure, (psig)

ID internal diameter of prover (in)

E modulus of elasticity for prover material (psi)

3.00E+07 psi for mild carbon steel

2.80E+07 psi for 303/316 series stainless steel

2.85E+07 psi for 17-4 PH stainless steel

OD outside diameter of prover (in)

WT prover wall thickness (in)

4.0 CTL - Correction factor for the effect of temperature on the density of the liquid inside the prover (CTLp), or meter (CTLm). Taken from actual table look-up of either API Table 6 or 24, as applicable, Petroleum Measurement Tables, (ASTM-D-1250/API 2540/IP-200), American Edition, issue of 1952.

5.0 CPL - Correction factor for the effect of pressure on the density of liquid inside the prover (CPLp), or meter (CPLm). Calculated per API MPMS Chapter 12.2, Part 1, issue of 5/95, paragraph 1.11.1.2, using the density at 60°F and prover temperature and pressure:

$$CPL = \frac{1}{\left[P - (Pe_a - Pb_a)\right] x \left[F\right]}, \text{ and}$$

$$\left(Pe_a - Pb_a\right) \geq 0$$

where:

Pb_a base pressure, in absolute pressure units

Pe_a equilibrium vapor pressure at the temperature of the liquid being measured, in absolute pressure units.

The liquid equilibrium vapor pressure (Pe_a) is considered to be equal to base pressure (Pb_a) for liquids that have an equilibrium pressure less than or equal to atmospheric pressure at flowing temperature.

For the determination of equilibrium vapor pressure (Pe_a) at flowing conditions for butane and propane services, refer to Chapter 2.0, Correlation Development, GPA Technical Publication TP-15, A Simplified Vapor Pressure Correlation for Commercial NGL's, issue of June, 1988.

P operating pressure, in gauge pressure units

F compressibility factor for the liquid, determined from the algorithm in:

a) API MPMS Chapter 11.2.1, Compressibility Factors for Hydrocarbons: 0-90°API Gravity Range, expressed in lbs/psig rounded to the nearest 0.5°API, and prover temperature, rounded to the nearest 0.5°F, or

b) API MPMS Chapter 11.2.2, Compressibility Factors for Hydrocarbons: 0.350-0.637 Relative Density (60/60°F) and - 0.5°F to 140°F Metering Temperature, expressed in lbs/psig rounded to the nearest 0.002 relative density, and prover temperature, rounded to the nearest 0.5°F, as applicable.

When (Pe_a - $Pb_{a)}$ = 0, CPL is calculated as:

$$CPL = \frac{1}{(1 - P \times F)}$$

6.0 CCF - Combined Correction Factor, obtained by serial multiplication of a set of applicable individual correction factors for the prover (CCFp), and meter (CCFm).

where: CCFp = CTSp * CPSp * CTLp * CPLp

CCFm = (CTLm * CPLm) * (CTSm, for propane service, if applicable)

Appendix 2-3

BASIC SYSTEM ARCHITECTURE

1.0 REQUIREMENT

Operation of a meter shall be stopped where an impending failure of a single remaining flow pulse generating and monitoring device, e.g., pulse preamplifier, flow computer (FC), & logic controller (LC), would expose any accumulated flow metering data to potential loss.

2.0 BASIC SYSTEM FEATURES

At a minimum, redundant flow computers shall be furnished for each pair of flow meters.

Commentary Note:

> *Designating 2 flow meters for each pair of flow computers maximizes the number of qualified flow computer vendors and ease of future replacement.*

The system shall incorporate a set of dual MMI's, redundant FC's, LC's, and printers (1 each for alarms and reports). All graphics and report generations are performed by the MMI computers using a commercially-available MMI package.

Communications between flow computers, MMI computers and LC's are via redundant digital communications links or networks. One flow computer is to be designated primary, with the other providing backup, & vice versa. This applies also to MMI computers and LC's.

3.0 * BASIC SYSTEM ARCHITECTURE

Commentary Note:

> *Other arrangements that differ from the basic system architecture, but meet all its functions shall also be considered. However, they shall ultimately be weighed against this basic system architecture in terms of, but not limited to, cost-effectiveness, reliability, flexibility, future vendor support, ease of maintenance and operations.*

Each flow computer shall simultaneously monitor the primary (A) and secondary (B) pulse signals of its corresponding flow meter as well as that of its backup flow computer, and vice versa.

The secondary pulse signals from each of the two flow meters shall also be monitored by a pair of redundant LC's, which also monitors other secondary pulse signals from other pairs of flow meters in the metering system, thus providing the following minimum features:

1) A pair of independent flow computers that can monitor, accumulate, and process raw flow pulse signals, then generate independent gross and net standard volume calculations, using the corresponding and consistent primary and secondary flow pulse signals for comparisons.

2) One set of redundant LC's that can monitor, accummulate, then properly scale or process raw flow pulse signals.

3) Upon failure of the designated primary flow computer, all of its data monitoring and control functions shall automatically be taken over by its secondary (backup) flow computer.

4.0 EXPLANATION ON WHEN ORDERLY SHUTDOWN IS IN ORDER

The following circumstances demonstrate the philosophy governing orderly shutdown:

1) If 1 of the 3 flow pulse monitoring devices fails (FC's, or LC's), loading operation may continue, as two other devices are still in operation.

2) If a second flow pulse monitoring device also fails within the same delivery or batch loading operation, leaving only one raw flow pulse monitoring device in operation, the affected flow meter shall be a candidate for an orderly, manual shutdown.

3) Upon failure of either of the two of the flow meter's pulse signal (e.g., due to wire fault, pick up coil or preamplifier malfunction, etc.), the affected flow meter shall be a candidate for an orderly, manual shutdown.

5.0 WIRE SEALING REQUIREMENT

MINPET's policy of wire-sealing equipment or their enclosures associated with royalty metering systems could adversely affect the operation of non-royalty metering ones when the two systems share common facilities. If this is unacceptable to the proponent organization, then royalty metering systems and process-based computer systems must be completely segregated.