Engineering Standard

SAES-J-300 30 March 2005

Level

Saudi Aramco DeskTop Standards

Table of Contents

1 Scope

1.1 This standard prescribes minimum mandatory requirements governing the design of process level measurements, alarming, automatic tank gauging systems and mass measurement of hydrocarbon liquids. Sections 5 through 12 of this Standard are not intended to be an exclusive listing of types of level instruments. When engineering considerations so dictate, other types may be used. The approval requirements prescribed in SAES-J-002, Paragraph 2.2 shall apply.

1.2 This standard does not cover calculation of petroleum quantities based on tank levels. Also, sampling, measurement of sediment and water (S&W) are excluded in this standard. These and other issues related to volume measurements are discussed in chapters 8, 10 and 12 of the API Manual of Petroleum Measurement Standards (MPMS).

1.3 Section 8 of this standard is not intended for custody measurement. Additional guidance and approval is mandatory if the proponent intends to utilize an Automatic Tank Gauging System in the future for Custody Transfer. Forward such request prior to the approval of the project proposal to the Technical Director, Custody Measurement Unit, Process & Control System Department, Dhahran.

2 Conflicts and Deviations

2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), Industry Standards, Codes, and Forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.

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

3 References

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

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-A-301	*Materials Resistant to Sulfide Stress Corrosion Cracking*
SAES-B-054	*Access, Egress, and Materials Handling for Plant Facilities*
SAES-B-057	*Safety Requirements: Refrigerated and Pressure Storage Vessels*
SAES-B-068	*Electrical Area Classification*
SAES-J-002	*Technically Acceptable Instruments*
SAES-J-003	*Basic Design Criteria*
SAES-J-400	*Temperature*
SAES-J-601	*Emergency Shutdown and Isolation Systems*
SAES-J-902	*Electrical Systems for Instrumentation*
SAES-J-903	*Intrinsically Safe Systems*
SAES-L-008	*Selection of Valves*

Saudi Aramco Standard Drawings

AA-036256	*Radar, Temperature and Manual Gauging Assembly for Floating Roof Tanks*
AE-036175	*Detail of Heavy Welding Boss for Threaded Connections to Vessels and Lines*
AB-036521	*Bridge Weld and Typical Brace Seal Welded and Socket Welded Valves on Process Lines*

Saudi Aramco Library Drawings

DC-950045	*Standard Instrument Standpipe*
DB-950046	*Instrument Piping Detail for Liquid Level Gauge Glasses*
DB-950047	*Instrument Piping Details for Pneumatic Level Instruments*
DB-950048	*Standard Instrument Piping Details for Electric Level Instruments*

3.2 Industry Codes and Standards

American Petroleum Institute (Manual of Petroleum Measurement Standards)

API MPMS 3.1A	*Standard Practice for Manual Gauging of Petroleum and Petroleum Products in Stationary Tanks*
API MPMS 3.1B	*Standard Practice for Level Measurement of Liquid Hydrocarbon in Stationary Tanks by Automatic Tank Gauging*
API MPMS 3.3	*Standard Practice for Level Measurement of Liquid Hydrocarbon in Stationary Pressurized Storage Tanks by Automatic Tank Gauging*
API MPMS 7.4	*Static Temperature Determination Using Fixed Automatic Tank Thermometers*
API MPMS 12	*Calculation of Petroleum Quantities*
API MPMS 16.2	*Mass Measurement of Liquid Hydrocarbons in Vertical Cylindrical Storage Tanks by Hydrostatic Tank Gauging*

American Society of Mechanical Engineers

ASME B1.20.1	*Pipe Threads, General Purpose (Inch)*

National Fire Protection Association

NFPA 70	*National Electrical Code*

4 General Design Requirements

All level measurement components and systems shall be suitable for continuous operation in environmental conditions specified in SAES-J-003, section 8.

4.1 Location and Orientation

Local instruments shall be accessible at grade level or from a platform. Gauge glasses shall be accessible from grade level, platform or fixed ladder. Standpipe and individual level instruments shall be connected directly to vessels and not to inlet or outlet piping. All connections shall be free draining. Connections to the bottom of vessels shall be avoided whenever possible, and shall not be used when settlement of solids may be expected. Local receiving instruments shall be installed 1.40 m above grade level. Access requirements shall meet SAES-B-054.

The design of all level instruments shall include an associated local gauge glass to allow range checking and visual level verification over the calibrated range of the instrument.

4.2 Taper Thread Requirements

All taper threads shall be in accordance with ASME B1.20.1.

4.3 Welding Bosses

Connections to vessels or standpipes shall be made with Type II, heavy welding bosses, as shown on Saudi Aramco Standard Drawing AE-036175.

4.4 Block Valves

Capability to isolate each individual instrument from the process shall be provided by an instrumentation root valve installed as close as possible to the vessel or standpipe connection. No fittings shall be allowed between this primary block valve and the connecting boss, except for a single pipe nipple. The root valves shall meet the requirements specified in SAES-L-008, section 7.11. Threaded connections between the root valve and the boss shall be seal or bridge welded per Saudi Aramco Standard Drawing AB-036521.

4.5 Standpipes

4.5.1 When several instruments are required on a vessel, a common standpipe shall be used. However, shutdown devices, such as dedicated level switches, shall be directly connected to the vessel. Standpipe connections shall be located per paragraph 4.1. For details of a typical standpipe refer to Saudi Aramco Library Drawing DC-950045.

4.5.2 Standpipes on spheroids, shall be fabricated from 6 inch (NPS) carbon steel pipe. Standpipes shall be supported from the spheroid shell. Standpipe connections to the spheroid shall be made by a 2 inch and a 3 inch isolating gate valve, located at the top and bottom of the standpipe, respectively. Both valves shall be in the lock-open (LO) position and car sealed.

4.5.3 Standpipes shall be insulated when the operational temperatures ranges are either above 70°C or below 0°C.

Commentary Note:

Standpipes shall not be used in low temperature service, i.e., -7°C or below.

4.5.4 Standpipes shall not be used on packed towers, across filter pads, demister pads, in viscous service and in applications where materials being handled contain high concentrations of solids.

On special applications, such as liquid-liquid interface measurement, standpipe to vessel connections shall be located as shown on the applicable piping and Process and Instrumentation (P&ID) drawings.

4.6 Saudi Aramco Library Drawings may be used as a guide for drafting special drawings, when existing Saudi Aramco Standard Drawings are not applicable. Individual drawings may be required for such reasons, as special process conditions, services, material requirements or installation requirements. Special drawings may be created from the library drawings, without a waiver.

4.7 Electrical

The electrical area classification shall be determined as per SAES-B-068.

5 Gauge Glasses

5.1 General Application

5.1.1 Gauge glasses in hydrocarbon service shall be transparent or reflex type heat-resistant glass with chambers machined from solid bar alloy steel and with drop-forged alloy steel covers. Illumination shall be provided to all gauges installed in poorly lighted areas. Illumination shall also be provided to all gauges where precise level readings are vital for safe operation of the process.

5.1.2 The pressure and temperature ratings of the gauge glasses shall be equal to or higher than the vessel design pressure and temperature. Minimum rating for the reflex type shall be 14,000 kPa (2,000 psig) at 40°C, and for the transparent type 7,000 kPa (1,000 psig) at 40°C.

5.1.3 Gauge glass gaskets shall be graphoil or graphite-impregnated type material. The gasket material must be asbestos-free and capable of sealing under the continuous pressure and temperature conditions set forth in paragraph 5.1.2.

5.2 Low Temperature Applications

5.2.1 Gauge glasses, in low temperature or low boiling point service, shall be large chamber reflex type with ¾ inch female NPT top and bottom connections. Two-inch flange connections may be used when justifiable.

5.2.2 Large chamber reflex gauges shall have a pressure rating of at least 1.25 times the vessel design pressure at the vessel design temperature.

5.2.3 Large chamber gauge glasses shall be supplied to the required single length dimension whenever possible instead of the manufactures standard lengths.

5.2.4 Frost gauges shall be specified for low temperature service below -7°C. Lucite frost shields shall be included and shall extend through the gauge glass insulation.

5.3 Limitations

5.3.1 Gauge glasses shall not be used on refrigerated storage tanks. Refer to SAES-B-057.

5.3.2 For pressurized storage vessels, gauge glasses shall be installed only if required for calibration of other instruments. The gauge glass shall be a single 320 mm gauge with ball check gauge cocks, except as limited in paragraph 5.3.3. The gauge glass shall be installed at the elevation required to calibrate the other instrument. The other instrument may be local or remote indicating.

5.3.3 Ball check type gauge cocks shall not be used in dirty services where waxy or gummy components exist and deposition can lead to potential blockage of the ball check flow passages. For corrosive service, the gage cock body and trim shall be made from corrosion resistant alloys which are compatible with the process fluids. The minimum requirement for corrosive service is stainless steel stem, seat and ball check.

5.4 Reflex Gauges

Reflex gauges shall be used on all clean services, except for liquid interface level. Weld pad type reflex gauges shall be used only in ambient temperature and atmospheric pressure applications.

5.5 Transparent Gauges

Transparent gauges shall be used for acid, caustic, dirty or dark-colored liquids, liquid interface, high viscosity fluids, high-pressure steam applications above 2100 kPa (300 psig), and for NGL with specific gravities less than 0.55. Suitable shields (mica, etc.) on the inside of the gauge shall be considered for steam, caustic and other fluids that may adversely affect glass.

5.6 Tubular Gauges

Tubular gauges shall not be used in hydrocarbon service. They may be used only in water or non-critical service applications, where the pressure is below 350 kPa (50 psig) and the temperature below 95°C. Tubular gauges shall not be used in fire water applications.

5.7 Installation

5.7.1 Gauge glass connections shall be top and bottom ¾ inch NPT taper thread or RF flanges for service rated for class 600. Minimum vessel connections shall be ¾ inch NPT. Vent and drain connections shall be a minimum 3/8 inch NPT.

5.7.2 Multiple gauge glass installations, which are designed to cover long level ranges, shall be designed to include a standpipe and overlapping gauge glasses. For additional details of typical installations, refer to Saudi Aramco Library Drawing DC-950046, Detail 4.

Gauge glasses, installed on the 6 inch spiral standpipe of spheroids, shall be visible and accessible from the stairway and shall have no traps in the piping.

5.7.3 Gauge cocks shall be provided on gauges installed in steam condensate, non-corrosive liquids and light clean hydrocarbon (e.g., naphtha and lighter compounds) service. The Gauge cocks provide shut off capabilities in the event of a gauge glass failure. The gauge cock shall be a ball check offset type with ¾ inch NPT male union, vessel or standpipe connection, ¾ inch NPT female gauge connection and ½ inch NPT female drain or vent connection. For additional details refer to Saudi Aramco Library Drawing, DC-950046. See paragraph 5.3.3 for limitations.

6 Magnetic Type Level Gauges

6.1 Application

6.1.1 A magnetic type gauge shall be used for services in which:

a) Gauge glass assemblies are not recommended for the measurement of dangerous or toxic fluids;

b) Glass breakage would be likely;

c) Gauge readings are not always visible because of the nature of the fluid being observed.

6.1.2 Magnetic gauge assembly shall be installed only in areas that are free of physical forces or materials that would adversely affect the magnetic operation of the system.

6.2 Installation

For gauge glasses in corrosive service, the top and bottom connections shall be ¾ inch female NPT or larger. Flanged connections are also acceptable. Standard assemblies shall be rated for 2,800 kPa (400 psig) and 230°C service. Refer to Saudi Aramco Library Drawing DC-950046.

7 Displacement Type Instruments

7.1 Application

7.1.1 Displacement type instruments may be used for liquid level ranges up to and including 1,830 mm. Use of this technology shall be limited to non-viscous process fluids with low concentration of solids. Displacement instrument shall be considered only if it can deliver superior performance over the differential pressure devices.

Commentary Note:

Distinction must be made between displacement and float devices. Displacers elements are heavier than the liquid being measured, and remains stationary. The measurement signal is derived from the buoyancy effect due to immersion in a liquid. A float device on the other hand, moves with the liquid level and the measurement signal is derived from the float motion or position. The 1830 mm restriction applies only to displacers.

7.1.2 Internal displacement type instruments shall be used where the process requires the primary element to be at the same temperature as the vessel liquid; where high sensitivity is required, where the density difference between liquid interface is small, or where the vessel can be opened for maintenance requirements without process interruption or hazard.

7.1.3 Displacement type instruments shall not be used in highly corrosive services or services where salts or other deposits may precipitate onto the sensing elements or on the walls of the sensing chamber.

7.1.4 The displacer shall be installed vertically. The center of the displacer shall be at the elevation at which the level in the vessel is to be maintained.

7.1.5 An air-fin extension shall be provided between the level sensing element and the transmitter, for applications where fluid temperatures will exceed 200°C.

7.2 External Displacement Type

7.2.1 Materials

Displacer chambers and torque tube housings shall be steel. Cast iron shall not be used. Displacers shall be 316 stainless steel with 316 stainless steel or Inconel torque tubes. For low temperature and other severe service applications materials compatible with the process shall be specified on the ISS.

7.2.2 Connections

Displacer chambers shall have 1½ inch NPT or 2 inch flanged connections. All displacer chambers shall have a rotatable head flange. All chambers shall be provided with a top flange to facilitate cleaning and removal of the displacer. For additional details on piping connections refer to Saudi Aramco Library Drawing, DC-950047.

7.3 Internal Displacement Type

7.3.1 Materials

Mounting flanges and torque tube housings shall be steel. Cast iron shall not be used. Displacers shall be 316 stainless steel with 316 stainless steel or Inconel torque tubes. For low temperature and other severe service applications materials compatible with the process shall be specified on the ISS.

7.3.2 Mounting

Side mounting instruments are preferred for tall vessels. A mounting flange shall be provided on the vessel for top-mounted instrument installation.

7.3.3 Installation

Internal displacement type instruments shall have ample clearance for removal of the displacer and rod. Provisions should be made on the vessel for access to the internal parts, e.g., a manhole. An internal stilling well of sufficient diameter shall be provided in the vessel to prevent hang-up of the displacer. Internal displacement type

instruments shall not be used in vessels where high turbulence is expected.

7.4 Displacer Transmitters

Microprocessor based smart transmitters shall be provided with all displacer units. The use of pneumatic transmitters is permitted only for local indication and control.

8 Automatic Tank Gauging (ATG) Systems

For large stationary tanks where the primary purpose of ATG is accurate level and volume determination, a direct level measuring device, such as Radar Tank Gauging (RTG), shall be applied. For applications where static mass measurement and on-line observed density is needed, a pressure based system, such as Hydrostatic Tank Gauging (HTG), shall be selected. Inferential calculation of level from mass and vice-versa are prone to errors and shall be permitted only when the accuracy of the inferred level is not of primary concern.

Only devices with no moving parts, proven Mean Time between Failure (MTBF) in excess of 50 years and a Mean Time To Repair (MTTR) of less than two (2) hours, shall be considered.

8.1 Radar Tank Gauging

8.1.1 Application & Installation

The RTG technology shall be used for all hydrocarbon service requiring level and level-based volume for tank farm operations. The selection of the RTG antenna shall be as follows:

8.1.1.1 Fixed Roof Tanks without Still Pipe

Cone or planar type microwave antennas shall be used on all clean products. The antenna shall be installed such that the microwaves can travel un-obstructed to the tank bottom. Obstacles, such as pipes and mixers, must not be present in the Radar beam spread. The Radar beam spread calculations must be performed to determine interference. If the radar beam touches the tank wall when the antenna axis is along the vertical plumb line, the antenna must be inclined away from the tank wall to eliminate the interference. The maximum permitted inclination shall be within vendor's specifications.

For condensing products that result in heavy deposits (e.g., asphalt & fuel oils), the antenna design shall be such that minor deposits or condensation will not disrupt level measurement accuracy. A parabolic antenna shall be used in such applications. A cleaning hatch or means to quickly remove and clean the antenna shall be provided. The selection of antennas and installation details must be reviewed and concurred by the selected vendor.

8.1.1.2 Floating Roof or Internal Floating Pan Tanks with Still Pipes

RTG especially designed to operate within a still pipe shall be utilized. For tanks at atmospheric pressure, the microwave transition cone shall be available for still pipes ranging from 6 to 12 inch, nominal pipe sizes. The gauge shall use low loss circular microwave transmission mode to eliminate measurement errors due to corrosion of the still pipe interior wall.

8.1.1.3 Spheroid Or Pressurized Tanks

RTGs, especially designed for LPG/LNG service, shall be mounted on a 4 inch NPS still pipe. The still pipe minimizes the impact of waves and surface boiling on the measurement accuracy. To compensate for composition changes in the vapor space, pressure and temperature measurements are mandatory. This will lead to higher and more consistent measurement accuracy.

In pressurized tanks, the vapor space generally consists of 100% concentration of hydrocarbon vapors. The microwave propagation, and consequently the level gauging accuracy, is significantly affected by the vapor concentration or density. The selected gauge must have proven algorithms for real time compensation of the observed level. Pressure and temperature sensors shall be provided per gauge vendor's specifications. The vapor pressure-temperature relationship must be known by the user for the successful implementation of the RTG installation.

The bottom datum plate and vendor supplied reference pins shall be installed on the still pipe to permit on-line calibration and future verification of the level. The number

of pins and the placement of the pins shall be in accordance with the vendor's recommendation. However, at least one verification pin must be placed above the maximum working level of the tank to permit on-line calibration checks when the tank is full. The orientation of the reference pins shall be permanently marked on the still pipe flange and shall be within ± 2 degrees.

Isolation block and bleed valves shall be provided to facilitate safe removal of the gauge head for in-service maintenance. Refrigerated LPG tanks shall be provided with two (redundant) automatic tank gauging systems.

For additional guidance, please refer to API MPMS 3.3.

8.1.1.4 Still Pipe Design for Atmospheric Tanks

For all new construction, the still pipe shall be fabricated from seamless, 8 inch NPS, schedule-40, carbon steel pipe. Pressure equalization slots or holes must be provided. The holes shall be placed on a single vertical line on the still pipe. For optimum accuracy, the size and the number of vent slots must not exceed the values recommended by the selected vendor. The still pipe shall be straight. The interior wall shall be smooth and free from burrs or any discontinuity of the inner diameter. The still pipe design shall be in compliance with the selected RTG vendor's recommendations.

For upgrade projects existing still pipes, from sizes 6 to 12 inches NPS are acceptable, for upgrade projects, provided the vent slots total area does not exceed vendor's recommendations for a specified level measurement accuracy and the still pipe design and condition is approved by the selected vendor. The condition of the still pipe effects measurement accuracy. Replacement should only be considered if the assessed condition of the pipe will impact the desired measurement accuracy stated in the project proposal. RTGs shall not be installed on existing still pipes used for hand dips.

The still pipe shall be guided at the top of the tank. The lower gauge well attachment to the tank shell or the tank bottom shall be such that minimum deflection will result due to hydrostatic tank deformation. The still pipe must be

vertical within 1.0 degree from the plumb line. For details refer to Saudi Aramco Standard Drawing, AA-036256 and API MPMS 3.1B, Section 3.6.2, Still Pipe Design.

8.1.1.5 Still Pipe Design for Pressurized Vessels

For all applications, the still pipe shall be fabricated from seamless, 4 inch schedule-10, 316 stainless steel pipe. Pressure equalization slots or holes must be provided. The holes shall be placed on a single vertical line on the still pipe. For optimum accuracy, the size and the number of vent slots must not exceed the values recommended by the selected vendor. The still pipe shall be straight, the interior wall shall be smooth and free from burrs or any discontinuity of the inner diameter. The still pipe design, slots size and pitch shall be in compliance with the selected RTG vendor's recommendations.

The still pipe shall be suspended from the top of the vessel. The lower end of gauge well may be attached to tank shell in a manner that permits vertical deflection due to hydrostatic tank deformation. The still pipe must be vertical within 1.0 degree from the plumb line. On large spheroids, means of checking and vertical alignment of the still pipe shall be provided.

A bottom deflector plate shall be installed to minimizes echo effects. The lower end of the still pipe shall be within 300 mm from the bottom of the vessel.

8.1.1.6 Gauging Hatch

For all atmospheric tanks, a reference gauge hatch must be provided in close proximity to the RTG, for manual ullage measurements and periodic accuracy verification. The RTG mounting and the reference gauge hatch shall be mechanically and rigidly connected to prevent errors due to differential movements. On a still pipe gauge, if the RTG design permits easy removal of the microwave transition cone, the RTG flange may be used as a gauging port.

8.1.1.7 Free Space Requirements

For initial installation and subsequent maintenance of all gauges, sufficient space above the tank in the X-Y-Z planes

shall be provided to facilitate easy removal of the gauge. These dimensions should be in accordance with the vendor's recommendations.

8.1.2 Product Temperature Measurement

Permanently installed, multiple spot temperature elements shall be used whenever the functional specification requires automatic computation of Gross Standard Volume (GSV) or Net Standard Volume (NSV). The number of averaging elements will depend on the tank height, temperature stratification and accuracy requirement. The field mounted data acquisition unit shall be capable of automatically averaging the temperature of the submerged probes.

The installation shall be per API MPMS 7.4, "Static Temperature Determination Using Fixed Automatic Tank Thermometers."

8.1.3 Local Indicators

An electronic local digital indicator shall be provided at the grade level. The indicator shall display the liquid level in meters-cm-mm or in ft-in-16th graduations and the product temperature when applicable, in user configurable units. The local indicator shall be installed 1.4 m above grade level.

8.1.4 Hazardous Area Classification

The specification for all equipment and installation of conduits and cables shall meet or exceed the area classification requirements, as per SAES-B-068. All enclosures and conduit sealing shall comply with section 5, SAES-J-902, "Electrical Systems for Instrumentation".

8.1.5 Intrinsic Accuracy

For high accuracy applications, the laboratory tested accuracy of the gauge shall be equal to or better than ± 1 mm over the entire range of the RTG. Vendors shall provide certification from a recognized international agency, such as the Dutch NMI or the German PTB, to support their claims. Installed accuracy is governed by section 8.3.

For general service, the laboratory tested accuracy of the gauge shall be equal to or better than ± 6 mm over the entire range of the RTG. Vendors shall provide certified test data to support their claims.

8.1.6 Operator Interface Unit

A Personal Computer (PC) based Man Machine Interface (MMI) and an industrial grade printer, shall be provided whenever the RTG system is not directly interfaced with a plant Digital Control System (DCS) or a host computer. The MMI shall be capable of handling configuration data, tank level displays and alarming functions.

8.1.7 Configuration

The RTG shall be configurable via the field bus from a control room installed personal computer or the plant host computer, running vendor compatible tank farm management software. No external (mechanical) zero or span adjustments are permitted. For single or stand alone installations without a field bus, calibration with a hand held programming device is acceptable.

8.1.8 Signal Transmission and Communication System

The vendor supplied communication system(s), which transmits data from the gauges to the remote operator interface unit via field mounted data acquisition units, shall utilize error detection techniques such that communication faults will not result in erroneous process data. Hardware design should provide galvanic isolation and interference filtering. The system architecture shall be flexible to accommodate modular expansion of tank gauging from one to 150 tanks.

The standard data acquisition unit or its equivalent shall be capable of interfacing with pressure and temperature signals without any additional hardware. These signals shall be integrated on the vendor supplied field bus. The communication system must not compromise the inherent accuracy of the measurement output signals. The process data displayed at the field indicator shall be the same as the data in the operator interface unit, in the control room. The data transmission system must have adequate speed to meet the update time required by the project specifications.

8.1.9 Data Security

The RTG shall be equipped with either a hard or soft switch, such that after the commissioning activities are completed the tank configuration data in the Erasable Programmable Read Only Memory (EPROM) at the gauge head, can be protected from accidental erasure. The tank management software shall have a password protection scheme to prevent accidental changes in the tank configuration data.

8.1.10 Stand Alone Operation

The RTG shall have the capability to operate in a stand alone mode and display level and temperature data on the local indicator without any assistance from the operator interface unit located in the control room and the tank management software installed in the PC.

8.1.11 Plant Host Computer Interface

The Operator Interface PC, equipped with the tank inventory management software, shall be capable of interfacing with a plant host computer via Modbus protocol. Alternatively, the field communication units shall be capable of interfacing directly with the host computer.

8.1.12 Safety Requirements

The RTG, during normal operation, bench testing or field service, shall not generate microwave power levels hazardous to humans. The maximum power level as per API MPMS 3.1B, Appendix B.2.4.2, shall not exceed 2 milliwatts. The RTG shall have approval from the Federal Communication Corporation (FCC, USA) and the Saudi Arabian Standards Organization (SASO). The vendor shall provide certification documentation to Saudi Aramco, upon request. For additional guidance refer to API MPMS 3.3, paragraph 2.2.

8.1.13 Power Supply and Wiring

Instrument power supply, signal and control wiring shall be in accordance with section-6 and section 7, SAES-J-902, "Electrical Systems for Instrumentation". For Intrinsically Safe (IS) systems, the design and installation shall be as per in SAES-J-903, "Intrinsically Safe Systems".

In addition, a local power disconnect switch, which is easily accessible to an Operator shall be provided at the gauge head.

8.2 Hydrostatic Tank Gauging

8.2.1 Application & Installation

HTG shall be applied to all applications where liquid products are stored and transferred by weight and/or on-line observed density measurement is required. This technology may be applied to LPG and chemicals, whenever these products are moved and traded by weight units only. Tank geometry must be precisely known to provide

accurate mass inventory management. Errors in calculating tank equivalent area will lead to significant errors in mass calculation. Inferential liquid level may be calculated from mass. However, the primary measurements are mass and density.

The HTG technology shall not be used for applications where level or level-based volume (from strapping table) is used for custody transfer, oil movement and storage. HTG shall not be applied in plants where the primary source of verification of the ATG system is based on manual level (hand-dip) measurements.

The design of Hydrostatic Tank Gauging systems for atmospheric tanks with or without floating roof, shall be governed by, API MPMS 16.2, "Mass Measurement of liquid Hydrocarbons in Vertical Cylindrical Storage Tanks By Hydrostatic Tank Gauging". The requirements stated in sections 8.2.2, 8.2.3 and 8.2.4, shall supplement the referenced MPMS.

8.2.2 Pressure Sensor Accuracy

The accuracy of the smart pressure transmitters shall be within ± 0.02% of the upper range value, at ambient temperature range between 0 - 70°C. This includes zero and span drifts over a six-month period. The accuracy shall be de-rated as per manufacture's recommendations when the process temperature is greater than 70°C.

8.2.3 Sensor Placement

The placement of pressure and temperature sensors shall be in accordance with API MPMS 16.2, Section 6. In addition, the following supplementary information shall apply:

- The horizontal centerline of the bottom pressure sensor, P1, shall be above the water bottom. Whenever possible, the P1 centerline should be aligned with the datum plate center line, which is the zero operating level but not the minimum tank level.

- The middle pressure sensor, P2, shall be located at a minimum distance of 2.4 m above the P1 transmitter. However, 3 m is preferred. For the low range transmitter, 0-62 kPa (0-9 psi) a minimum of 1.2 m is permissible if 2.4 m is not practical.

- The top transmitter, P3, shall be provided only for tanks operating above atmospheric pressure. The transmitter shall be mounted in a self draining orientation.

- Transmitters P1, P2 and the temperature probe shall be located on the same vertical line on the tank side. This vertical line shall be located approximately 90° from tank fill and discharge nozzles.

- All pressure transmitters shall be mounted to the tank nozzles with a 2 inch, ASME Class 150, raised face flanges. The tank nozzles shall be fabricated from 2 inch schedule 80 pipe. The tank nozzles shall be welded in exactly horizontal direction to facilitate draining.

8.2.4 HTG Processor

The microprocessor based, field mounted Hydrostatic Interface Unit, receives pressure and temperature signals and calculates mass, density, volume and level from standard HTG equations. The user may, when cost effective, terminate the pressure and temperature signals directly into a Distributed Control System (DCS). Computation of mass, density, volume and level shall be performed by the DCS from standard HTG equations. In this case, the Hydrostatic Interface Units will not be required.

8.3 Accuracy and Calibration Requirements

8.3.1 Atmospheric Tanks

The installed accuracy and field calibration requirements for an ATG system, is specified in API MPMS 3.1B, Section 1B.4. The installed accuracy of the ATG must be verified by comparing the level readings against manual gauging. Manual gauging shall comply with API MPMS 3.1A.

8.3.2 Pressurized Tanks

The ATG shall be calibrated by reading the known ullage of the reference pins or similar verification device. During calibration, at least one reference pin shall be above the liquid level. The reference pin shall be mechanically located with a maximum uncertainty of ± 1 mm. The ullage readings for each pin shall be recorded in the instrument specification sheets. Prior to commissioning or introduction of hydrocarbon to the pressure vessel the RTG must be capable of reading the reference pins with an accuracy of ± 1 mm. A series of three consecutive reading of the reference pins by the RTG must agree within ± 1 mm with a maximum spread of ± 3 mm.

8.3.2.1 The installed accuracy is considered suitable for high quality measurements if the maximum spread between three

consecutive level measurement at three different tank levels is within 3 mm and the maximum deviation between the average readings from the current verification does not exceed the average from the past verification by 3 mm.

8.3.2.2 The installed accuracy is considered suitable for general level measurement if the maximum spread between three consecutive level measurement at three different tank levels is within 12 mm and the maximum deviation between the average readings from the current verification does not exceed the average from the past verification by 25 mm.

8.3.3 The installed accuracy of the automatic temperature measurement system shall be within ± 0.25°C of the reference thermometer. Calibration and verification shall be as per API MPMS 7.4, paragraph 6.

8.3.4 The installed accuracy of the automatic on-line mass measurement system shall be within ± 0.1% of reading, for atmospheric cylindrical tank. For pressurized spherical vessels, an error of ± 0.5% of reading is acceptable.

The installed accuracy of the automatic on-line density measurement system, at reference temperature, shall be within ± 0.25% of reading for atmospheric cylindrical tank. For pressurized spherical vessels, an error of ± 0.5% of reading is acceptable.

8.4 Water Tanks

For water storage tanks, float-and-cable type instruments with counter weight and gauge board are acceptable. Differential pressure instruments shall be used whenever the level signal is transmitted to the control room. Refer to section 10.

8.5 Independent High High Level Alarms

8.5.1 A High High (HH) level switch shall be provided on all atmospheric hydrocarbon storage tanks. This switch shall activate an independent HH level alarm in the control room and if required, either divert the incoming flow or close the inlet valve per requirements specified by the proponent organization. The HH alarm and switches shall be independent of alarms generated by the automatic tank gauging system. The alarm system for this application shall be fail-safe or self-checking. The alarm set point on the level gauging system shall be selected such that approximately ten minutes time interval is available before the HH level is reached. The interval computation shall be based on nominal fill rate.

8.5.2 For pressurized or refrigerated hydrocarbon vessels, requirements specified in SAES-B-057, section 6 shall apply.

Commentary Note:

This requirement is applicable to all new construction and major tank farm Instrumentation upgrade projects. This requirement is not retroactive to existing facilities. However, the Safe Operating Committee (SOC) for each effected plant should evaluate potential exposure, risk and the need to add the HH level alarm provision.

9 Ball-Float Controllers

Application

Ball float controllers are acceptable only for air conditioning plants, water basins and non-critical utility services. They shall not be used for level control in process vessels.

10 Differential Pressure Type Instruments

10.1 Application

Differential pressure type instruments are preferred for most process level and for liquid-liquid interface level measurements. Transmitters with diaphragm seals are recommended for process fluids that are extremely viscous, containing entrained solids or in hot service.

10.2 Calibration

The instruments shall be calibrated for the anticipated operating density of the liquid in the vessel.

10.3 Purge System

In highly corrosive or viscous liquid services, a purge system may be considered where the addition of clear liquid or gas into a vessel is acceptable.

10.4 Local Indicators

Analog or digital indicators shall be provided for each level instrument. The selection of analog or digital technology shall depend on the proponent's requirements. This selection shall be specified on the Instrument Specification Sheets. The scale range for the analog indicators shall be from 0 to 100% of measured level range. The digital indicators shall display the liquid level in meters-cm-mm, graduations. The local indicators shall be installed 1.4 m above the grade level. The Local indicators shall meet the hazardous area classification and have a weatherproof case.

10.5 Transmitters

All transmitters used for level service shall be smart and microprocessor based. The instrument shall have a ½ inch NPT process connections, a universal pipe mounting bracket, a minimum body rating of 10,500 kPa (1,500 psig), and over range protection that is equal to or better than the body pressure rating. Meter body and sensing element isolation diaphragm material shall be minimum type 316 stainless steel. Hasteloy C and Monel shall be used whenever process fluid compatibility demands such materials. Output ranges shall be in accordance with SAES-J-003.

10.6 Installation

10.6.1 For open tanks, only the connection of the high pressure process connection is required. The low pressure connection of the instrument shall be protected from the entry of the dust and other airborne contaminants.

10.6.2 Instruments in wet and dry leg service shall be mounted at or below the lower vessel connection, preferably 1.4 m above grade level or operating platform. For additional details of typical wet and dry leg installations refer to Saudi Aramco Library Drawings, DC-950047 and DC-950048.

10.6.3 On vessels subject to rapid changes in level, such as gas-oil separating vessels, adjustable pulsation dampening in the transmitter or transmitter output may be required to improve stability.

10.6.4 For refrigerated LPG service, differential pressure level transmitters shall be installed above the process connections with dry pressure sensing legs. The pressure sensing legs shall be sufficiently heated so that any fluid in the sensing lines remains in a gaseous state at all times. Use of DP transmitter for refrigerated LPG tank level service, should be considered only when no other level measurement systems is feasible or as a secondary level measurement.

10.6.5 A diaphragm seal type installation shall include drain valves on the downstream side of the vessel process block valves, on both high and low pressure sides to allow in-place calibration of the transmitter.

11 Level Switches

11.1 Application

11.1.1 Emergency Shutdown

A dedicated float or displacer type level switch shall be used whenever analog level transmitters are not practical for the intended process. Emergency shutdown functions shall not be combined with control functions, refer to SAES-J-601, section 6.4 for details.

11.1.2 Alarms

Secondary devices, actuated by the output of a level transmitter, may be used for alarms.

11.1.3 On-Off Control

Internal tandem type displacement switches may be used for start-stop of pumps, open-close control of valves, initiation of high-low alarms, or combinations of these functions.

11.2 External Float Switch

11.2.1 External level switches shall be supplied with steel float chambers, having a flanged closure for internal inspection. The minimum flange rating for the float chamber shall be ASME class 300. Float and trim material shall be 316 stainless steel or as otherwise specified in the instrument specification sheet. Process connections shall be minimum 1 inch NPT.

11.2.2 For non-corrosive service, a magnet-type actuated switch is acceptable. Switches with packed gland connections between float and switch shall not be used.

11.2.3 Chamber materials, in wet sour service, shall comply with the requirements of SAES-A-301.

11.3 Internal Displacement Switch

11.3.1 Internal displacement switches shall have a steel flange for top mounting on vessel. Cast iron flanges shall not be used. Flange rating shall be equal to or higher than the vessel design pressure and temperature, but shall be minimum ASME class 150. Displacer and cable material shall be type 316 stainless steel. However, other displacer materials may be used if required by process conditions.

11.3.2 Internal displacement switches shall not be used for installation in refrigerated LPG tanks or similar low temperature applications.

11.4 Installation

11.4.1 Each external float switch shall have its own individual vessel or standpipe connections. The float or displacer chamber shall be installed with the longitudinal axis vertical. For details of typical installations refer to Saudi Aramco Library Drawings, DC-950047 and DC-950048.

11.4.2 Internal displacer switches shall be flange-mounted on top of the vessel. A mating flange shall be provided on the vessel. Clearance shall be provided for removal of the displacers. An internal stilling well shall be required for applications where liquid turbulence is excessive. The inside diameter of the stilling well shall be at least 25 mm larger than the displacer diameter. The stilling well shall be open at the bottom end and shall have a vent hole located above maximum level.

Level switch contacts shall be hermetically sealed or totally encapsulated. Switch contacts shall be wired in a fail-safe, de-energize to trip design. For example, contacts shall be closed during normal process levels. The contacts shall open at abnormal levels, to alarm or shutdown.

12 Capacitance-Type Instrument

12.1 Application

12.1.1 Capacitance-type level instruments shall be considered only where differential pressure or displacer type level devices are not suitable. Capacitance probes shall not be used in liquids that contain entrained gas.

12.1.2 Capacitance probes shall not be used as primary emergency shut-down devices.

12.1.3 Automatic temperature compensation shall be provided in probe circuitry for liquids in which the dielectric constant changes as a function of temperature.

12.2 Installation

12.2.1 Side mounting instruments shall be considered only for point level applications or for very large vessels. Capacitance level measurement probes must be top mounted. Probe length and mounting requirements shall be in accordance with manufacturer's instructions.

12.2.2 The preferred vessel installation is with a sealed isolating valve to allow the probe to be removed without releasing the process pressure.

12.2.3 The probe shall be installed so that it is not affected by the filling stream. If this is not feasible, the probe shall be protected with a shield or baffle.

13 Non-Contact Instruments

Newer technologies such as ultrasonic, microwave and process radar gauges may be applied as an alternative to conventional level measurement devices whenever these technologies can demonstrate proven track record. Use of non-contact instruments requires approval by the Supervisor, Instrumentation Unit, Process Instrumentation Division, Process & Control Systems Department. The manufacturer shall concur with the application and the installation.

Revision Summary

30 April 2003	Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with minor revisions.
30 March 2005	Editorial revision to replace NACE MR0175 with newly approved SAES-A-301.