



# Engineering Standard

SAES-J-300

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Level

Document Responsibility: Instrumentation Standards Committee

## Saudi Aramco DeskTop Standards

### Table of Contents

1	Scope.....	<a href="#">2</a>
2	Conflicts and Deviations.....	<a href="#">2</a>
3	References.....	<a href="#">2</a>
4	General Design Requirements.....	<a href="#">4</a>
5	Sight Level Gauge Glasses.....	<a href="#">7</a>
6	Magnetic Level Indicator Gauges (MLI).....	<a href="#">9</a>
7	Guided Wave Radar (GWR) Level Transmitters.....	<a href="#">11</a>
8	Differential Pressure Level Transmitters.....	<a href="#">12</a>
9	Displacement Level Transmitters.....	<a href="#">14</a>
10	Capacitance Level Transmitters.....	<a href="#">16</a>
11	Level Switches.....	<a href="#">16</a>
12	Level Instrument Restrictions.....	<a href="#">18</a>
13	Radar Tank Gauging (RTG) Systems.....	<a href="#">18</a>

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Revised paragraphs are indicated in the right margin

Primary contact: Abdul Razak, Mokhtarudin on +966-3-8801303

Page 1 of 24

## 1 Scope

- 1.1 This standard prescribes minimum mandatory requirements governing the design of process level measurement and radar tank gauging systems.
- 1.2 The Radar Tank Gauging portion of this standard is not intended for custody measurement.

## 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-B-054](#)                      *Access, Egress, and Materials Handling for Plant Facilities*

[SAES-B-057](#)                      *Safety Requirements: Refrigerated and Pressure Storage Tanks & Vessels*

[SAES-J-002](#)                      *Regulated Vendor List for Instruments*

[SAES-J-003](#)                      *Instrumentation-Basic Design Criteria*

[SAES-J-601](#)                      *Emergency Shutdown and Isolation Systems*

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<a href="#"><u>SAES-J-902</u></a>	<i>Electrical Systems for Instrumentation</i>
<a href="#"><u>SAES-J-903</u></a>	<i>Intrinsically Safe Systems</i>
<a href="#"><u>SAES-J-904</u></a>	<i>FOUNDATION™ fieldbus (FF) Systems</i>
<a href="#"><u>SAES-L-108</u></a>	<i>Selection of Valves</i>
<a href="#"><u>SAES-P-100</u></a>	<i>Basic Power System Design Criteria</i>

#### Saudi Aramco Standard Drawings

<a href="#"><u>AA-036256</u></a>	<i>Radar, Temperature and Manual Gauging Assembly for Floating Roof Tanks</i>
<a href="#"><u>AE-036175</u></a>	<i>Detail of Heavy Welding Boss for Threaded Connections to Vessels and Lines</i>
<a href="#"><u>AB-036521</u></a>	<i>Bridge Weld and Typical Brace Seal Welded and Socket Welded Valves on Process Lines</i>

#### Saudi Aramco Library Drawings

<a href="#"><u>DC-950045</u></a>	<i>Standard Instrument Standpipe</i>
<a href="#"><u>DB-950046</u></a>	<i>Instrument Piping Detail for Liquid Level Gauge Glasses</i>
<a href="#"><u>DB-950047</u></a>	<i>Instrument Piping Details for Pneumatic Level Instruments</i>
<a href="#"><u>DB-950048</u></a>	<i>Standard Instrument Piping Details for Electric Level Instruments</i>

### 3.2 Industry Codes and Standards

#### American Petroleum Institute (Manual of Petroleum Measurement Standards)

<i>API MPMS 3.1A</i>	<i>Standard Practice for Manual Gauging of Petroleum and Petroleum Products</i>
<i>API MPMS 3.1B</i>	<i>Standard Practice for Level Measurement of Liquid Hydrocarbon in Stationary Tanks by Automatic Tank Gauging</i>
<i>API MPMS 3.3</i>	<i>Standard Practice for Level Measurement of Liquid Hydrocarbon in Stationary Pressurized Storage Tanks by Automatic Tank Gauging</i>
<i>API MPMS 7</i>	<i>Temperature Determination</i>
<i>API MPMS 12.1.1</i>	<i>Calculation of Petroleum Quantities</i>

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American Society of Mechanical Engineers

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

*ASME B31.3 Process Piping*

National Fire Protection Association

*NFPA 70 National Electrical Code (NEC)*

International Organization for Standardization

*NACE MR0175 / ISO 15156 Petroleum and Natural Gas Industries-  
Materials for use in H<sub>2</sub>S-Containing  
Environments in Oil and Gas Production*

*PED 97/23/EC Pressure Equipment Directive*

## 4 General Design Requirements

All level measurement components and systems shall be suitable for continuous operation in environmental conditions specified in [SAES-J-003](#).

### 4.1 Instrument Selection

This Standard is not intended to be an exclusive listing of types of level instruments. When engineering considerations so dictate and when not prohibited, other types may be used. Selection of level instrument shall be from vendors listed in [SAES-J-002](#).

### 4.2 Volume and BS&W Calculations

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 the API Manual of Petroleum Measurement Standards (MPMS).

### 4.3 Custody Transfer by RTG

The Radar Tank Gauging portion of this standard is not intended for custody measurement. Additional guidance and approval is mandatory if the proponent intends to utilize a Radar Tank Gauging System for Custody Transfer. Forward such requests to the Technical Director, Custody Measurement Unit, Process & Control Systems Department, Dhahran.

#### 4.4 Standpipes

4.4.1 When several instruments are required on a vessel for control and monitoring purposes, a common standpipe shall be used. The process shall be non-plugging, the tap nozzle size shall be at least 2 inches and the common isolation valves on the tap nozzle shall be car sealed open. For details of a typical standpipe refer to Saudi Aramco Library Drawing [DC-950045](#).

4.4.2 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.

4.4.3 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.*

4.4.4 Standpipes shall not be used for ESD functions.

4.4.5 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.

4.4.6 For applications, very sensitive to density change, the use of stand pipe shall be reviewed and approved by proponent.

4.4.7 When required, a dedicated standpipe shall be provided for vessel boots. The standpipe for vessel level measurement shall not be used for boot level measurement.

#### 4.5 Location and Orientation

Local instruments shall be accessible at grade level or from a platform. Local level sight gauges and magnetic level indicators 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. However, when used, bottom vessel connections shall include an internal nozzle extension to reduce bottom solids from entering

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the standpipe. Local receiving instruments shall be installed 1.40 m above grade level. Access requirements shall meet [SAES-B-054](#).

#### 4.6 Local Level Gauge

The design of process or safety system level instruments shall include an associated local level gauge (sight glass or magnetic level indicator) to allow calibration, range checking and visual level verification over the calibrated range of the instrument.

#### 4.7 ESD Level Measurement

Selection of level instrumentation for ESD service shall meet requirements in this standard. Level instrument installation shall meet requirements in [SAES-J-601](#).

#### 4.8 Taper Thread Requirements

All taper threads shall be in accordance with [ASME B1.20.1](#).

#### 4.9 Welding Bosses

Threaded connections to vessels or standpipes shall be made with Type II, heavy welding bosses, as shown on Saudi Aramco Standard Drawing [AE-036175](#).

#### 4.10 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-108](#). Threaded connections between the root valve and the boss shall be seal or bridge welded per Saudi Aramco Standard Drawing [AB-036521](#).

4.11 Saudi Aramco Library Drawings may be used as a guide for drafting project specific drawings, when existing Saudi Aramco Standard Drawings are not applicable. Project Specific drawings may be created from the library drawings without a waiver.

#### 4.12 Electrical

4.12.1 Electrical and electronic level instruments installed in hazardous areas shall meet listing/certification requirements specified in [SAES-P-100](#) and the NFPA 70 - National Electric Code (NEC).

4.12.2 [FOUNDATION™ fieldbus](#) level instruments shall meet the specific

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hazardous area certification requirements of [SAES-J-904](#).

- 4.12.3 Level instruments which discharge energy directly into the process shall have their sensor electronics certified for the electrical area classification inside the vessel.
- 4.12.4 All level transmitters shall be HART or [FOUNDATION™ fieldbus](#) microprocessor based smart transmitters with integral indicators.

## 5 Sight Level Gauge Glasses

### 5.1 General Application

- 5.1.1 Sight Level 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. Area lighting shall be provided for all gauges installed in poorly lighted areas. Gauge illumination shall also be provided to all transparent gauges where readings are taken at night or 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 minimum 3/4 inch female NPT top and bottom connections. Flange connections may be used when required.
  - 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 manufacturers' standard lengths.
  - 5.2.4 Frost gauges shall be specified for low temperature service below -7°C. Lucite or suitable alternative frost shields shall be included and shall
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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 316 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 (e.g., mica) 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 when required, RF flanges, class 600 minimum. Minimum

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vessel connections shall be  $\frac{3}{4}$  inch NPT. Vent and drain connections shall be a minimum  $\frac{3}{8}$  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 [DB-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 or gasket failure. The gauge cock shall be a ball check offset type with  $\frac{3}{4}$  inch NPT male union, vessel or standpipe connection,  $\frac{3}{4}$  inch NPT female gauge connection and  $\frac{1}{2}$  inch NPT female drain or vent connection. For additional details refer to Saudi Aramco Library Drawing [DB-950046](#). See paragraph 5.3.3 for limitations.

## 6 Magnetic Level Indicator Gauges (MLI)

### 6.1 Application

- 6.1.1 An MLI shall be used for dangerous or toxic services or services in which obstruction or coating, due to process fluid nature, is very likely.
- 6.1.2 MLI assemblies shall be installed only in areas that are free of physical forces or materials that would adversely affect the magnetic operation of the system.
- 6.1.3 MLIs shall not be installed in dirty or plugging service where debris or buildup can cause float sticking.

### 6.2 Mounting

MLI assemblies shall be installed with top, bottom, or side connections, minimum 1 1/2 inch NPT or 2 inch RF flanged, class 300 minimum. Standard assemblies shall be rated for 2,800 kPa (400 psig) and 230°C service. Installation is similar to external cage displacers - refer to Saudi Aramco Library Drawing [DB-950047](#).

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### 6.3 Materials

MLI chambers and float materials shall be compatible with process fluid as a minimum, as specified on the ISS.

### 6.4 Construction

6.4.1 The MLI chamber shall be constructed of schedule 40S pipe at a minimum. The diameter of the chamber shall be as required by the MLI manufacturer and suitable for the application. (Typical diameters are 2 inch or greater.) The pipe schedule shall be increased to 80S or greater as required by design pressure and temperature and applicable code calculations (ASME B31.3 or PED 97/23/EC), or when noted on the ISS.

6.4.2 Chamber branch connections may be fabricated with one of the following methods:

- a) Pipe nipple saddle welded to chamber. The pipe nipple between the chamber and the process connection flange shall be 1 inch 40S minimum. This method is only permitted for class 300 assemblies.
- b) O-let saddle welded to chamber. The o-let and associated pipe nipple shall be 1 inch 40S minimum. The use of o-lets are required for class 600 assemblies and above, unless the method outlined in c) is utilized.
- c) Butt-Weld Tee construction. A butt weld tee may be utilized to create the MLI chamber branch connection when required either by the ISS or when full-bore connections between the chamber and process connections are required. The wall thickness of the tee shall match that of the chamber.
- d) Extruded outlets. The practice of extruding outlet connections from the base chamber material is not permitted due to concerns associated with material strength and Stress Corrosion Cracking, especially in high chloride applications.

#### *Commentary Notes:*

*Oversized chambers with guide rods are recommended for applications where the process fluid may boil or flash due to temperature differences between the process vessel and gage column. This type of chamber configuration is recommended for all light end hydrocarbon applications where the normal operating temperature is below 0°C to prevent the float from sinking.*

*Magnetic bargraph/flag type indicators are recommended.*

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*Follower, shuttle or any alternate indicator that utilizes a single component for level indication are not advised.*

## **7 Guided Wave Radar (GWR) Level Transmitters**

### **7.1 GWR Applications**

- 7.1.1 GWR is the preferred liquid level and liquid-liquid interface level measurement technology – for both process and ESD applications. Other level measurement technology may be used if GWR is not suited to the application.

*Commentary Notes:*

*Distinction must be made between GWR radar and non-contact 'free space' process radar level transmitters. This standard only addresses GWR, not non-contact radar. There are five main types of GWR probes available on the market, (rigid and flexible single probes, rigid and flexible twin probes and coaxial), GWR is well tested and suited to process level measurement applications within Saudi Aramco facilities.*

*GWR is recommended for use on all clean applications within Saudi Aramco. This includes hot (e.g., boiler steam drum, crude column bottoms) and cold services (e.g., boiling propane, cryogenic). However, GWR is not currently recommended for slurries, viscous or sticky products, product coating materials or for emulsion layer interface detection inside GOSP desalters and dehydrators.*

*Non-contact 'free space' process radar may be considered for level applications where GWR is not suitable.*

- 7.1.2 Any 'dead zones' on the wave guide probe shall be designed outside the operating range of the GWR instrument. In no case shall a process level be capable of entering a probe 'dead zone'.
- 7.1.3 Flushing ports shall be provided for all wave guide probes in viscous or dirty service.

### **7.2 GWR Mounting, Materials, and Connections**

- 7.2.1 GWR wave guide probes shall be mounted such that they may be removed while the process remains in-service. For pressurized process vessels, probes shall be flange mounted in external bypass chambers.
- 7.2.2 GWR Bypass chamber material shall meet the requirements of the application, and be steel construction minimum. Chamber connections shall be 2 inch flanged on the top, bottom, or sides. Standpipes may be used for GWR bypass chambers.

- 7.2.3 An associated local sight level gauge or magnetic indicator is required for all GWR level transmitters installations to allow for process level verification and calibration. One level gauge or MLI per standpipe is acceptable.
- 7.2.4 Appropriate GWR process valving and connections shall be provided for process isolation and for GWR calibration. Such connections shall include aventi, and separate filling test port.
- 7.2.5 Dual chamber GWR with MLI designs shall only be permitted when installing onto existing vessels where spare nozzles aren't available or where it is impracticable to install a suitable standpipe.

## **8 Differential Pressure Level Transmitters**

### **8.1 Application**

Differential pressure level transmitters may be used for process and ESD level and for liquid-liquid interface level measurements if Radar (GWR or non-contact) is not suitable for the application. Transmitters with diaphragm seals are recommended for process fluids that are highly viscous, containing entrained solids or in hot service.

### **8.2 Calibration**

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

### **8.3 Purge System**

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

### **8.4 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 have the capability to display the liquid level in distance/length graduations. The local indicators shall be installed 1.4 m above the grade level. The Local indicators shall have a weatherproof case.

## 8.5 Transmitters

All transmitters used for level service shall be HART or [FOUNDATION™ fieldbus](#) smart and microprocessor based. The instrument shall have 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](#).

## 8.6 Installation

- 8.6.1 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.
- 8.6.2 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, [DB-950047](#) and [DB-950048](#).
- 8.6.3 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.
- 8.6.4 Use of DP transmitter for refrigerated LPG tank level service should be considered only when GWR level measurement is not feasible for the application. Differential pressure level transmitters in refrigerated LPG service 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.
- 8.6.5 A diaphragm seal type installation shall include drain valves between the process vessel block valves and the diaphragm seal - on both high and low pressure sides of the transmitter. Diaphragm seal transmitters shall be mounted at or below the lower vessel connection, preferably 1.4 m above grade or operating platform.
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## 9 Displacement Level Transmitters

### 9.1 Application

- 9.1.1 Displacement level transmitters may be used for liquid level ranges up to and including 1,830 mm (72 inches). Use of this technology shall be limited to non-viscous process fluids with low concentration of solids. Displacement transmitters shall be considered for a specific application only if radar or differential pressure level devices are not suitable.

*Commentary Note:*

*Distinction must be made between displacement and float devices. Displacer elements are heavier than the liquid being measured, and remain 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.*

- 9.1.2 Displacement level transmitters shall normally be installed in cages external to the process vessel, to allow for maintenance without process interruption or hazard.
- 9.1.3 Internal displacement type instruments shall be used only 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, and where the vessel can be opened for maintenance requirements without process interruption or hazard.
- 9.1.4 Displacement type instruments shall not be used in highly corrosive services or services where salts or other deposits may precipitate onto the displacer or on the walls of the chamber.
- 9.1.5 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.
- 9.1.6 An air-fin extension shall be provided between the level sensing element and the transmitter, for applications where fluid temperatures will exceed 200°C.

### 9.2 External Displacement Level Transmitters

#### 9.2.1 Materials

Displacer chambers and torque tube housing materials shall meet requirements of the application. Cast iron shall not be used. As a

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minimum, displacers shall be minimum 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.

#### 9.2.2 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 [DB-950047](#).

### 9.3 Internal Displacement Level Transmitters

#### 9.3.1 Materials

Mounting flanges and torque tube housings shall be steel. Cast iron shall not be used. Displacers shall be minimum 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.

#### 9.3.2 Mounting

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

#### 9.3.3 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.

#### 9.3.4 Still Wells

A process vessel internal displacer shall be mounted inside an internal mounted guide pipe, termed a still well, to protect and guide the displacer. The still well shall be open at the bottom, shall include adequate equalization and vent holes along its length, and be of sufficient diameter to prevent hang-up of the displacer. Internal displacement type instruments shall not be used in vessels where high turbulence is expected.

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#### 9.4 Displacer Transmitters

HART or [FOUNDATION™ fieldbus](#) microprocessor based smart transmitters shall be provided with all displacer units. The use of pneumatic transmitters is permitted only for local indication and control.

### 10 Capacitance Level Transmitters

#### 10.1 Application

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

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

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

#### 10.2 Installation

10.2.1 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.

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

10.2.3 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.

### 11 Level Switches

#### 11.1 Application

##### 11.1.1 Emergency Shutdown

A dedicated float, displacer or vibronic type level switch shall only be used in ESD service when radar, differential pressure, or displacer level transmitters are not practical for the application. Emergency shutdown functions shall not be combined with control functions, refer to [SAES-J-601](#), for details.

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#### 11.1.2 Alarms

Displacement, float or vibronic switches may be used for process alarming.

#### 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 Displacer, Float and Vibronic Switch

11.2.1 External level switches shall be supplied with steel chambers, having a flanged closure for internal inspection. The minimum flange rating for the level switch 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 All materials, in contact with wet sour service process fluid, shall comply with the requirements of [NACE MR0175/ISO15156](#).

### 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 minimum. Other displacer materials shall 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 level switch shall have its own individual vessel or standpipe connections. The level chamber shall be installed with the longitudinal axis vertical. For details of typical installations refer to Saudi Aramco Library Drawings, [DB-950047](#) and [DB-950048](#).

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- 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 still well shall be required for applications where liquid turbulence is excessive. The inside diameter of the still well shall be at least 25 mm larger than the displacer diameter. The still well shall be open at the bottom end and shall have a vent hole located above maximum level.
- 11.4.3 Level switches shall be hermetically sealed or totally encapsulated mechanical microswitches. Mercury switches shall not be used. Switch contacts shall be wired in a fail-safe, de-energize to alarm design. For example, contacts shall be closed during normal process levels. The contacts shall open at abnormal levels to alarm. Vibronic switches shall be supplied with a self-test diagnostic facility.

## 12 Level Instrument Restrictions

### 12.1 Ball Float Level Controllers

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.

### 12.2 Ultrasonic Level Measurement

Ultrasonic level measurement shall be used only on non-critical utility service including sewage and water only sumps. Ultrasonic level measurement shall not be used in oily water sump pits or dedicated hydrocarbon applications.

## 13 Radar Tank Gauging (RTG) Systems

Radar Tank Gauging (RTG) technology shall be used for level and level based volume measurements on all hydrocarbon inventory tanks and tank farms. Hydrostatic Tank Gauging (HTG), Servo Tank Gauging (STG), or float and tape based tank level gauges shall not be used.

### 13.1 Application and 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:

#### 13.1.1 Fixed Roof Tanks without Still Wells

Cone or planar type microwave antennas shall be used on all clean

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products. The antenna shall be installed such that the microwaves can travel un-obstructed to the tank bottom. Obstacles, such as pipes and mixers, shall be designed around based on the RTG vendors' requirements.

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 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.

#### 13.1.2 Floating Roof or Internal Floating Pan Tanks with Still Wells

RTGs especially designed to operate within a still well shall be utilized. The gauge shall use low loss circular microwave transmission mode to eliminate measurement errors due to corrosion of the still well interior wall.

#### 13.1.3 Spheroid or Pressurized Tanks

RTGs, designed for LPG/LNG service, shall be mounted on a 4 inch NPS still well to minimize the impact of waves and surface boiling on the measurement accuracy. Pressure and temperature measurements are mandatory to compensate for composition changes in the vapor space.

The bottom datum plate and vendor supplied reference pins shall be installed on the still well per vendor requirements, to permit on-line calibration and future verification of the level. 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 well flange and shall be within  $\pm 2$  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](#).

#### 13.1.4 Still Well Design for Atmospheric Tanks

For all new construction, an RTG still well shall be provided. The still well shall be installed such that minimum deflection will result due to hydrostatic tank deformation.

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The still well shall be designed and installed based on Saudi Aramco Standard Drawing [AA-036256](#), vendor requirements, and [API MPMS 3.1B](#).

#### 13.1.5 Still Well Design for Pressurized Vessels

For all pressurized vessel applications, a still well shall be provided. The still well shall be fabricated from seamless, 4 inch Schedule-10, 316 stainless steel pipe and designed and installed per RTG vendor requirements.

#### 13.1.6 Gauging Hatch

For all atmospheric tanks, a reference gauge hatch shall be provided in close proximity to the RTG, for manual ullage measurements and periodic accuracy verification. See Saudi Aramco Standard Drawing [AA-036256](#).

#### 13.1.7 Maintenance Access Requirements

Sufficient access 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.

### 13.2 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 design and installation shall be per [API MPMS 7](#), "Temperature Determination."

### 13.3 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-16<sup>th</sup> graduations and the product temperature when applicable, in user configurable units. The local indicator shall be installed 1.4 m above grade level.

### 13.4 Hazardous Area Classification

RTG equipment installed in classified areas shall meet the listing/certification requirements specified in [SAES-P-100](#) and in the NEC.

### 13.5 Intrinsic Accuracy

For high accuracy applications, the laboratory tested accuracy of the gauge shall

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be equal to or better than  $\pm 1$  mm over the entire range of the RTG. Vendors shall provide certification from a recognized international agency, such as the Dutch Nederland Meetinstituut (NMI) or the German Physikalisch-Technische Bundesanstalt (PTB), to support their claims.

For general service, the laboratory tested accuracy of the gauge shall be equal to or better than  $\pm 3$  mm over the entire range of the RTG. Vendors shall provide certified test data to support their claims.

### 13.6 Operator Interface Unit

A Personal Computer (PC) based Human Machine Interface (HMI) 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 HMI shall be capable of handling configuration data, tank level displays and alarming functions.

### 13.7 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.

### 13.8 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.

### 13.9 Data Security

The RTG shall be equipped with either a hard or soft switch, such that tank configuration data in 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.

### 13.10 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.

### 13.11 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 shall not exceed 2 milliwatts. The RTG shall have approval from the Federal Communication Commission (FCC, USA) and the Saudi Arabian Standards Organization (SASO). The vendor shall provide certification documentation to Saudi Aramco, upon request.

### 13.12 Power Supply and Wiring

Instrument power supply, signal and control wiring shall be in accordance with [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.

### 13.13 Calibration Requirements

#### 13.13.1 Atmospheric Tanks

The installed accuracy and field calibration requirements for an RTG system shall be as specified in [API MPMS 3.1B](#). The installed accuracy of the RTG must be verified by comparing the level readings against manual gauging. Manual gauging shall comply with [API MPMS 3.1A](#).

#### 13.13.2 Pressurized Tanks

The RTG shall be calibrated by reading the known ullage of the reference pins or similar verification device. During calibration, at least

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one reference pin shall be above the liquid level. The reference pin shall be mechanically located with a maximum uncertainty of  $\pm 1$  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  $\pm 1$  mm. A series of three consecutive reading of the reference pins by the RTG must agree within  $\pm 1$  mm with a maximum spread of  $\pm 3$  mm.

13.13.3 The installed accuracy of the automatic temperature measurement system shall be within  $\pm 0.5^\circ\text{C}$  of the reference thermometer. Calibration and verification shall be as per [API MPMS 7](#).

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

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

#### 13.14 Water Tanks

For water storage tanks, float-and-cable type instruments with counter weight and gauge board are acceptable. Process level instruments may be used when a remote level signal is required.

#### 13.15 Independent Inventory Tank High High Level Alarms

13.15.1 An independent High High (HH) level alarm shall be provided on all atmospheric hydrocarbon storage tanks. This alarm shall be activated by a level transmitter which is completely independent of the inventory level monitoring RTG system. The independent HH level alarm shall annunciate 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 independent alarm and level transmitter system for this application shall not fail undetected. The alarm set point on the inventory RTG system shall be set such that approximately ten minutes time interval is available before the independent HH level alarm is reached. The interval computation shall be based on nominal fill rate.

- 13.15.2 For pressurized or refrigerated hydrocarbon vessels, alarm requirements specified in [SAES-B-057](#) 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.*

**Revision Summary**

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|------------------|--|
| 30 April 2012    | Major revision to delete GWR large coax cable requirement; added requirement on level chamber design and encourage the use of non-contact radar and MLI. |
| 17 February 2013 | Editorial revision to change the primary contact person.   |