Engineering Standard

SAES-Z-003 15 February 2006

Pipelines Leak Detection Systems

Saudi Aramco DeskTop Standards

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1 Scope

This Standard defines the minimum mandatory requirements governing the scoping, design, installation, performance and online testing of pipelines Leak Detection Systems (LDS).

This standard applies to liquid and gas hydrocarbon pipelines excluding flowlines, trunklines, and test lines. New pipelines projects shall install appropriate LDS based on pipelines application and classification as detailed in this standard.

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), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Process & Control Systems Department (P&CSD) 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 requests to the Manager, Process & Control Systems Department (P&CSD) 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-102	*Air Pollutant Emission Source Control*
SAES-B-064	*Onshore and Nearshore Pipeline Safety*
SAES-J-002	*Technically Acceptable Instruments*

SAES-J-003	*Basic Design Criteria*
SAES-J-100	*Process Flow Metering*
SAES-J-200	*Pressure*
SAES-J-400	*Temperature*
SAES-J-601	*Emergency Shutdown and Isolation Systems*
SAES-J-902	*Electrical Systems for Instrumentation*

Saudi Aramco Materials System Specifications

23-SAMSS-030	*Remote Terminal Units*
34-SAMSS-820	*Instrument Control Cabinet-Indoor*
34-SAMSS-821	*Instrument Control Cabinet-Outdoor*

Saudi Aramco Inspection Requirements

Form 175-343600	*Inspection & Testing Requirements, Pipeline Leak Detection Systems (LDS)*

3.2 Industry Codes and Standards

American Petroleum Institute

API PUBL 1130	*Computational Pipeline Monitoring*
API PUBL 1149	*Pipeline Variable Uncertainties & their Effect on Leak Detectability*
API PUBL 1155	*Evaluation Methodology for Software Based Leak Detection Systems*

Environmental Protection Agency

EPA530/UST-90/010	*Standard Test Procedure to Evaluating Leak Detection Method: Pipeline Leak Detection Systems*

4 Terms and Definitions

This section contains definitions for acronyms, abbreviations, classes as they are used in this document.

4.1 Acronyms and Abbreviations

API	American Petroleum Institute
DCS	Distributed Control System

EPA	Environmental Protection Agency
G	Sweet Gas
GS	Sour Gas
ISA	The International Society for Measurement & Control
L	Sweet liquid
LDS	Leak Detection System
LS	Sour Liquid
LV	Volatile Sweet Liquids
LVS	Volatile Sour Liquids
SCADA	Supervisory Control and Data Acquisition
RER	Rupture Exposure Radius

4.2 Class definition

Below are location class definitions, for treatment of location classes refer to SAES-B-064:

Class 1: *Class 1 locations are undeveloped areas within the RER for which the population density index for any 1 kilometer segment is 10 or less.*

Class 2: *Class 2 locations are areas within the RER for which the population density index is 11 through 30 or pipeline sections adjacent or crossing primary or secondary highways as defined by the Saudi Arab Government Ministry of Transport (see clarifications below). Location Class 2 shall extend 500 meters or the RER distance, whichever is less, from the edge of the highway right-of-way. The portion of subsea pipelines located between Lowest Astronomical Tide (LAT) and points 0.4 kilometer on the seaward side of the LAT-line shall be designated for location class 2. Location Class 2 shall be the minimum used for the portion of these pipelines located between LAT-line and the onshore anchor.*

Class 3: *Class 3 locations are areas within the RER for which the population density index is more than 30.*

Class 4: *Class 4 locations are areas within the RER in which a school, hospital, hotel, prison, or shopping mall or similar retail complex, or wedding hall is located, as well as any Class 3 areas which include buildings of more than four occupied floors.*

5 Design

5.1 General

5.1.1 Pipelines leak detection systems shall detect leaks if and when they occur, estimate the magnitude and location of a leak and generate operator alert/alarms. Leak detection systems shall be selected based on one of the following:

5.1.1.1 For onshore pipelines, the selected leak detection system shall meet the minimum performance requirement as stated in table 5 through 8.

5.1.1.2 For pipeline network or pipelines that are not classified by SAES-B-064, a leak sensitivity study that consider risk assessment, shall be conducted that determines the impact of the pipeline (s) leak or rupture on the neighboring community, highway traffic, and environment. This study considers minimum response time and the amount of product released until total isolation is achieved. This study determines required leak detection system performance criteria and performance tradeoffs for the pipeline or pipeline network under consideration. Tables 5 through 8 outline the minimum performance requirements.

5.1.2 Technology selections shall be considered for each specific pipeline application to meet this standard criteria and suite a given pipeline configuration. The selection of technology shall take into consideration communication infrastructure, monitoring system and field instrumentation.

5.1.3 The operating requirements of each leak detection system, including instrumentation accuracy, repeatability and measurement precision, communication reliability and sampling frequency should determine whether the leak detection system would share or use compatible instrumentations of the specific pipelines monitoring system.

5.1.4 The design shall utilize to the maximum extent possible the existing field equipment and communication infrastructure without degrading the leak detection system's ability to recognize potential or actual leak as a result of inadequate data acquisition frequency or bad data quality.

5.1.5 Environmental impact should be considered for selecting LDS for cross-country pipelines. The environmental impact analysis shall include air, land, water, energy, and noise level.

5.2 Performance Criteria

Leak detection performance shall consider overall leak detection components such as field instruments, communication devices and media, and LDS internal components. Selecting proper type of Leak Detection System shall be governed by the following performance criteria:

5.2.1 **Reliability**: Measure of the Leak Detection System's ability to report possible existence of a leak on the pipeline, while operating within the envelop established by the leak detection system design. The established envelop includes the number of acceptable false alarms, minimum leak size and response time. Table 1 defines the minimum ranges of reliability for LDS selection.

Table 1 – Reliability

Range	Description
High	Shall not exceed one false alarm per year of 18 mm (0.75 inch) leak size, and 15 minutes response time
Medium	Shall not exceed three false alarms per year of 25 mm (1 inch) leak size, and 30 minutes response time
Low	Shall not exceed ten false alarms per year of 50 mm (2 inches) leak size, and 60 minutes response time

Commentary Note:

The 18 mm (0.75 inch) leak size was driven using estimated pinhole to cause incident levels (Major, Moderate, and Minor. As an example, the leak system shall be installed to detect a leak of spill size less than 1000 BBL (Minor level). The spill flow rate and the time shall not exceed the minor incident level spill quantity (1000 BBL within 8HRS). The time to stop the leak should be divided between mobilization time, repair time and leak detection instrument response time.

5.2.2 **Sensitivity**: A composite measure of the size of the leak that the system is capable of detecting at steady state and the time required the system to generate an alarm in event that a leak of that size should occur. Table 2 defines the minimum ranges of sensitivity for LDS selection.

Table 2 – Sensitivity

Range	Description
High	18 mm (0.75 inch) of leak size within 5 minutes
Medium	18 mm (0.75 inch) of leak size within 10 minutes
Low	18 mm (0.75 inch) of leak size with one hour

5.2.3 **Accuracy:** The validity of the estimated leak flow rate, total volume lost, and leak location within an acceptable degree of tolerance. Table 3 defines the minimum ranges of accuracy for LDS selection.

Table 3 – Accuracy

Range	Description
High	18 mm (0.75 inch) of leak size ± 200 meters (657 ft) of actual leak location
Medium	18 mm (0.75 inch) of leak size ± 1,609 meters (1 mile) of actual leak location
Low	18 mm (0.75 inch) of leak size ± 3,219 meters (2 mile) of actual leak location

5.2.4 **Robustness**: Is a measure of the Leak Detection System's ability to continue to function and provide useful information, even under changing conditions of pipeline operation, or in conditions where data is temporary lost or suspected. Table 4 defines the minimum ranges of robustness for LDS selection.

Table 4 – Robustness

Range	Description
High	Loss of a field sensor/communication link will not degrade performance
Medium	Loss of a field sensor/communication link may reduce accuracy and/or sensitivity of detecting leaks by one range level of table 2 and/or 3.
Low	Loss of a field sensor/communication link may cause failure to detect leaks

5.3 Leak Detection System Type Selection

This standards does not require specific leak detection technology or product, however, the standard sets the performance measure for pipelines applications.

5.3.1 The following pipelines applications are addressed by this standard:

G Sweet gas (treated gas, i.e., sale gas with specification A-120 (Hydrogen Sulfide, grains/100 SCF (grains/100 CM))

GS Sour gas (gas concentration H_2S >1% Hydrogen Sulfide)

L Sweet liquid (stabilized crude or treated condensate <300 ppm Hydrogen Sulfide)

LS Sour liquid (untreated hydrocarbon) >300 PPM Hydrogen Sulfide

LV Volatile sweet liquids <300 ppm Hydrogen Sulfide)

LVS Volatile sour liquids >300 ppm Hydrogen Sulfide)

5.3.2 Pipeline Leak Detection System performance requirements

The following tables (5 thought 8) state the minimum performance measure requirements for each corresponding class of pipeline applications.

Table 5 – Location Classes 1

Performance Measure	Service					
	G	GS	L	LS	LV	LVS
Reliability	Low	Low	Low	Low	Low	Low
Sensitivity	Low	Low	Low	Low	Low	Low
Accuracy	Low	Low	Low	Low	Low	Low
Robustness	Low	Low	Low	Low	Low	Low

Table 6 – Location Classes 2

Performance Measure	Service					
	G	GS	L	LS	LV	LVS
Reliability	Low	Medium	Low	Medium	Low	Medium
Sensitivity	Low	Medium	Low	Medium	Low	Medium
Accuracy	Low	Medium	Low	Medium	Low	Medium
Robustness	Low	Medium	Low	Medium	Low	Medium

Table 7 – Location Classes 3

Performance Measure	Service					
	G	GS	L	LS	LV	LVS
Reliability	Medium	High	Medium	High	Medium	High
Sensitivity	Medium	High	Medium	High	Medium	High
Accuracy	Medium	High	Medium	High	Medium	High
Robustness	Medium	High	Medium	High	Medium	High

Table 8 – Location Classes 4

Performance Measure	Service					
	G	GS	L	LS	LV	LVS
Reliability	High	High	Medium	High	Medium	High
Sensitivity	High	High	Medium	High	Medium	High
Accuracy	High	High	Medium	High	Medium	High
Robustness	High	High	Medium	High	Medium	High

5.4 Leak Monitoring Package-Software Engine

5.4.1 Leak monitoring software shall provide continuous operator alert and logging functions for the pipelines including real time simulation capability.

5.4.2 Leak monitoring software shall provide history archive of actual leak detected and suspected or filtered events.

5.4.3 Leak monitoring software shall provide report to indicate suspected leak details with capability to print or display on the designated operator workstation. The system shall announce the location of the leak within time fame that does not exceed twice of the leak detection time specified in table 2. The report may include topographical locations coordinates, etc.

5.5 Field Instrumentation Selection Criteria

The selection, application and installation of leak detection field instrumentation shall meet the reliability and robustness measures for the pipeline class. Conventional instruments such as pressure, temperature, etc shall meet requirements referenced in section 3.1. Other instruments shall be selected based on selected LDS recommendation.

5.6 Remote Terminal Units (RTU)

The field devices may be dedicated for the leak detection application or shared with a DCS or SCADA. Selection of either approach will be determined by the application performance measures. This also may determine the use of dedicated communication media and operator interface subsystems.

6 Testing

6.1 The Leak Detection System performance as tested, shall meet one of the follow:

- Performance measures determined by the leak detection (risk assessment) study per pipelines' proponent approved test procedure or,
- Approved international standard procedure (i.e., API, EPA) or
- Third party approved procedure, which will be provided by vendor supplying the LDS.

6.2 New LDS project shall develop functional specification, FAT and SAT procedures. The project shall consider commissioning the system through an actual product release. The project shall develop and obtain approval for product release procedure.

6.3 As minimum, leak detection system shall be periodically tested per Table 9. The tests shall demonstrate correct functionality of field instrumentations, communication and monitoring systems.

Table 9 – Testing Intervals

Performance Measure	Service					
	G	GS	L	LS	LV	LVS
Class I	Annual	Annual	Annual	Annual	Annual	Annual
Class II	Annual	Annual	Six months	Annual	Annual	Annual
Class III	Three months	Three months	Six months	Six months	Three months	Three months
Class IV	Three months	Three months	Six months	Six months	Three months	Three months

Revision Summary

15 February 2006 Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with no other changes.