Engineering Standard

SAES-J-505 31 January 2005
Combustible Gas and Hydrogen
Sulfide in Air Detection Systems

Saudi Aramco DeskTop Standards

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1 Scope

This Standard defines the minimum mandatory requirements governing the design and installation of fixed hydrogen sulfide and combustible gas-in-air monitoring systems for personnel and plant protection.

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 General Supervisor, Process Instrumentation Division, 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 requests to the General Supervisor, Process Instrumentation Division, 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 applicable parts of the latest editions 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-J-002	*Technically Acceptable Instruments*
SAES-J-003	*Basic Design Criteria*
SAES-J-502	*Analyzer Shelters*
SAES-J-801	*Control Buildings*

SAES-J-902	*Electrical Systems for Instrumentation*
SAES-J-903	*Intrinsically Safe Systems*
SAES-K-002	*Air Conditioning Systems for Essential Operating Facilities*
SAES-K-502	*Combustion Gas Turbines*
SAES-P-100	*Basic Power System Design Criteria*

Saudi Aramco Materials System Specifications

23-SAMSS-010	*Distributed Control Systems*
23-SAMSS-030	*Remote Terminal Units*
34-SAMSS-514	*Combustible Gas and Hydrogen Sulfide Monitors*
34-SAMSS-623	*Programmable Controller Based ESD Systems*
34-SAMSS-830	*Programmable Logic Controller*

3.2 Industry Codes and Standards

Canadian Standards Association

CSA C22.2 No. 152	*Combustible Gas Detection Instruments*

International Electrotechnical Commission

(IEC) 61000-4-3	*Electromagnetic Compatibility (EMC) Part 4-3*

International Society for Measurement and Control

ANSI/ISA-12.13.02 - 2003 (IEC 61779-6 Mod)	*Recommended Practice for the Installation, Operation , and Maintenance of Combustible Gas Detection Instruments*
ISA-RP92.0.02 Part II - 1988	*Installation , Operation , and Maintenance of Toxic Gas-Detection Instruments ; Hydrogen Sulfide*

National Fire Protection Association

NFPA 72	*National Fire Alarm Code*
NFPA 325M	*Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids for LEL of Gases*

4 Definitions

Attended operation: 24-hour-per-day operation where personnel are continuously in attendance.

Control building: A structure which contains process control equipment. It may be an operator shelter, a process interface building, or a central control room.

DCS: Distributed Control System (DCS): A process control system that is composed of distinct modules. These modules may be physically and functionally distributed over the plant area. The distributed control system contains all the modules and associated software required to accomplish the regulatory control and monitoring of a process plant, excluding field instruments, remote terminal units, auxiliary control systems and Plant information systems.

Emergency Shutdown System (ESD): A system composed of sensors, logic solvers, and final control elements for the purpose of taking the process, or specific equipment in the process to a safe state when predetermined conditions are violated, i.e., to isolate, de-energize, shutdown or de-pressure a process unit or process equipment. Other terms commonly used throughout the hydrocarbon and petrochemical industry include Safety Instrumented and Safety Interlock Systems (SIS).

Fail-safe state: The condition to which an instrument or system shall revert upon loss of power, logic signal or motive force. Unless otherwise specified, the fail-safe state for a normally energized safety system shall be the de-energized state, with no power or logic voltage being applied to an element or final operator.

LEL: Lower explosive limit. This is the minimum concentration of a gas in a gas/air mixture at which the mixture will explode if exposed to an ignition source.

Parts per Million (PPM): A unit of measurement used for small portions or concentrations. In gas analysis, it expresses the volume of gas present in terms of its relationship to a whole of 1 million parts of air. 1% = 10,000 ppm. 1% of volume = 10,000 ppm, 100% of volume=1,000,000 ppm.

Programmable logic controller (PLC): A digital, electronic controller, designed for use in an industrial environment. A PLC uses a programmable memory for the internal storage of user-oriented instructions for implementing specific functions to control, through digital or analog inputs and outputs, various types of machines or processes.

Triple modular redundant (TMR) system: An emergency or safety shutdown system which employs a 2-out-of-3 (2oo3) voting scheme to determine appropriate output action, based on the application of three separate processors with triplicate inputs and outputs (I/O) components and bus structure, with all systems running in parallel.

Unattended operation: One shift operation, two shift operation or operation at unmanned stations.

5 Design

5.1 General

5.1.1 Fixed gas detection systems shall measure and provide alarms for high concentration of hydrogen sulfide or combustible gas in air as specified in the "NFPA 325M "for flammable applicable gas groups.

The system shall be designed to provide a timely response to an alarm situation and to prevent unauthorized system bypass or alarm reset. The design shall allow for each gas detector (sensor) to be accurately and effectively tested or calibrated at regular periods. The system design shall provide the means for testing each detector without disabling the entire system or causing accidental shutdown of equipment as per ANSI/ISA-12.13.02 - 2003 (IEC 61779-6 Mod) and Canadian Standard Association CSA C22.2 No.152.

5.1.2 The system shall use standard equipment, provided by manufacturers listed in SAES-J-002, ″Technically Acceptable Instruments.″

5.1.3 The system shall comprise one or more detectors connected to a control unit or logic system (as specified in sections 6.4.2 and 6.4.3) to provide audible and visual alarms in the field and in attended control buildings.

5.1.4 The system shall not be used to automatically initiate a shutdown of process equipment. Automatic shutdown of building ventilation systems shall be in accordance with SAES-K-002, "Air Conditioning Systems for Essential Operating Facilities."

5.1.5 Fire detection and control shall not be incorporated into the gas detection system.

5.2 Environmental Conditions

Each part of the detection system, alarms and associated electronic circuits shall be designed to operate in an environment as specified in SAES-J-003, "Basic Design Criteria″, in accordance with its particular application and location.

6 System Description

6.1 General

Continuous surveillance of ambient air to detect the presence of hydrogen sulfide or combustible gas in designated areas shall be accomplished by a gas detection system which incorporates the following components:

a) Detectors and enclosures (detector housings);

b) Logic system or control unit;

c) Interconnecting transmission cable;

d) Visible and audible alarms inside attended control buildings, at detector locations, and at the entrance gates of unattended locations.

6.2 Detector Selection

6.2.1 Detectors (sensors) shall use poison-resistant elements. Detectors and associated ancillary control equipment shall be specified in accordance with 34-SAMSS-514, ″Combustible Gas and Hydrogen Sulfide Monitors″ and SAES-J-002, "Technically Acceptable Instruments."

6.2.1.1 Solid state, diffusion adsorption-type detectors shall be used for continuous monitoring of hydrogen sulfide. Sensor response shall not be affected by ambient temperature variations.

6.2.1.2 Catalytic bead-type diffusion detectors are preferred for continuous monitoring of combustible gas.

Utilization of infrared open path detectors shall require prior approval of the Manager of the Proponent Organization and the General Supervisor, Process Instrumentation Division, Process & Control Systems Department.

6.2.1.3 The specific or predominant gas which is to be detected at the designated location shall be specified, and the detector shall be calibrated for that gas.

6.2.1.4 When more than one combustible gas is present at a particular location, the detector shall be specified to be calibrated for the hardest-to-detect (least sensitive) component.

6.2.1.5 The combustible gas to be used for calibration shall be as per the CSA for the following conditions:

a) for instruments intended specifically for sensing methane or intended for general purpose combustible gas detection, methane shall be used for LEL sensors calibration,

b) for instruments intended for general purpose combustible gas detection but excluding methane, propane gas can be used for LEL sensor calibration,

c) for instruments intended for sensing a specific combustible gas or vapor other than methane, the actual specific gas shall be used as recommended by the manufacturers.

6.2.2 The calibrated range for fixed detectors shall be:

a) 0 to 100 PPM - hydrogen sulfide in air

b) 0 to 100% LEL - combustible gas in air

6.2.3 Detectors which have a transmitter located with the sensing element shall be used. The transmitted signal shall be linear, within a range of 0 to 22 mA, per the following requirements:

a) Detector trouble/open loop alarm (0-4 mA DC)

b) Detector bypass/calibration mode alarm (0-4 mA DC)

c) Analog output signal (4-20 mA DC)

d) Signal overrange alarm (greater than 20 mA DC)

Alternately the detector transmitter output signal can utilize digital communications protocols options such as Modbus RTU, HART, ASCII, or Foundation field bus if applicable. The above alarm requirements still apply when using signals other than 0-22 mA.

6.2.4 Detectors shall incorporate an integral linear scale or digital indicator, or a temporary connection for detector calibration.

6.2.5 Detectors shall incorporate smart microprocessor calibration and fault diagnostic features. Calibration shall be non-intrusive, i.e., may be performed without opening the sensor/transmitter enclosure.

6.2.6 Detectors shall incorporate non-interactive zero and span adjustments

6.2.7 Hydrogen sulfide and infrared point combustible gas detectors shall have automatic temperature compensation for ambient temperature and humidity changes.

6.2.8 Detectors shall be protected against radio frequencies and electromagnetic interferences in accordance with IEC 61000-4-3, Level 3 (at a 10 V/m power level).

6.2.9 Detectors shall also be furnished with sunshades if required by site conditions.

6.2.10 Special detectors must be specified to be installed in the gas turbine high temperature compartments with remote calibration facilities.

6.3 Detector Sitting

6.3.1 The need and specific location for fixed detectors shall be assessed on a case-by-case basis as per ISA-RP92.0.02, Part II - 1998 and with consultation with Loss Prevention Department.

6.3.2 Detection shall be provided on the basis of protection of specific spot hazards rather than general gridded area protection.

6.3.3 Detectors should normally be located adjacent to identifiable, single-point, potential release locations where there is a significant risk of a hydrogen sulfide or combustible gas leak, such as pump and gas compressor seals, valves, etc. The exact location and number of detectors shall be determined by Operations and Loss Prevention Departments.

6.3.4 For hydrocarbon liquids, combustible gas detection shall be used only for potential release sources of flammable liquids with a true vapor pressure equal to or greater than 200 kPa(abs) (29 psia) at 54°C.

6.3.5 Pump groups in the same service which warrant protection shall be considered as a single hazard. When there are two or more pumps, one detector shall be installed at each end of the row, as a minimum.

6.3.6 Compressors in sour service shall have two hydrogen sulfide detectors, one located at each seal.

6.3.7 Burners of hydrogen sulfide combustors and incinators shall be considered a hazard warranting hydrogen sulfide detection.

6.3.8 Detectors shall be located in the air intake ducting of air conditioning systems of attended control buildings in accordance with SAES-J-801.

6.3.9 Detectors shall be located inside analyzer shelters in accordance with SAES-J-502.

6.3.10 Gas compressors skids shall have at least three gas detectors located along side the compressor skid where gas is expected to be released from the seals.

6.3.11 When possible, detectors shall be installed after major welding and painting has been completed.

6.3.12 Detectors installed inside the enclosure of the Combustion Gas Turbines shall be located as per SAES-K-502, paragraph 14.4.7

6.4 System Configuration

6.4.1 General

6.4.1.1 Detectors shall be monitored by a logic system as described in section 6.4.3 below.

6.4.1.2 Only facilities without a logic system may utilize a conventional control unit to monitor gas detectors. The control unit shall be provided by the detector manufacturer.

6.4.1.3 Control units or logic systems shall be located inside electrically unclassified control buildings on structures as vibration-free as possible.

6.4.1.4 Control units and logic systems shall be designed to accept analog inputs from the detectors or specified digital communication protocols

Control units and logic systems shall incorporate the logic necessary to handle the various signal levels and functionality of the detectors as specified in section 6.2.3. Alarms shall be generated as specified in section 7.2.

6.4.1.5 Logic shall be designed to be fail-safe and shall de-energize to alarm. Normally open (shelf state) contacts shall be closed during normal operation and shall open on alarm.

Exception:

Contacts controlling beacons and horns shall close on alarm.

6.4.2 Control Unit

6.4.2.1 Single-channel, stand-alone control units or multi-channel control units with one control channel per detector may be used in accordance with section

6.4.2.2 Provided with an expansion capacity (rack space) of 20% of the total number of utilized channels.

6.4.2.3 Hydrogen sulfide and combustible gas control units may be installed together in the same rack.

6.4.2.4 Control units shall incorporate either an integral linear analog meter or a digital readout device to indicate the level of gas concentration for each channel.

6.4.3 Logic System

6.4.3.1 A logic system may be any of the following devices:

a) Programmable logic controller (PLC) dedicated for gas detection system only or stand alone PLC from proven manufacturers

b) Triple modular redundant programmable logic controller (TMR-PLC)

c) Distributed control system (DCS) with hardware redundancy configuration.

d) RTU for well sites and pipe lines.

6.4.3.2 PLCs, TMR-PLCs, DCS and RTU plc types shall be specified in accordance with 34-SAMSS-830, 23-SAMSS-010, 34-SAMSS-623, and 23-SAMSS-030 respectively.

6.4.3.3 Consideration shall be given to system reliability. Redundant processors should be considered to minimize the consequences of a common mode processor failure.

6.4.4 Meter Scale Range

6.4.4.1 Meter scales for hydrogen sulfide indication shall be 0-100 ppm.

6.4.4.2 Meter scales for combustible gas indication shall be 0-100% LEL.

7 Alarm Requirements

7.1 General

7.1.1 The design of the control and alarm system shall enable any part of the facility that is being monitored to be identified quickly.

7.1.2 Field mounted audible and visual alarm devices shall be installed in the vicinity of the gas detectors to alert personnel working at that particular

location. These same alarm conditions shall also be annunciated in the attended control buildings.

7.1.3 At unattended facilities, a set of audible and visual alarms shall be located so as to be easily discernible from the security gate.

7.2 Alarm Set points

7.2.1 Each control unit or logic system shall provide two separate, non-interactive alarm set points per detector, fully adjustable over the entire detector range.

7.2.2 Alarm set points on hydrogen sulfide detection instruments shall be factory set at the following levels:

Critical (High-high) alarm - 50 PPM Hydrogen Sulfide

Warning (High) alarm - 20 PPM Hydrogen Sulfide

7.2.3 Alarm set points on combustible gas detection instruments shall be factory set at the following levels:

Critical (High-high) alarm - 50% Lower Explosive limit

Warning (High) alarm - 25% Lower Explosive Limit

7.2.4 Each control unit or logic system shall provide the following alarms per detector to indicate detection loop status:

a) Detector trouble/open loop alarm (0-4 mA DC)

b) Detector bypass/calibration mode alarm (0-4 mA DC)

c) Signal Over range Alarm (greater than 20 mA DC)

7.2.5 The Critical alarm shall be latching and shall require a deliberate manual reset operation at the attended control building. The critical alarm can be manually reset only when the detected gas level falls back below the warning alarm set point.

7.2.6 A conventional control unit shall incorporate three (3) SPDT relays per detector to provide output contacts for the following:

a) Warning (High) alarm.

b) Critical (High-high) alarm.

c) System Fault Alarm.

7.3 Control Building Alarms

7.3.1 Alarms shall be displayed on a conventional alarm annunciator or on dedicated displays on a multi-purpose CRT. The CRT need not be dedicated to gas alarm displays. The following alarms (see Section 7.2 for alarm settings) shall be displayed:

- Individual Critical alarm for each detector
- Individual Warning alarm for each detector
- Common Fault alarm initiated by any detector

7.3.2 The alarms detailed in section 7.3.1 plus the Critical alarm reset shall be logged on a sequence of events log and historized.

7.3.3 Alarm windows for hydrogen sulfide and combustible gas detection systems shall utilize colors that are easily distinguishable from any other operational or process alarms.

7.3.4 A common hydrogen sulfide and combustible gas audible alarm (horn) and a set of flashing beacons comprising one blue beacon for hydrogen sulfide and one red beacon for combustible gas shall be installed in an attended control building and shall be initiated by any Critical alarm only. For extensions to existing installations, the established plant beacon color code shall be followed. The beacons shall be visible from all locations in the control building as far as practical. The audible alarm shall have a distinctive tone to differentiate it from any other operational or process alarms.

The audible sound level should be at least 15 dB above the average ambient sound level or 5 dB above the maximum sound level as per NFPA 72.

7.3.5 Each detector control unit or logic system shall be designed to provide a means for silencing (acknowledging) the audible alarm in the attended control building only and shall be so configured that subsequent Critical alarms will re-initiate the alarm.

7.3.6 Each detector control unit or logic system shall be designed such that the flashing beacon in the attended control building can only be extinguished when the detected gas level falls back below the Warning alarm set point and the system is manually and deliberately reset in the attended control building.

7.3.7 No field reset shall be permitted in an attended location. Reset at the detector location is permitted only in unattended facilities.

7.4 Field Alarms

7.4.1 Field alarm devices shall consist of a dedicated horn and a flashing beacon installed on a common stand adjacent to each gas detector.

Exception:

Beacons shall not be installed on offshore platforms without prior approval of the Saudi Aramco Marine Department.

7.4.2 A single horn and flashing beacon may be provided for detectors that are grouped together in a small area, i.e., a compressor skid. Where both hydrogen sulfide and combustible gas detectors are installed within the group, two beacons shall be installed as per the color code described in section 7.4.3 below. The horn shall be audible and the flashing beacon(s) shall be visible from all locations around the monitored area.

7.4.3 Blue lenses shall be fitted to hydrogen sulfide beacons and red lenses to combustible gas beacons. This is to provide identification and to distinguish them from any other field alarms. For extensions to existing installations, the established plant beacon color code shall be followed.

7.4.4 Flashing beacons and horns shall be installed outside analyzer shelters in accordance with SAES-J-502.

7.4.5 The Critical alarm of each detector shall actuate the horn and the flashing beacon adjacent to the corresponding detector.

7.4.6 The horn audio level shall be high enough to be heard above the normal background noise from all locations within the respective operating module or plant. The beacons shall be visible from all directions.

Commentary Note:

With the approval of the Operating Organization, horns with distinct sounds for LEL and H_2S may be used.

7.4.7 In unattended facilities, the field alarms shall be actuated by any Warning, or Critical alarms. Automatic shutoff of the audible alarm after a time period specified by the manufacturer shall be provided in order to prevent overheating of the alarm.

7.4.8 For unattended facilities, an audible alarm and an additional set of flashing beacons comprising one blue beacon for hydrogen sulfide, one red beacon for combustible gas and one white beacon for equipment fault alarms, shall be provided at the entrance gate. All alarms shall be clearly labeled. For extensions to existing installations, the established plant beacon color code shall be followed.

8 Electrical Requirements

8.1 Power Supply

8.1.1 The supply voltage for gas detection system instruments, including all audible and visual alarm devices, shall be 120 VAC, 60 Hz, from an uninterruptible power supply (UPS). In the absence of a regular UPS system the gas detection system instruments shall be supplied from a reliable 120 VAC, 60 Hz supply, and shall incorporate battery back-up for a minimum duration of 30 minutes.

Gas detection system can be also supplied from the logic solver such as DCS or PLC with 24 VDC or 125 VDC.

8.1.2 Control unit or logic system power supply modules shall be redundant to prevent a single power supply failure from disabling the detection system. Power supply specification shall conform to the limits shown in Table 1 of SAES-J-902.

Table 1 – Power Supply

System/Device	Nominal	Supply Voltage Tolerance	NEC Class
Annunciator Power	24 VDC 125 VDC 120 VAC, 60 ±2 Hz	21 - 28 VDC 113 - 137 VDC 110 - 126 VAC	1 or 2 1 or 3 1 or 3
Shutdown and isolation system power	24 VDC 125 VDC 120 VAC, 60 ±2 Hz	21 - 28 VDC 113 - 137 VDC 110 -126 VAC	1 or 2 1 or 3 1 or 3
Field switch contacts	24 VDC 125 VDC 120 VAC, 60 ±2 Hz	21 - 28 VDC 113 - 137 VDC 110 - 126 VAC	1 or 2 1 or 3 1 or 3
Analog signal (loop power)	24 VDC (4-20 mA)	21 - 28 VDC	1 or 2
Instrumentation power	24 VDC 120 VAC, 60 ±2 Hz	21 - 28 VDC 110 - 126 VAC	1 or 2 1 or 3

8.2 Intrinsically Safe Systems

Intrinsically safe design may be used only with prior approval of the General Supervisor, Process Control Systems Division, Information Technology. See SAES-J-903, "Intrinsically Safe Systems."

8.3 Area Classification and Certification

8.3.1 Electrical and electronic equipment in hazardous areas shall meet listing/certification and installation requirements specified in SAES-P-100, Section 8.

8.3.2 Equipment certified by authorities not listed in SAES-P-100 may be used with prior approval of the General Supervisor, Process Instrumentation Division, Process & Control Systems Department.

9 Installation

9.1 Detector Installation

Detectors shall be installed on surfaces free from vibration. Detectors shall be fitted with guards to protect them from mechanical damage and the effects of rain, water wash, strong wind, dust, sun and sand.

In general, for lighter-than air gases, sensors should be sited above the level of the potential sources of release, whereas for the detection of heavier-than air gases or vapors, sensors should be sited below the potential sources of release and installed close to the ground (12" - 18" above grade). Detectors shall be oriented downward.

However, it is necessary for the investigative beam of the open path infrared sensors to traverse without obstruction in the area where the presence of the gas is to be detected.

9.2 Accessibility

Detectors shall be readily accessible for calibration. If necessary, access platforms shall be provided as needed, per SAES-B-054.

9.3 Contamination

Detectors shall be protected from greases or silicone oils to prevent contamination and shall be located away from direct sprays of oils and other liquids.

9.4 Cabling and Wiring

The interconnecting cable between the detector and the control unit or logic system shall be shielded. Detector cables and control unit or logic system wiring shall conform to the requirements of SAES-J-902. Electrical installation in hazardous locations shall conform to SAES-P-100.

10 Gas Detection System Testing

Gas detection system shall be periodically tested for proper operation, response and alarming. The test shall cover field detectors, alarms, horns, beacons, control unit logic

and control room common alarms. The test interval shall be per the manufacturer's recommendation or every three months, whichever interval is shorter.

Gas detection systems which include sensors, logic controllers, alarms, etc must be checked and maintained by suitably qualified personnel in adherence to manufactures' procedures and instructions

11 Gas Detection System Aging Characteristics

The typical life time for properly installed and maintained sensors is between 2 to 5 years. However, sensors calibration must be checked after they have been exposed to high concentration of flammable gases or vapors to validate their response and functionalities.

Continuous zero drift is considered as sign of sensor unsatisfactory operation, which needs replacement in this case.

Sensors which are equipped with on-board sensor life indicator should be checked periodically to confirm their healthy functionality.

Revision Summary

31 January 2005 Major revision.