Engineering Standard

SAES-J-903 31 January 2005

Intrinsically Safe Systems

Saudi Aramco DeskTop Standards

Table of Contents

1 Scope

1.1 "Intrinsic safety" is a design and construction method that can be applied to electrical instruments and their interconnection wiring for safe use in a hazardous (classified) location.

1.2 This standard defines the conditions to be fulfilled to meet Saudi Aramco requirements for intrinsically safe (I.S.) systems. Any deviation from this standard shall be approved in writing by the General Supervisor, Process Instrumentation Division, Process & Control Systems Department (P&CSD).

1.3 This standard is not intended as a guide for equipment design.

1.4 Electrical hazardous areas are classified per SAES-B-068.

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, 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 General Supervisor, Process Instrumentation Division, P&CSD of Saudi Aramco, Dhahran.

3 References

The latest edition or revision of the following standards, specifications, codes, forms, and drawings shall, to the extent specified herein, form a part of this standard.

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-008	*Restrictions to Use of Cellars, Pits, and Trenches*
SAES-B-068	*Electrical Area Classifications*

SAES-J-005	*Instrumentation Drawings and Forms*
SAES-J-902	*Electrical Systems for Instrumentation*
SAES-O-126	*Blast Resistant Control Buildings*
SAES-P-100	*Basic Power System Design Criteria*

3.2 Industry Codes and Standards

The International Society for Measurement and Control

ISA RP12.6	*Wiring Practices for Hazardous (Classified) Locations Instrumentation Part 1: Intrinsic Safety*
ISA RP12.2.02	*Recommendations for the Preparation, Content, and Organization of Intrinsic Safety Control Drawings*
ISA TR12.2	*Intrinsically Safe System Assessment Using the Entity Concept*
AG-163 rev. 2.0	*Foundation Fieldbus Application Guide 31.25 kbit/s Intrinsically Safe Systems*

National Electrical Manufacturers Association

NEMA 250	*Enclosures for Electrical Equipment (1000 Volts Maximum)*

National Fire Protection Association

NFPA 70 - 2005	*National Electric Code (NEC)* *Article 500, Hazardous (Classified) Locations* *Article 504, Intrinsically Safe Systems* *Article 505, Class I, Zone 0, 1, and 2 Locations*

4 Definitions

Associated Apparatus: Apparatus in which the circuits are not necessarily intrinsically safe themselves, but which affect the energy in the intrinsically safe circuits and are relied upon to maintain intrinsic safety. The associated apparatus represents the primary means to limit energy to field devices located in hazardous areas. It often consists of an intrinsic safety barrier or isolator.

Commentary Note:

Active galvanic isolators are the preferred type of associated apparatus.

Control Drawing: A drawing or other documentation provided by the manufacturer of the intrinsically safe or associated apparatus that details the allowed interconnections between the intrinsically safe and associated apparatus.

Fault: A defect or electrical breakdown of any component, spacing or insulation that alone or in combination with other faults, may adversely affect the electrical or thermal characteristics of the intrinsically safe circuit. If a defect or breakdown leads to defects or breakdowns in other components, the primary and subsequent defects and breakdowns are considered to be a single fault.

Intrinsically Safe Apparatus: Apparatus in which all the circuits are intrinsically safe.

Intrinsically Safe Circuit: A circuit in which any spark or thermal effect, produced either normally or in specified fault conditions, is incapable, under the test conditions prescribed, of causing ignition of a mixture of flammable or combustible material in air in its most easily ignited concentration.

Intrinsically Safe System: An assembly of interconnected intrinsically safe apparatus, associated apparatus, and interconnection cables in which those parts of the system that may be used in hazardous (classified) locations are intrinsically safe circuits.

Intrinsic Safety Ground Bus: A grounding system which has a dedicated conductor separate from the power system and which is reliably connected to a ground electrode in accordance with Article 504.50 of the NEC and as specified in the I.S. control drawing.

Normal Operation: Intrinsically safe apparatus or associated apparatus conforming electrically and mechanically with its design specification.

Simple Apparatus: A device which will not generate or store more than 1.5 V, 100 milliamps, and 25 milliwatts, or a passive component that does not dissipate more than 1.3 watts and is compatible with the intrinsic safety of the circuit in which it is used. Examples are switches, thermocouples, light-emitting diodes, and resistance temperature detectors (RTDs).

5 General

5.1 The use of Intrinsic Safety as a protection method is required for all instruments located within Class I, Zone 0 areas. In other electrical hazardous areas (Class I, Zone 1 and Zone 2), I.S. systems shall only be used where other methods of protection are impractical.

5.2 When required as part of Foundation Fieldbus systems, the I.S. design shall use a method of protection other than intrinsic safety for the fieldbus trunk to allow a higher level of current to the segment than is possible with intrinsic safety. Intrinsically safe spurs shall be generated by including voltage, current and

power limiting components and limiting the internal capacitance and inductance within a field mounted Fieldbus Barrier. This approach is outlined in Section 4.3, Foundation Fieldbus Application Guide, AG-163 Revision 2.0.

6 Equipment

6.1 Only equipment, apparatus or devices that have been certified, labeled or listed as intrinsically safe (I.S.) by a third party testing laboratory shall be used or installed under this standard.

Exception:

If the field device is classified as simple apparatus, certification is not required.

6.2 As third party testing laboratories, only the agencies listed in SAES-P-100, Table 2 are acceptable under this standard.

For equipment, devices, or apparatus certified as intrinsically safe, only those that are certified as category EEX or AEX "ia" shall be used.

Commentary Note:

The identifying letter for intrinsic safety is "i" followed by either "a" or "b," identifying whether the equipment is suitable for Zone 0 (ia) or Zone 1 (ib). Intrinsically safe systems are limited by this standard to those certified "ia" to simplify the selection process and to ensure that an I.S. system is safe to install in all locations (Zone 0, 1, or 2).

7 Procedure

The proponent/PMT shall follow the following procedure when using the intrinsic safety protection technique.

7.1 The proponent/PMT shall prepare an I.S. System design package and submit to Process Instrumentation Division, P&CSD for review during engineering design.

7.2 During installation and commissioning, the I.S. system shall be inspected by the proponent and the Inspection Department for compliance with the I.S. control drawing. P&CSD/PID/Instrumentation Unit shall be contacted with any questions regarding compliance with I.S. system design requirements.

Exception:

Intrinsically safe circuits that are part of third party certified systems, are factory installed, and require no modification in the field, are acceptable without an I.S. design package review and inspection required in Section 6.1 and 6.2 above.

8 I.S. System Design Package

The I.S. system design package shall consist of the following documentation:

8.1 Electrical area classification drawing.

8.2 Plan drawing showing the overall I.S. system from the instruments in the hazardous areas to the instruments in the non-hazardous area (usually the control room). For sake of clarity, the drawing shall show the I.S. system only.

Demarcation lines between the non-hazardous (safe) area and the hazardous area portions of system shall be clearly shown. The respective areas shall be labeled "non-hazardous (safe)" and "hazardous area".

8.3 Loop diagrams showing termination assignments in junction boxes and marshalling panels.

8.4 I.S. System Certification Information

A System Control Drawing shall be provided including all Entity Concept parameters for each component in the intrinsically safe system. I.S. system control drawings shall be prepared in accordance with ISA RP12.2.02. The I.S. system control drawing shall reference the applicable Instrument Loop Diagram (ILD) or Instrument Segment Diagram (ISD), ref. SAES-J-005.

The Certifying agency, Certificate number, and Date of certification shall be supplied for each component in the intrinsically safe system.

Exception:

If the field device is classified as simple apparatus, certification of the device itself is not required. However, all devices included in the Intrinsically Safe loop, shall be shown on the System Control Drawing.

To assess the intrinsic safety of the interconnected equipment, the entity parameters shall be compared (including the calculated interconnecting cable capacitance and inductance) in accordance with ISA TR12.2. Entity parameter calculations shall be submitted with the I.S. system design package for Process Instrumentation Division, P&CSD review.

Commentary Note:

The I.S. system "control drawing" consolidates the entity parameters for the intrinsically safe field instrument and the associated apparatus as well as the allowable capacitance and inductance of the interconnecting cables. Having this information on a single drawing referenced to the Instrument Loop Drawing (ILD) is critical when making modifications to the loop in the future.

8.5 Cable/Wire Information

8.5.1 Size of individual pair or triad, capacitance per unit length, and inductance per unit length.

Commentary Note:

IEC 61158-2 Physical Layer fieldbus standard cable is 0.8 mm^2 (18 AWG) conductor size.

8.5.2 Cable length, meters (feet)

8.5.3 Insulation Rating

Interconnecting cables shall be specified with a minimum insulation rating of 600 Volts.

8.5.4 Cable manufacturer

8.6 Grounding Plan

8.6.1 Overall control building grounding plan

8.6.2 I.S. system grounding plan for associated apparatus, cable shields, and enclosures.

9 Installation

As proper installation is critical for intrinsically safe circuits to operate safely, special attention shall be given to the installation requirements below:

9.1 Field Instrument

The intrinsically safe instrument enclosure shall be sealed to provide adequate ingress protection (NEMA 4X or IP 65).

Commentary Note:

With Intrinsically Safe systems, the instrument enclosure and wire raceway (conduit, tray, etc.) only provide mechanical protection. Therefore, an instrument installed as Intrinsically Safe does not require an "explosion proof" seal and the interconnecting cable raceway must only be sealed at the point of exit from the hazardous area if it can transport hazardous gases into the non-hazardous area.

9.2 Interconnecting wiring

Typical instrument wiring consists of a shielded, twisted pair/triad from a field located device to the associated apparatus (typically the IS barrier) located in a

control room or process interface building. The interconnecting cables used in an intrinsically safe circuit must be electrically compatible with the intrinsically safe components being used. See section 7.4 for the requirement to include cable capacitance and inductance contributions on the system certificate or system control drawing.

9.2.1 Conductors of intrinsically safe circuits shall not be placed in any raceway, cable tray, or cable with conductors of any non-intrinsically safe circuit.

9.2.2 Mechanical protection of the conductors to each individual instrument from the field-mounted instrument to the field junction box shall be provided in the form of conduit or steel wire armor and cable tray/channel per SAES-J-902. Where cable systems are used with tray/channel, the cable shall be well supported throughout its length and the length of unsupported cable at the field instrument shall not exceed 0.5 meters.

9.2.3 Dedicated intrinsically safe field termination cabinets (junction boxes) shall be provided to maintain positive separation of intrinsically safe from non-intrinsically safe wiring. Where several intrinsically safe instrumentation loops are involved, individual pair/triad from each instrument located in the field may be routed to a common field termination cabinet. The field termination cabinet will serve as a transition point from individual pair/triad to a multi-pair/triad cable. Multi-core cables shall not combine intrinsically safe and non-intrinsically safe signals.

Field termination cabinets (junction boxes) shall be NEMA Type 4X or IP 65 (reference NEMA Standards Publication No. 250).

9.2.4 Multi-pair/triad cables shall be routed from the field termination cabinets (junction boxes) to the control room or process interface building in cable trays, in conduits, or by direct burial cable provided the cable is approved for cable tray use or for direct burial. Cables shall be sealed against the passage of gas and vapors as required by the National Electrical Code NFPA 70, SAES-B-008, and SAES-O-126.

9.2.5 The standard practice of separating thermocouple, 4-20 milliamp, and digital alarm signals shall be observed. This segregation shall be maintained in the field via dedicated, intrinsically safe field junction boxes. Signal segregation shall be maintained up to the marshalling panels, where signals may be consolidated to the extent specified in SAES-J-902.

Care shall be taken to avoid locating interconnecting cables containing intrinsically safe circuits close to overhead power distribution lines or heavy current carrying cables. Refer to SAES-J-902 for minimum spacing requirements between parallel cable runs of different signal types.

Commentary Note:

The associated apparatus (I.S. barrier) in an Intrinsically Safe loop only protects the field device and interconnecting wiring from unsafe voltage levels on the controls system side of the "non-hazardous" terminals. Positive separation between Intrinsically Safe interconnecting cables and non-Intrinsically Safe conductors ensures that the Intrinsically Safety of the loop is not compromised by a fault on the field side of the associated apparatus "hazardous area" terminals.

9.3 Termination

8.3.1 I.S. system wiring shall be terminated in dedicated marshalling cabinets or compartments within marshalling cabinets that house the associated apparatus. I.S. cables shall enter the cabinet through cable entries completely separate and opposite from the non-intrinsically safe connecting cables to the control system.

Cabinets that contain the associated apparatus shall be located within air-conditioned analyzer shelters, process interface buildings, or control rooms.

Exception:

The associated apparatus may be installed in the field when supplied as part of the vendors standard product offering certified for use in the intended hazardous area.

Commentary Note:

The associated apparatus (barrier) may be installed within a field mounted, NEMA 4X enclosure provided the certification mark on the device identifies it may be safely installed in the intended hazardous location. The certification marking on the associated apparatus is completely separate from the entity parameters listed for the output terminals (used to match the associated apparatus with the intrinsically safe instrument located in the hazardous area).

9.3.2 The I.S. cables from the field instrument shall be terminated on the "hazardous area" terminations of the associated apparatus and shall be secured or tie-wrapped separately from the non-intrinsically safe cables terminated on the opposite end "safe area" terminals of the associated apparatus. A minimum of 2 inches (50 mm) shall be maintained

between the I.S. and non-I.S. cables within the cabinet that contains the associated apparatus.

9.3.3 All spare wires shall be terminated at terminal blocks and grounded to the intrinsic safety ground bus. Unused wires shall also be insulated at their hazardous area ends.

9.3.4 The minimum clearances between terminals of intrinsically safe circuits and any grounded metal shall be 3 mm (⅛ inch), unless that terminal is intended to be grounded. The clearance between two terminals of different intrinsically safe circuits shall be at least 6 mm (¼ inch).

9.4 Grounding

9.4.1 I.S. system grounding shall conform to the I.S. system vendor's grounding recommendations and all I.S. control drawing requirements.

All intrinsically safe circuit grounds shall be connected to the grounding system with dedicated I.S. grounding conductors separate from non-intrinsically safe, or equipment, or power grounds.

Commentary Note:

In the case of Radar Tank Gauging (RTG) systems, the tank grounding system (or tank structure) serves as both the intrinsically safe ground and the electrical safety ground. The installation of a separate I.S. ground rod at each tank is not required.

9.4.2 In cabinets housing the associated apparatus, the intrinsic safety ground bus shall be connected to a node in the overall plant ground grid by dedicated, redundant, insulated copper cables not smaller than #4 AWG. To identify the intrinsically safe grounding conductors as being different from other ground connections, the grounding conductor insulation color shall be green with blue tracer (or banded with blue tape).

Where screens/shields are used, they shall be covered by an outer insulating sheath. They shall be grounded at the associated apparatus intrinsic safety ground point and insulated at the hazardous area end. Where screened multipair/multitriad cables interconnect within field junction boxes with individual screened pair/triad cables, insulated terminals shall be provided for the ongoing continuity of the screens/shields.

9.4.3 When zener diode type barriers are used, the maximum resistance between the farthest point on the intrinsic safety barrier ground and the

plant grounding system (the point at which the incoming electricity supply neutral is grounded) shall not exceed 1 Ohm.

Commentary Note:

The low impedance (1 Ohm or less) ground connection is not required when active galvanic isolators are used as the associated apparatus.

9.4.4 All metal enclosures for intrinsically safe circuits shall be grounded to the plant grounding system with a minimum of #4 AWG copper wire with green insulation.

9.4.5 All metal cable trays used for intrinsically safe wiring shall be grounded to the plant grounding system with a minimum of #4 AWG copper wire with green insulation.

9.4.6 Cable protective armor, if used, shall be grounded to plant grounding system at the field junction box.

9.5 Identification

9.5.1 All intrinsically safe system components shall be so identified.

9.5.2 All junction boxes, cable trays, conduits, cables, cabinets, and instrument housings shall be labeled as containing intrinsically safe circuits or equipment. The means of identification shall be visible after installation. Label spacing on cable tray, conduit, and interconnecting cables shall not exceed 25 feet (8 meters).

Commentary Note:

Self-sticking markers are recommended (e.g., Brady Polyester 0.112 mm thickness, permanent acrylic adhesive 0.026 mm, clear over laminate type). Specify light blue letters on white background for the control cabinets, conduit runs, and local junction boxes (¾ inch x 8 inch length color field with ½ inch letter height).

9.5.3 Light blue color coding shall be used to identify intrinsically safe wiring. The preferred practice is to specify intrinsically safe interconnecting cables with a blue outer jacket. Alternatively, blue sleeves slipped over the jacket at all points of termination may be used to identify I.S. wiring.

10 Modification of Intrinsically Safe Systems

10.1 A log shall be maintained, by the responsible proponent organization, of all modifications to existing I.S. systems. Drawings shall be modified and the

design approved using Entity Concept parameters (Reference ISA RP12.6 and ISA TR12.2).

10.2 Only devices, apparatus, and equipment that have been approved, certified, or labeled as Intrinsically Safe shall be used when existing Intrinsically Safe instrumentation loops or systems are modified.

Exception:

If the field device is classified as a simple apparatus, certification is not required.

10.3 Installation shall be in accordance with existing system documentation (System Control Drawing) and manufacturers' instructions.

11 Maintenance and Testing

11.1 An I.S. system may be tested and maintained under live (working) conditions provided the portable test equipment used has been certified and approved as intrinsically safe for the particular atmospheric hazard. Otherwise, a hot work permit shall be issued.

11.2 Only safety barriers/isolators of the same type, make, or catalog number shall be used to replace defective safety barriers/isolators.

11.3 Only devices of the same make, type, and catalog number or replacement recommended by the manufacturer shall be used to replace any device in the system.

11.4 Any changes, additions/deletions of components to/from a loop, shall be recorded at the operating facility in the appropriate Saudi Aramco drawings.

Revision Summary

31 January 2005 Major revision.