Valmet FORWARD

Valve communication solutions

Technical guide

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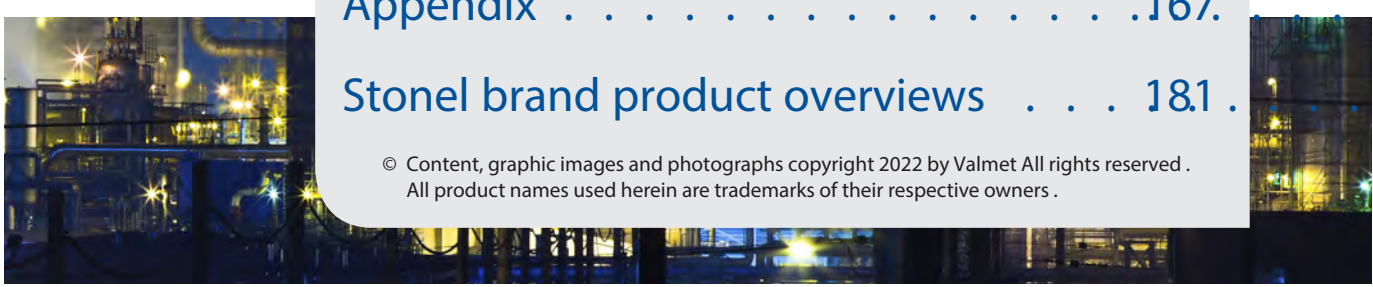
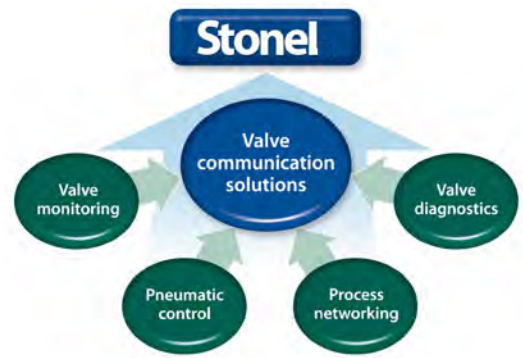


Stonel focus

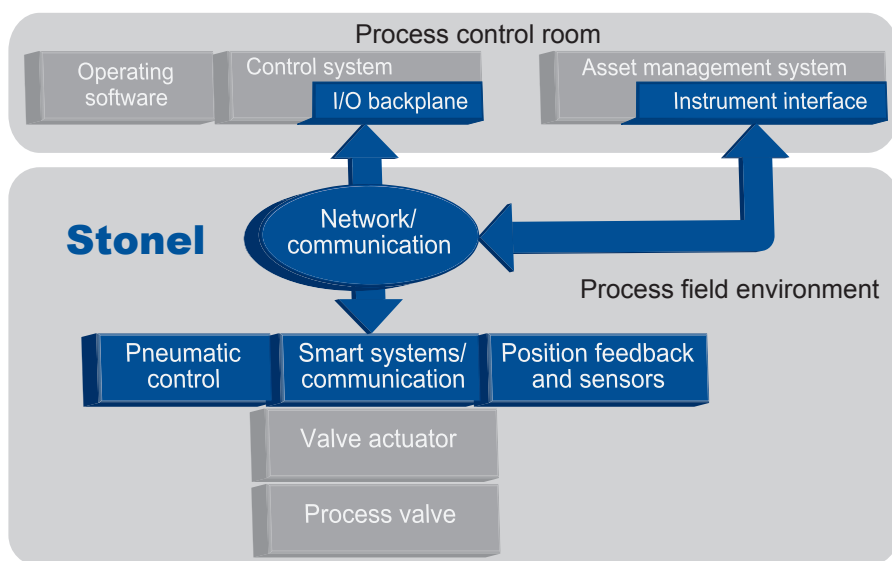


- Valve monitoring includes field-based control circuits and sensor technologies
- Pneumatic control is used for discrete valve actuation control
- Process networking consists of digital communication protocols for field-based applications
- Valve diagnostics combines monitoring, communication and smart systems to support ongoing valve maintenance and trouble-shooting

Stonel brand contributes to customer success by creating valve communication solutions which improve process performance and reduce total life cycle costs. At Stonel, "Valve communication solutions" cover the full spectrum of applications from discrete (On/Off) valve monitoring/communication at the control valve in the field to integrating each of them into the plant's operating and maintenance systems to optimize process operations.

Stonel technical guide has been created to assist valve automation suppliers and integrators in gaining a comprehensive understanding of the technologies available and the standards used for valve communication solutions in process applications worldwide.

Control architecture



This diagram shows where Stonel brand valve communication and control and process networking products are used in the process environment.

Our aim: Improve process performance and reduce total life cycle costs

Stonel brand value propositions

Monitoring/communication

- Consistent, reliable operation
- Reduced space requirements
- Fast set-up and installation
- Easy to maintain and operate
- Long life

Pneumatic control

- High reliability with standard plant air
- 24 VDC or 120 VAC with same unit
- Standard rebreather capability
- Wide temperature range options
- Low power consumption
- Intermediate control options

Our objective is to add value for each facet of the valve communication solution.

ValvePoint valve communication and control products attach directly to most automated and manual valve applications in the process environment.

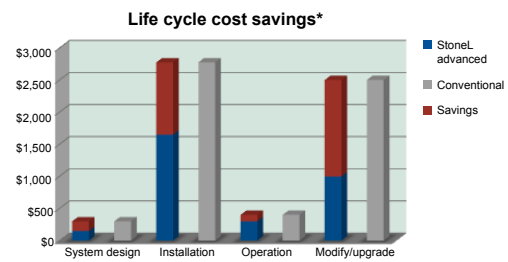
Stonel brand value propositions

Process networking

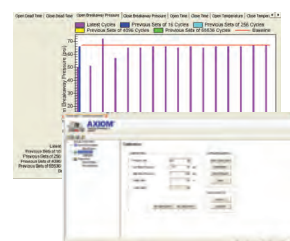
- Simple design and wiring
- Reduced installation costs
- Lower infrastructure costs
- Increased process flexibility
- Faster start-up
- Greater information availability

Valve diagnostics

- Lower valve maintenance costs
- Faster troubleshooting
- Increased process uptime
- Improved maintenance planning



* Based on installation of 20 automated valves located an average distance of 60 meters from I/O cabinet or gateway. AS-Interface protocol is used with Axiom diagnostic valve communication and control platform. Specific costs may vary depending on application.



Stonel FieldLink process networking products cost effectively interconnect valve communication terminals (VCTs) into the plant control system. With intelligent valves communicating via standard field-based protocols predictive maintenance and diagnostics may also be realized!

Notes

Quick reference

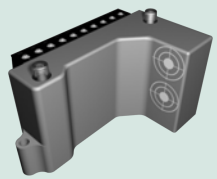
Notes

Hazardous area protection concepts				
	Explosion/flameproof page 122	Nonincendive equipment page 125	Tray cabling page 128	Intrinsically safe page 130
Protection concept	Ex	NIE	Tr Cbl *(IEC used different nomenclature)*	IS
Brief description	• Contain ignition inside conduit system. • Cool vented gases to prevent ignition outside containment vessel.	• Nonincendive equipment must not create arcs or sparks or must have arcing components contained in an hermetically sealed chamber. • Nonincendive equipment must not have surface temperatures exceeding vapor-air or dust-air ignition temperatures.	• Current and voltage limited power supplies. • Cabling is rated for ITC and/or PLTC and supported by cable tray or with special mechanical means. • IEC allows elastomeric and thermoplastic sheathed cable without other restrictions.	• Prevents ignition of gas, vapor or dust-air mixture. • Energy limited into circuits under fault conditions by barriers. • Potential inductive and capacitive energy in circuit components must be limited and coordinated with barrier.
Applicable areas	NEC Class I & II, Division 1 & 2 IEC Ex d, Zone 1 & 2	NEC Class I & II, Division 2 IEC Ex n, Zone 2	NEC Class I & II, Division 2 IEC Ex n, Zone 2	NEC Class I & II, Division 1 & 2 IEC Ex ia, Zone 0, 1 & 2 Ex ib, Zone 1 & 2
Fieldbus protocols	All	All	All	Foundation Fieldbus H1 Profibus-PA
Segment power availability	• Not limited	• Not limited	• PLTC: 100 watts or 3.3 amps @ 30 VDC • ITC: may be up to 5 amps • IEC cable: may be up to 6 amps	• Typically up to 100 mA @ 24 VDC with FISCO method
Enclosure requirements	• Explosionproof/flameproof housing with approvals	• Nema 4/IP54 enclosures with nonincendive component approvals • IP54 or better with Ex nA or Ex nC component ratings	• Same as nonincendive equipment or explosionproof • May use compression fittings on enclosures with terminations for ITC or PLTC cable	• Nema 4/IP54 enclosure with intrinsically safe apparatus approvals • IP 54 with Ex ib or ia rated components per entity or FISCO
Conduit/ cabling requirements	NEC • Rigid metal conduit • MI (Mineral Insulated, Metal Sheathed) or MC (Metal Clad) where flexibility required • Sealing components for all enclosures (except those with special ratings) IEC • Rigid metal conduit • Armored cable • Non-armored cable (country specific) • Cable glands for enclosure seal	NEC • Rigid metal conduit • MI, MC or liquidtight flexible conduit • IEC allows thermoplastic or elastomeric sheathed cable IEC • Single sheath	NEC • PLTC or ITC in Cable Tray • PLTC or ITC as open wiring up to 15 m (50 ft) protected by angles, struts or messenger wire. • MC flexible conduit or liquidtight where flexibility is required. IEC • Single sheath no restrictions.	NEC • General purpose cabling IEC • General purpose cabling
Cost analysis/ comments	Wiring costs are high. However, number of devices per segment is maximized holding down installation cost per device. Device power must be removed for maintenance. Seal components must be used if removing individual device from network.	Moderate wiring costs and devices per segment is maximized, dramatically reducing installed cost per device. Devices may be opened under power but power must be removed before manipulating wiring. Field devices may be removed without sealing off remainder of network.	Wiring costs are low. Number of devices per segment is typically not limited, resulting in very low installed cost per device. Current limited power supplies are required for PLTC and ITC.	Wiring costs are low. However, number of devices per segment is typically a maximum of 4 to 6 (power delivery limitations) and IS barriers are required for each segment resulting in higher installation costs per device.

Communication protocols			
	AS-Interface page 64	DeviceNet page 79	Foundation Fieldbus page 88
Protocol			
Topology	Not limited	Trunk/drop with branching	Trunk with branching or chicken foot
Max distance (Voltage drop may further limit distance)	100 m (328 ft) | 300 m (984 ft) with 2 repeaters Additional distance with multiple parallel repeaters. Tuners and terminators available for special extensions.	500 m @ 125 Kbit/s | 250 m @ 250 Kbit/s 100 m @ 500 Kbit/s (Based on thick cable. Max spur length 6 m; cumulative spur length 156 m/125 Kb, 78 m/250 Kb, 39 m/500 Kb)	1900 m (6200 ft) | 120 m spur[5] Using FISCO 1000 m (Max spur length 2-12 devices 120 m, 13-14 devices 90 m, 15-16 devices 60 m)
Max # devices	31 | 62 with extended addressing	62	32 theoretical | (16 practical maximum)
Cabling	Unshielded untwisted pair	(2) 2-wire with shield | (5-wire bundle)	Shielded twisted pair
Max power delivery	Current: up to 8 amps | Voltage range: 26.5 to 31.6 VDC	Current: up to 8 amps | Voltage range: 11 to 25 VDC	Current: up to 500 mA | Voltage range: 9 to 32 VDC
Hazardous area wiring	Explosionproof and nonincendive devices; conduit, tray cabling and nonincendive wiring	Explosionproof and nonincendive devices; conduit and tray cabling	IS, explosionproof and nonincendive devices; conduit, IS, tray cabling and nonincendive wiring
Data transfer size	4 bits	1 byte variable up to 8 bytes	2 bytes discrete | 5 bytes analog variable
Bus access method	Cyclic polling	Selectable: cyclic polling, change of state and more (device specific)	Publisher-subscriber method with data transfer. Token passing client-server for calibration and diagnostics.
Transmission rate	167 Kbit/s	125 Kbit/s | 250 Kbit/s | 500 Kbit/s	31.25 Kbit/s | (IEC 61158-2)
Approximate cycle time	3 ms | Varies with # of devices and times scanned (3 I/O per device with 16 devices)	9 ms | 6 ms | 3 ms (3 I/O per device with 16 devices using cyclic polling)	1 second (3 I/O per device with 16 devices assuming use of 50% of macrocycle)
Special features	Analog available with 2.1 version masters with multi-scan 3.0 version offers diagnostic and data transfer capabilities.	EDS file used for device parameters and rapid start-up	Function blocks used for process control may be distributed into field devices. Time stamping of data optimizes control.
Strengths	• Low cost • Easy to install • Easy to support • Fast • Supports high power • Flexible topology	• Interfaces to A-B • Flexible implementation • Flexible data capabilities • Supports high power • ODVA marketing	• Long length • Well supported • Convenient user objects • Extensive diagnostics • Capable of being IS
Weaknesses	• Short bus length • Limited data/node	• 4-20 mA instrumentation not widely available	• Moderate speed • Expensive field devices • Limited bus power
Optimal applications	Use for discrete I/O where low cost and simplicity are important. May readily interface with most PLC, DCS systems. Gateways conveniently to high level protocols.	Use for discrete I/O into Allen Bradley PLCs. Also may be desirable for motor control applications.	Use for analog I/O in process or discrete I/O over long distance. Use for IS analog & discrete I/O. Supported by many process instrument manufacturers throughout the world.

Communication protocols				
	Profibus-DP page 101	Profibus-PA page 101	Modbus page 108	HART page 114
Protocol	PROFIBUS-DP	PROFIBUS-PA	MODBUS	HART COMMUNICATION PROTOCOL
Topology	Trunk/drop	Trunk with branching or chicken foot	Trunk/drop	HART hand-held | 4-20 mA multiplexer
Max distance (Voltage drop may further limit distance)	1200 m @ 94 Kb/s | 400 m @ 500 Kb/s 100 m @ 12 Mb/s	1900 m (6200 ft) | 120 m spur Using FISCO 1000 m	1200 m (4000 ft)	Multiplexer 3,048 m (10,000 ft)
Max # devices	32 up to 126	32	32	Handheld: 1 | Multiplexer: 15
Cabling	Shielded twisted pair	Shielded twisted pair	Shielded twisted pair	Handheld: Direct connection Multiplexer: Shielded twisted pair
Max power delivery	Current: up to 8 amps Voltage range: 11 to 25 VDC (Power supplied on separate wire pair from communication signal.)	Current: up to 500 mA Voltage range: 9 to 32 VDC	Current: up to 87 amps Voltage range: 11 to 25 VDC	Loop powered
Hazardous area wiring	Explosionproof and nonincendive devices; conduit and tray cabling	Intrinsically Safe (IS), explosionproof and nonincendive devices; conduit, IS, tray cabling and nonincendive wiring	Explosionproof and nonincendive devices; conduit and tray cabling	Explosionproof and nonincendive devices; conduit and tray cabling
Data transfer size	1 byte variable, up to 244 bytes	1 byte variable, up to 244 bytes	1 byte variable (RTU mode)	0-253 bytes
Bus access method	Token passing for multi-master, cyclic polling for data to master; acyclic for diagnostic and calibration	Transparent to Profibus-DP w/ coupler. Cyclic polling for data & acyclic for diagnostics & calibration with link master.	Synchronous and asynchronous poll and response	Master slave
Transmission rate	9.6 Kbit/s to 12 Mbit/s	31.25 Kbit/s (IEC 61158-2)	9 Kbit/s to 56 Kbit/s	1.2 Kbps
Approximate cycle time	0.5 ms @ 12 Mb/s (3 I/O per device with 16 devices using cyclic polling)	100 ms (3 I/O per device with 16 devices using cyclic polling)	75 ms @ 38.4 Kbit/s (3 I/O per device with 16 devices using synchronous polling)	(Not applicable)
Special features	GSD file used for device parameters	Couples directly to DP in transparent manner (DP limited to 45 Kbit/sec) or links to DP as a slave/master to PA	—	Multi-drop available
Strengths	• Long length • Very fast • Well supported in Europe and North America	• Long length • Well supported in Europe • Capable of being IS	• Easy to install • Easy to support • Long length • Widely used on existing DCS systems	• Numerous products • Well supported worldwide • Convenient for commissioning
Weaknesses	• Must have auxiliary power	• Moderate speed • Limited bus power • Connected to control system via Profibus-DP	• Moderate speed • Must have auxiliary power	• Diagnostics not widely used • Limited multidrop capability
Optimal applications	Use for high speed analog and discrete I/O and for variable speed drives. Supported by European mfgs. Ideal for high speed AS-i gateway applications.	Use for analog I/O in process or discrete I/O over long distance. Use for IS analog and discrete I/O. Supported by many European instrument manufacturers.	Use for field devices with discrete and analog I/O over long distances. Common legacy bus used with AS-i gateways.	Configuration of analog instruments Diagnostics of analog instruments

Switches and sensors								
	Switch type	Function		Technology	Electrical rating	Cycle life	Recommended use	Special comments
Mechanical Quartz platform		SPDT 	_V	Snap-acting, silver contacts	10 amp @ 125/250 VAC	400,000	Ideal for high power circuits May be used with AC computer inputs, Not recommend for DC computer inputs	Low cost; Snap-acting mechanism prone to corrosive attack; Seal offs required in all hazardous areas
			_W	Snap-acting, gold contacts	1 amp @ 125 VAC; 0.5 amp @ 30 VDC	100,000	Low cycle life applications for computer inputs	Same as standard mechanical but good for low power application
		DPDT 	14	Snap-acting, silver contacts	4.5 amp @ 125/250 VAC	250,000	Dual circuits in high power applications which must operate simultaneously	Not recommended for additional reliability due to redundancy; both switches operate off of single mechanism
Maxx-Guard Quartz platform	 Hermetically sealed reed glass encapsulated	SPDT 	_G	Rhodium contacts	0.30 amp @ 24 VDC 0.20 amp @ 120 VAC	5 million	AC or DC computer input circuits	Protection required for use in long cable runs with 120 VAC circuits
			_S	Rhodium contacts	0.30 amp @ 24 VDC; 0.20 amp @ 120 VAC	5 million	Computer input for AC and DC circuits	Same as _G with LED indication
			_H	Tungsten contacts	2.0 watts minimum 100 watts maximum 3.0 amp maximum 240 VAC maximum	5 million	High power switching applications	Not recommended for DC computer input applications
			_M	Rhodium contacts	0.15 amp @ 24 VDC	5 million	Intrinsically safe passive switching input	No protection circuitry needed
		SPST 	_P	Ruthenium contacts	0.15 amp @ 30 VDC 0.15 amp @ 125 VAC	5 million	AC or DC computer input circuits	Protection required for use in long cable runs with 120 VAC circuits

Switches and sensors						
	Switch type	Function	Technology	Electrical rating	Recommended use	Special comments
Quartz, Eclipse and Prism platforms						
Dual module  • Two (dual) solid state inductive proximity sensors with conventional discrete outputs or communication • Unlimited cycle life • 5 year warranty		33 SST	2-wire AC/DC power transistor switching	0.30 amp @ 125 VDC/VAC Solenoid wire terminations	AC or DC Computer inputs in conventional applications	Max leakage current of 0.5 mA Max voltage drop of 7 V
		44 NAMUR (EN 60947-5-6)	2-wire DC current varying	Target On I<1 mA Target Off I>3 mA Voltage range 6 to 29 VDC Solenoid wire terminations"	Intrinsically safe with repeater barrier	Repeater barrier acts as input switch for computer I/O
		92 DeviceNet	4-wire network with 62 devices/segment	2 DI & 2 DO (4 W @24 VDC), 1 AI 4-20 mA auxiliary;	Interface with Rockwell PLCs; Used for discretes I/O	Available in same configuration as stand alone I/O module
		93 Foundation Fieldbus	2-wire IS , low power network with approximately 16 devices/ segment	2 DI & 2 DO (bus powered outputs; piezo valves)	Use with very long wiring runs or where analog and a few discretes are interspersed	Not available in Eclipse
		94 Foundation Fieldbus	Same as "93" but not IS; Also has separate 24 VDC power outputs	2 DI & 2 DO (externally powered outputs; 4 W @24 VDC)	Foundation Fieldbus communication with auxiliary power bus	Not available in Eclipse
		95 Modbus	4-wire network with 32 devices/segment	2 DI & 2 DO (4 W @24 VDC), 1 AI 4-20 mA auxiliary	Use for direct interface to PLCs	
		96 AS-Interface	2-wire network with 31 devices/segment	2 DI & 2 DO (4 W @24 VDC), 2 DI auxiliary	Low cost discrete network ideal for field applications	Typically interfaced into higher level network
		97 AS-Interface (extended addressing)	Same as "96" except 62 devices/network	2 DI & 1 DO, 2 DI auxiliary	Used when high concentrations of discrete Nodes	

Switches and sensors					
Switch type	Function	Technology	Electrical rating	Recommended use	Special comments
Axiom AX and Axiom AMI platforms					
C module  • Magnetic resistive sensor with continuous (C) sensing integrated with output switching, current outputs or communication • Integrated diagnostics options • Unlimited cycle life • 5 year warranty	33 SST	2-wire AC/DC power transistor switching; Solenoid input signal conditioner accepts AC or DC inputs	0.25 amp @ 125 VDC/VAC, Short circuit protected Solenoid input 0.6 W @ 22 to 130 VDC/VAC	AC or DC computer inputs in conventional applications with either AC or DC solenoid power	Max leakage current of 0.5 mA Max voltage drop of 7 V
	44 NAMUR (EN 60947-5-6)	2-wire DC current varying	Target On I <1 mA; Target Off I >3 mA Voltage range 6 to 29 VDC Solenoid wire terminations for IS solenoid coil 0.5 W @ 12 VDC	Intrinsically safe with repeater barrier for inputs and conventional barrier for solenoid output	Repeater barrier acts as input switch for computer I/O
	71 4-20 mA with HART diagnostics	4-20 mA position feedback with Hart; Solenoid input accepts 24 VDC	4-20 mA @ 14-35 VDC; 24 VDC Nominal with Hart digital signal for comprehensive diagnostics, and numerous remote settings Solenoid input 0.5 W @ 24 VDC Conventional; 0.5 W @ 12 VDC IS	Critical discrete valve applications where diagnostic information is valuable	Senses 3 different pressure levels; Senses solenoid current and voltage levels. Remote open and closed switch settings, max & min pressure settings and winking included
	80 Expeditor	4-20 mA position feedback 4-20 mA position control 24 VDC solenoid power	Feedback 4-20 mA @ 9-35 VDC; 24 VDC Nominal Position Control 4-20 mA @ 9-35 VDC; 24 VDC Nominal Solenoid input 0.5 W @ 24 VDC Conventional; 0.5 W @ 12 VDC IS	Fill control Flow dampening Partial stroke testing	Solenoid power input must be energized for position control capability to function
	92 DeviceNet	4-wire network with 62 devices/segment	2 DI & 2 DO, 1 AI 4-20 mA auxiliary;	4-wire network with 62 devices/segment	
	93 Foundation Fieldbus	2-wire IS, low power network with appox 16 devices/segment	2 DI & 2 DO (bus powered outputs; piezo valves)	2-wire intrinsically safe, low power network	
	94 Foundation Fieldbus	Same as "93" but not IS; Also has separate 24 VDC power outputs	2 DI & 2 DO (externally powered outputs; 24 VDC)	4-wire bus network for high power outputs	
	95 Modbus	4-wire network with 32 devices/segment	2 DI & 2 DO, 1 AI 4-20 mA auxiliary	4-wire traditional bus network	
	96 AS-Interface	2-wire network with 31 devices/segment	2 DI & 2 DO, 2 DI auxiliary	2-wire discrete bus network (31 devices/network)	
	96 AS-Interface with diagnostics	2-wire network with 31 devices/segment with diagnostics	2 DI & 1 DO, remaining bits used for diagnostics, remote switch settings & winking	2-wire discrete bus network (31 devices/network) in critical applications	Senses 2 different pressure levels & solenoid status; Remote open & closed switch settings and winking included
	97 AS-Interface (extended addressing)	Same as "96" except 62 devices/network	2 DI & 1 DO, 2 DI auxiliary	Same as "96" except 62 devices/network	

Valve control platforms			
	Axiom AX page 183	Axiom AMI page 186	Quartz page 188
Platform			
Hazardous ratings* NEC/CEC	Class I Div 1&2 explosionproof Class I Div 1&2 intrinsically safe Class I Div 2 nonincendive	Class I & II Div 1&2 intrinsically safe Class I Div 2 nonincendive	Class I Div 1&2 explosionproof Class I Div 1&2 intrinsically safe Class I Div 2 nonincendive
IECEx	Ex d IIC T6 explosionproof (Zone 1, 2)	Ex ia IIC T5 intrinsically safe (Zone 0, 1, 2) Ex nA, nc IIC nonincendive (Zone 2)	Ex d IIC T5 explosionproof (Zone 1, 2) Ex ia IIC T5 intrinsically safe (Zone 0, 1, 2)
Enclosure ratings	Nema 4, 4X and 6 IP 66, IP 67	Nema 4, 4X and 6 IP 67	NEMA 4, 4X and 6 IP 67
Capabilities	Discrete monitoring Communication terminal (VCT) Discrete pneumatic control Diagnostics Uses advanced analog sensing technology (C-module)	Discrete and analog monitoring Communication terminal (VCT) Discrete pneumatic control Diagnostics Uses advanced analog sensing technology (C-module) Intermediate control	Discrete and analog monitoring Communication terminal (VCT) Uses dual module system Uses individual sensor/switches (multiples of 2, 4 or 6) and position transmitters
Typical applications	1/4 turn pneumatically actuated valves	1/4 turn pneumatically actuated valves	1/4 turn pneumatically actuated valves 1/4 turn manually operated valves Positioner mounted Linear globe, gate (Stroke lengths from 1/2" to 6")
Switch/sensor	SST N.O. sensor NAMUR module (EN 60947-5-6; IS)	SST N.O. sensor NAMUR module (EN 60947-5-6; IS) Expeditor (for intermediate control)	Mechanical switches Position transmitters Expeditors SPST or SPDT Maxx-Guard SST N.O. sensor NAMUR sensor (EN 60947-5-6; IS)
Available protocol/VCT	AS-Interface and AS-Interface with diagnostics DeviceNet Foundation Fieldbus Modbus	AS-Interface and AS-Interface with diagnostics DeviceNet Foundation Fieldbus HART 4-20 mA with diagnostics Modbus	AS-Interface DeviceNet Foundation Fieldbus Modbus

* Only models listed on manufacturer's website are approved per specific rating.

Valve communication platforms				
	Eclipse page 190	Prism page 192	Hawkeye HK page 194	Hawkeye HX page 195
Platform				
Hazardous ratings* NEC/CEC	Class I Div 1&2 intrinsically safe Class I Div 2 nonincendive	Class I Div 1&2 intrinsically safe Class I Div 2 nonincendive	Class I Div 1&2 intrinsically safe Class I Div 2 nonincendive	Class I Div 1&2 explosionproof Class I Div 1&2 intrinsically safe Class I Div 2 nonincendive
IECEx	Ex ia IIC T5 intrinsically safe (Zone 0, 1, 2)		Ex ia IIC T6 intrinsically safe (Zone 0, 1, 2)	Passive
Enclosure ratings	NEMA 4, 4X and 6 IP 67	NEMA 4, 4X and 6 IP 67	NEMA 4, 4X and 6 IP 67	NEMA 4, 4X and 6 IP 67
Capabilities	Discrete monitoring Communication terminal (VCT) Uses dual module system	Discrete monitoring Communication terminal (VCT) Discrete pneumatic control Uses dual module system	Discrete monitoring Single switch/sensors	Discrete monitoring Single switch/sensors
Typical applications	1/4 turn pneumatically actuated valves	Linear diaphragm valves Linear angle valves (Stroke lengths from 1/8" to 2")	Linear globe, gate (Stroke lengths from 3/8" to unlimited)	Linear globe, gate (Stroke lengths from 3/8" to unlimited)
Switch/sensor	SST N.O. or N.C. sensor NAMUR sensor (EN 60947-5-6; I.S.)	SST N.O. sensor NAMUR module (EN 60947-5-6; I.S.)	SST N.O. or N.C. sensor NAMUR sensor (EN 60947-5-6; I.S.)	SST N.O. or N.C. sensor NAMUR sensor (EN 60947-5-6; I.S.)
Available protocol/VCT	AS-Interface DeviceNet Modbus	AS-Interface DeviceNet Foundation Fieldbus Modbus	Not available; must use I/O module	Not available; must use I/O module

* Only models listed on manufacturer's website are approved per specific rating.

Process networking solutions (enclosure guide)			
Enclosure	FieldBlock page 199	Junction module page 198	FieldRack page 197
Enclosure descriptions	Nonincendive and general purpose enclosure for corrosive and field applications	Explosionproof and nonincendive enclosure for corrosive and field applications	Cabinet for enclosing control elements in field applications
Masters and gateways	Not available	Not available	
Power supplies	Not available	Not available	
Input/output modules			
Drop connectors			
Power conditioners and repeaters	Not available		
Special models	Not available		Not available
Type	• Nonincendive equipment • NEMA 4, 4x, and 6	• Explosionproof and nonincendive equipment • NEMA 4, 4x, and 6	• Nonincendive equipment • NEMA 4, 4x, and 6

Platform characteristics (MEE)

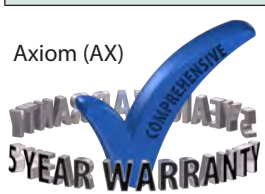
Mechanical selection (for Stonel brand platforms)							
Mechanical	Axiom (AX)	Axiom (AMI)	Quartz	Eclipse	Hawkeye HK	Hawkeye HX	Prism
Orientation	1/4 turn	1/4 turn	1/4 turn & some Linear	1/4 turn	Linear	Linear	Linear
VDI/VDE 3845 mounting	Yes	Yes	Available	Yes	No	No	No
Conduit entries	2	2	2 or 3	2	1	1	2
Visual indication	Mechanical & LED	Mechanical & LED	Mechanical & LED	Mechanical & LED	LED	None	Mechanical & LED
Height above mounting surface	4"	4"	4"-6"	2.5"	N/A	N/A	8"

Electrical selection (for Stonel platforms)							
Electrical	Axiom (AX)	Axiom (AMI)	Quartz	Eclipse	Hawkeye HK	Hawkeye HX	Prism
Mechanical switches	No	No	Yes	No	No	No	No
Proximity reed switches	No	No	Yes	No	No	Yes	No
Solid state & NAMUR sensors	Yes	Yes	Yes	Yes	Yes	No	Yes
Max number of switches/ sensors	2	2	6	2	1	1	2
4-20 mA transmitter option	No	No	Yes	No	No	No	No
Integral pneumatic	Standard	Standard	No	No	No	No	Option
Intermediate control	Option	Option	Option	No	No	No	No

Environmental selection (for Stonel brand platforms)							
Environmental	Axiom (AX)	Axiom (AMI)	Quartz	Eclipse	Hawkeye HK	Hawkeye HX	Prism
Flameproof (Zone 1 & 2)	Yes	No	Yes	No	No	Yes	No
Intrinsically Safe (Zone 0 & 1)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NonIncendive (Zone 2)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IP67 & NEMA 4/4X	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Approvals	Refer to website for specific approvals for specific models Not all model numbers nor switch/sensor technologies have approvals - consult factory						
Factory Mutual (cFMus)	Yes	Yes	Yes	Yes	Yes	No	Yes
ATEX (Europe)	Yes	Yes	Yes (QX, QN-Ex ia)	Yes (Ex ia)	Yes (Ex ia)	No	No
IECEx (International)	Yes	No	Yes (QX)	No	No	No	No
INMETRO (Brazil)	No	Yes (Ex n)	Yes (QX)	Yes (Ex ia)	No	No	No
KOSHA (Korea)	No	No	Yes (QX)	No	No	No	No
GOST R (Russia)	No	No	Yes (QX)	Yes (Ex ia)	No	No	No
RTN (Russia)	No	No	No	No	No	No	No
CCOE (India)	No	No	Yes (QX, QN-Ex ia)	No	No	No	No
NEPSI (China)	No	Yes (Ex n)	Yes (QX)	Yes (Ex ia)	No	No	No
JIS (Japan)	No	No	No	No	No	No	No
SHABA (South Africa)	No	No	No	No	No	No	No
UkrSEPRO (Ukraina)	No	No	No	No	No	No	No

Warranty							
	Axiom (AX)	Axiom (AMI)	Quartz	Eclipse	Hawkeye HK	Hawkeye HX	Prism
Solid state sensors	5 years						
Proximity reed switches	N/A	N/A	2 years	N/A	N/A	2 years	N/A
Mechanical switches	N/A	N/A	2 years	N/A			
Pneumatics	5 years	2 years	2 years	N/A			
Linkage kits	2 years						
Comprehensive	5 year	N/A					

Axiom (AX)



Chemical compatibility (corrosion resistance)

Key

1 Aluminum
2 Polycarbonate
3 Stainless steel
4 Epoxy
5 Polysulfone

A No effect (recommended)
B Moderate effect
U Severe effect (not recommended)
FC Fusion coating recommended on polycarbonate
--- No test data or experience available

Chemical compatibility (corrosion resistance)

Chemical	1	2	3	4	5
Acetic acid	A	B	A	B	A
Acetone	A	FC	A	U	B
Acetylene	A	--	A	A	--
Alcohol, amyl-	B	FC	A	A	A
Alcohol, butyl-	B	FC	A	A	A
Alcohol, ethyl-	B	FC	B	A	B
Ammonia, liquid	A	--	A	A	A
Ammonium hydroxide	B	FC	B	A	B
Beer	A	A	A	A	A
Benzene	B	FC	A	B	U
Boric acid	B	A	B	A	U
Brine	U	B	B	--	A
Bromine	U	FC	U	U	U
Calcium carbonate	U	--	B	A	--
Calcium chloride	B	A	B	A	A
Carbon tetrachloride	U	FC	B	A	A
Chlorine	B	FC	B	--	U
Chromic acid	U	B	U	B	U
Citric acid	U	B	A	A	A
Creosote	B	FC	B	--	--
Ethyl chloride	--	--	A	A	U
Ethylene	A	--	A	--	A
Ethylene oxide	U	--	B	A	A
Fluorine	B	--	A	U	U
Freon (and other similar refrigerant)	B	--	A	A	B
Gasoline	A	FC	A	A	B
Heptane and hexane	A	B	A	A	A
Hydrochloric acid, 10%	U	A[1]	U	A	A
Hydrogen (gas)	A	--	A	--	--
Hydrogen peroxide	A	A	B	B	A
Hydrogen sulfide	B	A	A	A	--
Isopropyl ether	A	A	A	U	A
Jet fuel (JP 4,5,6)	A	--	A	A	B
Kerosene	A	--	A	A	B
Methane	A	--	B	--	--
Methyl chloride	U	FC	A	A	U
Methyl ethyl ketone	B	FC	A	B	U
Methylene chloride	B	FC	A	A	U
Naptha	A	FC	B	A	A
Natural gas	A	--	A	--	--
Nickel chloride	U	FC	B	A	--
Nitric acid (10%)	B	A	A	A	A
Nitric acid (80%)	U	B	B	U	U
Nitrous oxide	U	--	B	--	--
Oils (animal)	A	B	A	A	--
Oil (diesel)	A	A	A	A	A
Oil (mineral)	A	B	A	A	A
Phosphoric acid (85%)(air free)	U	B	U	B	A
Potassium chloride	U	A	B	A	A
Potassium hydroxide (10%)	U	FC	A	A	A
Potassium hydroxide (70%)	U	FC	A	A	A
Potassium phosphate	U	---	A	--	--
Propane (LP gas)	A	A	B	A	B
Soaps and detergents	B	B	A	A	A
Sodium chloride	B	A	B	A	A
Sodium hydroxide (10%) (caustic soda)	U	B	A	A	A
Sodium hydroxide (50%) (caustic soda)	U	FC	B	A	A
Sodium phosphate (monobasic)	U	--	A	A	--
Sulfur dioxide	B	B	A	A	B
Sulfuric acid (7-40%)	U	A	U	A	A
Tannic acid	B	B	B	A	A
Toluol and toluene	A	FC	A	B	U
Turpentine	B	B	B	B	B
Urea	B	A	B	--	B
Vinyl Chloride	B	--	B	--	--
Water, salt	U	--	B	A	A

[1] Temperatures less than 30° C

Valve monitoring/communication

Overview

Mechanical (see page 16)

- Valve/Actuator/Gearbox adapting requirements?
  - Rotational requirement?
  - Other special mounting requirements?
- Special visual indication requirements?

Electrical (see page 16)

- Communication? (see process networking page 59)
- Conventional switching?
  - Open and closed?
  - Computer input? Voltage and current requirements?
  - Other inputs? Voltage and current requirements?
- Continuous feedback
  - 4 to 20 mA?
  - Potentiometric?

Environmental (see page 17)

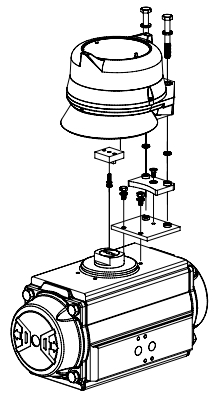
- Area classification
  - Explosion proof, gas group or dust group, division/zone?
  - Intrinsically safe, gas group, division/zone? (This will have implications for voltage and current levels at the switch sensor.)
  - Nonincendive, gas group or dust group, division/zone?
- Enclosure protection
  - Protection from liquids, jets, immersion?
  - Protection from dusts?
- Corrosion protection
  - Exposure to chemical or other corrosive attack?

The MEE (Mechanical, Electrical, Environmental) acronym may be used as a guide to determine the customer's requirements in the specific application. These are typical questions used to size up the users application. (List is not all inclusive but represents a cross sectional sampling of questions for typical applications.)

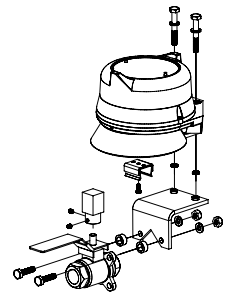
Mechanical: valve actuator adaptation

Quarter-turn

Quartz mounting to standard NAMUR 1 actuator



Quartz mounting to manual valve

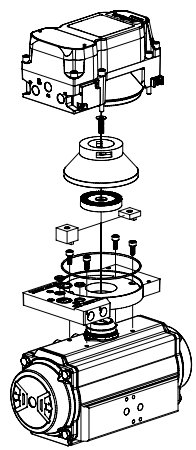


There are thousands of quarter-turn and linear actuator, valve, gearbox and other mounting patterns. We provide kits to readily adapt to most of these configurations.

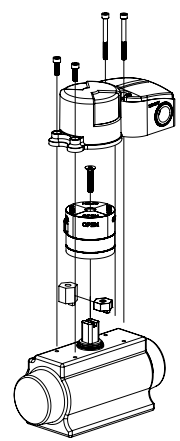
Mechanical: valve actuator adaptation

Quarter-turn

Axiom AMI mounting to standard NAMUR 1 actuator



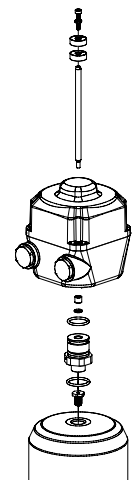
Eclipse EN mounting to standard NAMUR 1 actuator



Mechanical: valve actuator adaptation

Linear

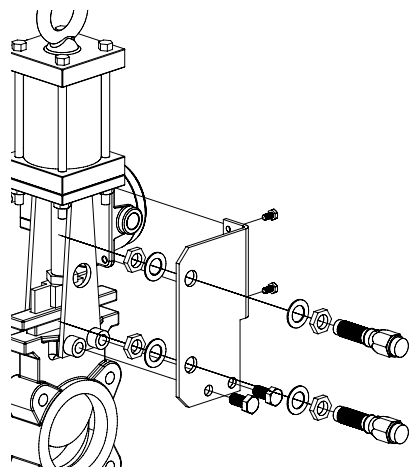
Prism on sanitary diaphragm



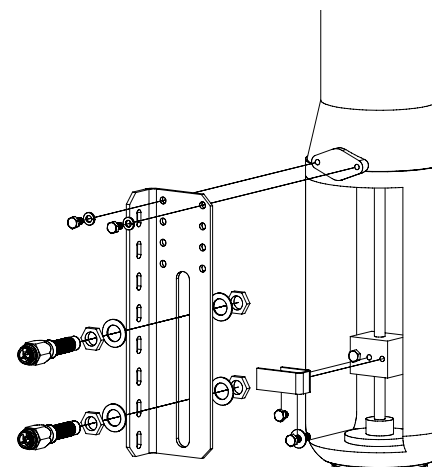
Mechanical: valve actuator adaptation

Linear

Hawkeye on knifegate valve



Hawkeye on globe valve



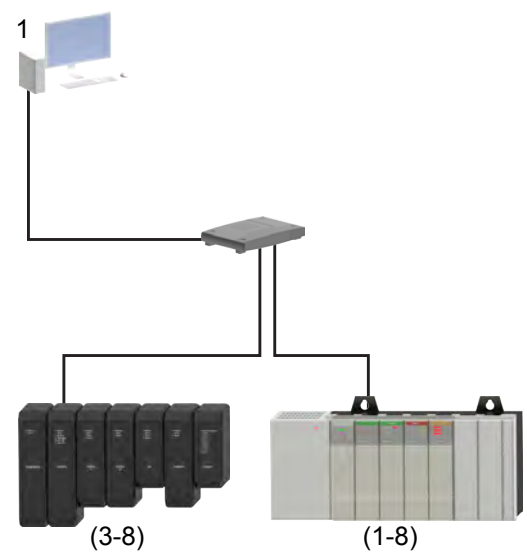
Electrical: valve monitoring and control circuits

Overview

This section covers valve monitoring circuits for interfacing to PLC or DCS control systems. Mechanical and proximity sensors are described for use in conventional intrinsically safe (IS) and non-IS applications.

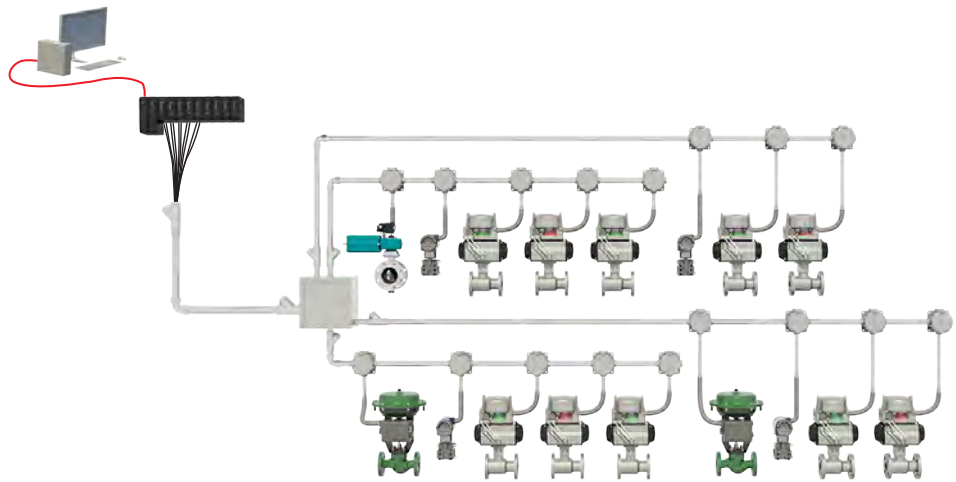
Process control inputs and outputs (I/O)

1. PLC/DCS System
2. Logic control
3. Power supply
   (Typically will need auxiliary power supply for output power or bus network.)
4. Input cards (~8 discrete)
5. Output cards (~4 discrete)
6. Bus interface card
7. Analog input card
8. Analog output card



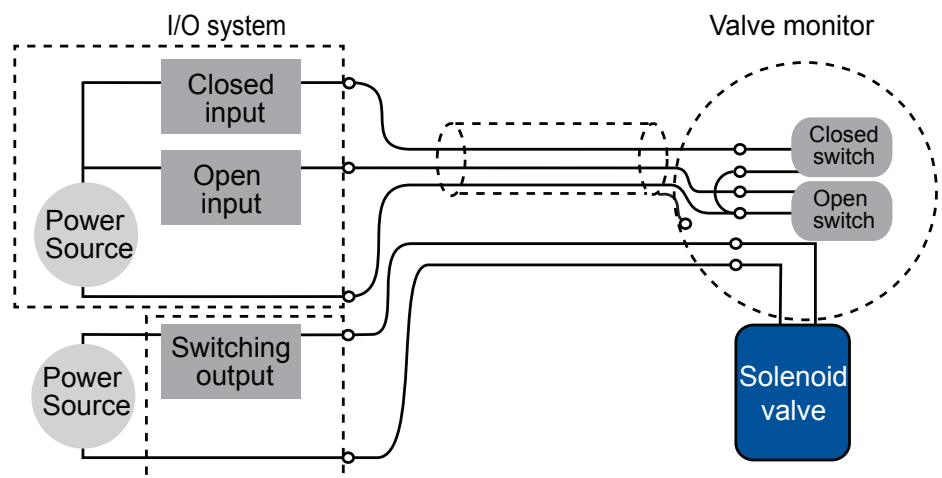
A typical PLC/DCS has several components for interfacing various types of signals; discrete inputs, discrete outputs, analogs and various bus protocols. Our products may be conveniently interfaced to these cards depending on the input or output requirements.

Conventional automated valve installation



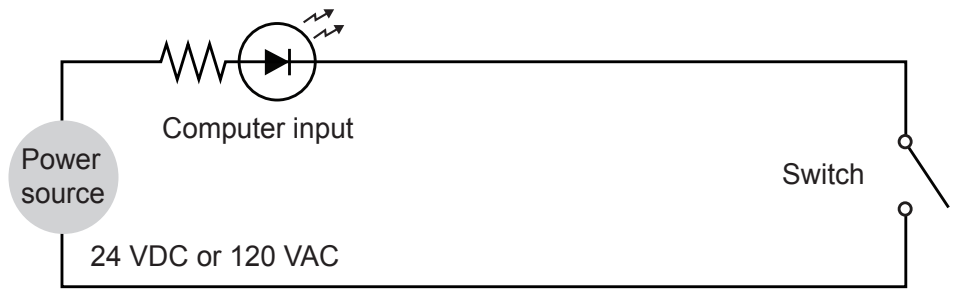
A conventional installation in a hazardous area will have all the monitoring and control circuits inside the conduits. The conduits would typically be fed into a “marshalling” cabinet in the field which would then utilize several large multi-conductored “homerun cables” connecting all devices to the PLC/DCS.

Monitoring and control circuits



This is how a typical valve monitor is wired to a PLC or DCS. Each switch and solenoid valve must be connected in its own circuit and have its own I/O point at the DCS. It is typical for the commons to be shared at the switches to reduce the number of wires from six to five.

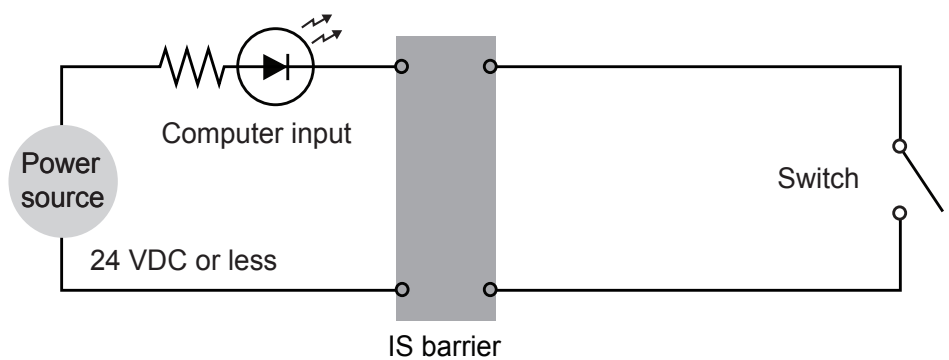
Valve monitoring circuit



- Estimate over 95% provide feedback into solid state (computer) inputs
- Market split between 120 VAC and 24 VDC
- Current levels typically 20 mA or less

This diagram represents a valve monitoring circuit, with the power source and input located in the control room of the plant and the switch located in the field device a significant distance away. For any circuit to operate, there has to be a power source, a load, and the wire that makes up the circuit. The switch opens and closes the circuit enabling or stopping current flow thus turning on or off the computer input indicating valve position. What is the load in this circuit?

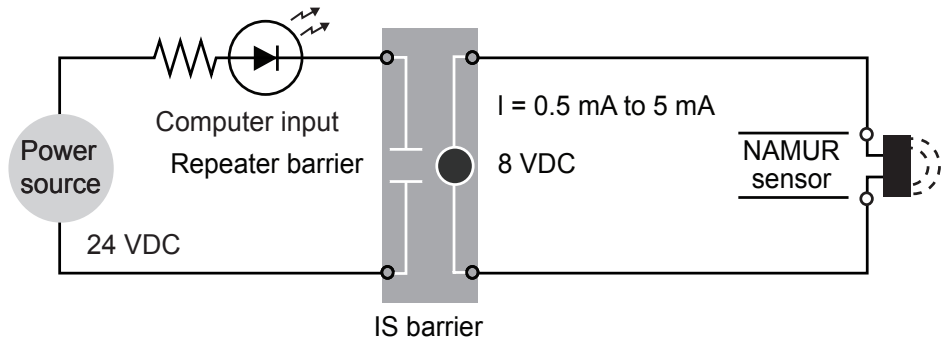
Intrinsically safe switch circuit



- Estimate 5% to 10% of monitoring and control circuits are intrinsically safe
- Barrier typically drops 2 to 3 volts
- Current and voltage are typically less than 20 VDC and 10 mA at switch

This diagram shows the same valve monitoring circuit but in an IS application. It has the same elements as before with the addition of an IS barrier to limit the voltage and current into the hazardous area should an overvoltage or short circuit fault occur. The barrier will have internal resistance and, as a result, will have a voltage drop across it under normal conditions. An analysis must be done to ensure that this circuit will work with the computer input due to the barrier voltage drop.

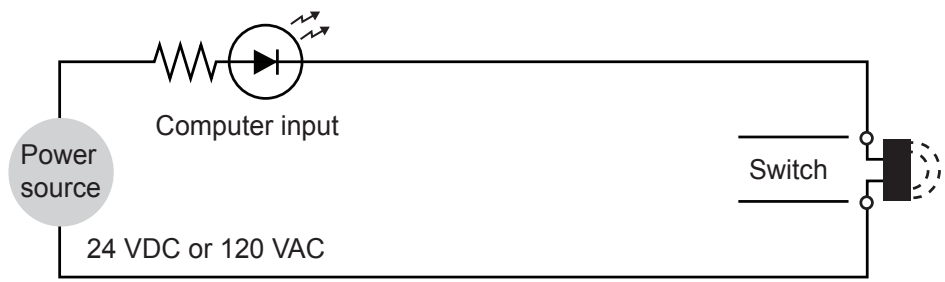
Intrinsically safe NAMUR sensor circuit



- Barrier off state (target off): Current in NAMUR sensor circuit > 2.1 mA
- Barrier on State (target on): Current in NAMUR sensor circuit < 1 mA
- Best circuit to use for IS on/off valve monitoring
- Defined by EN 60947-5-6

This IS circuit uses a NAMUR sensor which is specifically designed to work with the repeater barrier for IS applications. Since the sensor and repeater barrier are designed to work together, no functional analysis is required. However, an analysis to make sure the IS parameters match will still have to be performed. For IS valve monitoring, using a NAMUR sensor with the proper barrier is the most straight forward method.

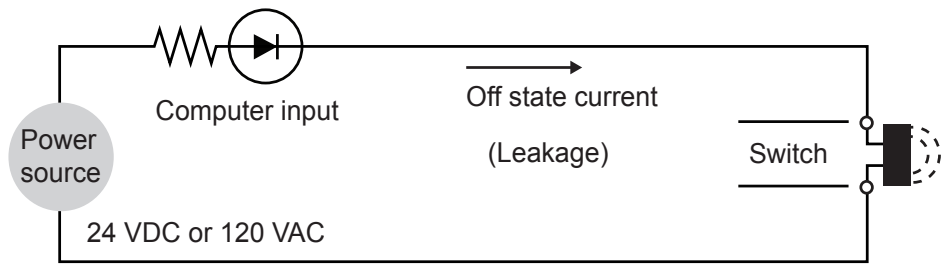
Proximity two-wire sensors



- Used as a more reliable direct replacement for mechanical and reed switches
- May be used in 24 VDC or 120 VAC circuits with computer inputs or moderate power switching applications
- Leakage current and voltage drop must be considered

This is the same circuit as the original valve monitoring diagram except the switch is replaced by a solid state two wire sensor, such as a Stonel SST proximity sensor. Additional information is provided on the following pages regarding the considerations necessary for leakage current and voltage drop.

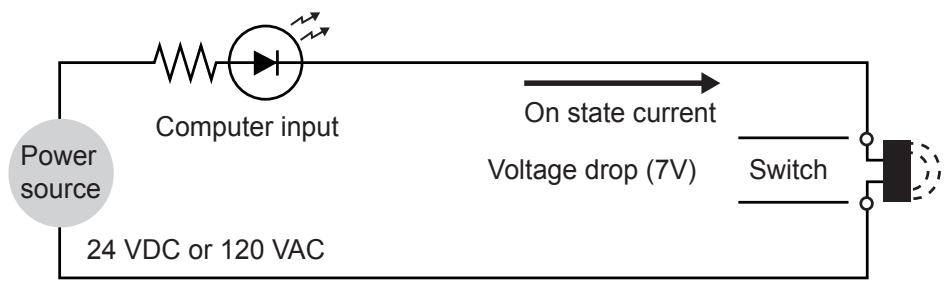
Proximity two-wire sensor, off state



- Leakage current is required to keep sensor functioning properly in “off state”
- Computer inputs are in off state with current < 0.5 mA
- Stonel leakage current < 0.5 mA

In order for a solid state sensor to operate, it has to have voltage applied to it at all times and it also has to have current flowing through it at all times. Leakage current is the current flowing in the circuit when the sensor is “off” so that the sensor will operate. This current has to be very low so that it does not turn on the computer input. The leakage current in Stonel SST sensors typically will not turn on a computer input with very few exceptions. Contact us if you have concerns about your specific computer input cards.

Proximity two-wire sensor, on state



- Voltage drop is amount of voltage required across the sensor for proper operation in the “on state”
- Computer inputs typically require up to 90 VAC in 120 VAC; up to 14 VDC in 24 VDC
- Compatible with most computer I/O but need to check
- Voltage at computer input = PS voltage – switch drop

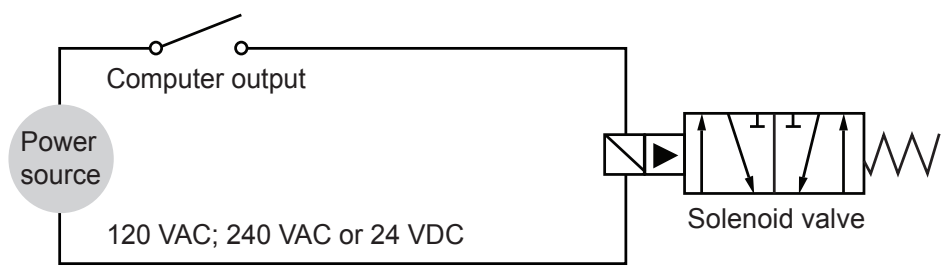
For the sensor to operate it must have voltage applied across it in the "on" state. This is called the voltage drop. If the voltage drop is too high, it will not turn on the computer input. Stonel SST sensor voltage drop typically will not affect most computer input cards. However, if there are any concerns regarding a specific input card please contact our technical support.

Analog input circuit

- 4 to 20 mA circuit
- Current changes with changing valve position
- Feedback present throughout entire valve stroke

This circuit provides a changing current with changing valve position. The current is typically 4 mA when the valve is closed and 20 mA when open. Current will change linearly throughout valve travel so that exact valve position is known.

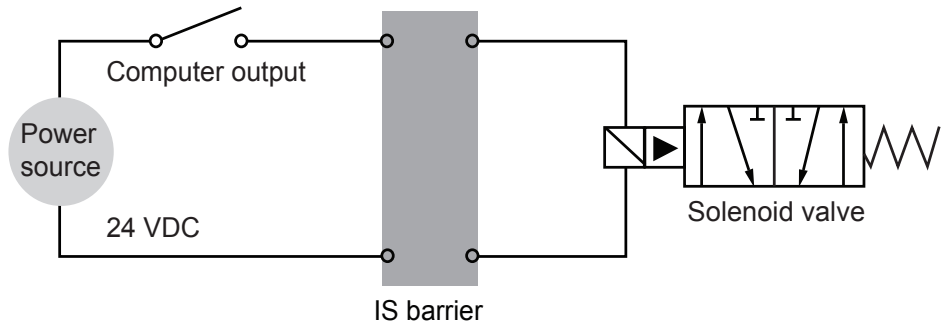
Valve solenoid circuit



- Computer output energizes or de-energizes solenoid valve
- Voltages are typically 24 VDC, 120 VAC or 240 VAC
- AC coils have inrush when first energized; DC coils do not.
- Universal input valves that work on both 24 VDC and 120 VAC are available (Axiom C-module).

In this circuit, the load is the solenoid valve coil. The computer output controls the switch to start or stop current in the circuit. When the solenoid valve is energized, it will shift and direct compressed air to the actuator to open or close the valve. When de-energized, the solenoid will shift back to the fail safe position to exhaust the air from the actuator and close or open the valve depending on the actuator configuration.

Intrinsically safe valve solenoid circuit



- Voltage at solenoid valve = PS voltage – IS barrier drop
- Barriers typically drop 12 V so on a 24 VDC system, a 12 VDC IS solenoid is required
- To meet IS requirements, the valve must be IS approved and typically ½ W or less and its entity parameters match those of the barrier

This is the same solenoid circuit with the addition of the IS barrier. The barrier will have a voltage drop (typically about 12 VDC) so that in a 24 VDC system, a 12 VDC IS coil is used.

Electrical: switches and sensors

Overview

This section discusses the various types of switches and sensors used by Stonel products, along with their advantages and disadvantages.

Switch/Sensor types

- Mechanical

- Proximity; Reed type

- Proximity; Solid state

We use three types of switches and sensors which are used in different platforms.

Refer to quick reference page 10.

Mechanical switch types

Single pole double throw (SPDT) silver contacts

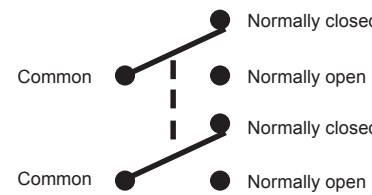
- Use for 125/250 VAC only
- Operating Life of 400,000 cycles

Single pole double throw (SPDT) gold contacts

- Use for 125 VAC and 30 VDC computer inputs
- Operating life of 100,000 cycles

Double pole double throw (DPDT) silver contacts

- Use for 125/250 VAC only
- Operating life of 250,000 cycles



Mechanical switches should be used in higher power, higher voltage applications. Only the gold contact version is suitable for low voltage computer inputs. The silver contact versions require the higher power/higher voltage switching to clean off the oxidation that can occur on the contacts. If they are used in low power computer inputs, it is possible that the oxidation build-up on the contacts will cause them to have high contact resistance making the circuit fail. Also note that the operating life is low.

Mechanical switches

Advantages

- High power (Up to 10 amps @ 250 VAC)

Disadvantages

- Wear out and corrode
- Oxidize and fail in 24 VDC computer inputs
- Require seal off in hazardous areas

PLC and DCS inputs are low power so generally not suited for mechanical switches.

Competitor differentiation

- None; Competitor switches are similar

If the application requires high power (3A to 10A), then these are the switches to use. Otherwise a different choice will give better reliability in low power computer circuits.

Refer to quick reference page 11.

Proximity reed type switches

Single pole single throw (SPST) Ruthenium contacts

- Use for 30 VDC and 125 VAC computer inputs
- Operating life of 5 million cycles

Single pole double throw (SPDT) Tungsten contacts

- Use for 125/250 VAC only
- Operating Life of 5 million cycles

Single pole double throw (SPDT) Rhodium contacts

- Use for 24 VDC and 120 VAC computer inputs
- Operating life of 5 million cycles

The proximity reed type switches are available with Ruthenium, Tungsten, and Rhodium contacts. Ruthenium and Rhodium are better suited for computer inputs. The Tungsten contacts are not recommended for 24 VDC computer inputs because they require higher power switching to clean the contacts. Proximity switches are a better choice for computer inputs than mechanical switches. However, they have moving parts and are packaged in a specially sealed glass capsule which may lose its hermetic seal over time.

Proximity reed type switches

Advantages

- Moderate power switching (up to 3 amps @ 30 VDC up to 0.3 amp @ 250 VAC)
- No seal offs required
- Long life

Disadvantages

- May lose hermetic seal over time
- Contact sticking at 120 VAC (non Tungsten)
- Require magnets to trigger
- Need special application knowledge

Competitive advantages

- Protection circuitry guards against contacts sticking
- LED

Because these switches are hermetically sealed (mechanical switches are not), they are considered nonincendive and they do not need a seal off in a hazardous area.

Refer to quick reference page 10.

Proximity solid state switches

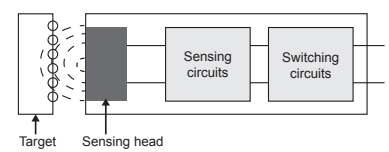
- NAMUR sensor (EN 60947-5-6)
- Three-wire solid state
- Two-wire solid state

We use three types of solid state sensors for inductive discrete position sensing.

Solid state sensing technologies

Capacitive

- Operation: Triggers off any object
- Analysis: Reliable technology but may indiscriminately trigger from undesirable targets



Hall effect

- Operation: Magnetic field generates voltage
- Analysis: Magnetic field strength changes with temperature and vibrational movement which could affect accuracy

Magnetic resistive (Axiom)

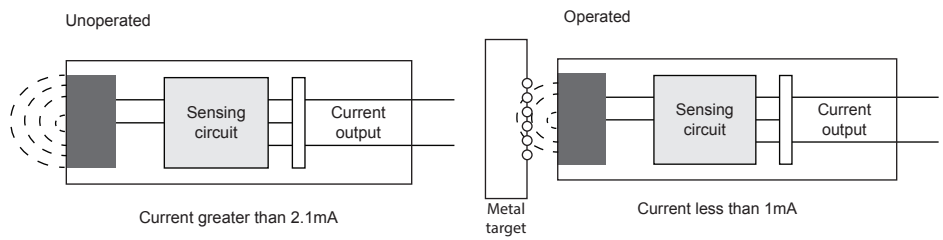
- Operation: Resistance changes with changing magnetic flux direction
- Analysis: Reliable operation and cost effective (accuracy of 0.5 degrees)

Inductive (dual module, Eclipse and Hawkeye)

- Operation: Triggers off conductive metal object
- Analysis: Reliable, proven, minimal power, low cost and very stable with temperature extremes

Several technologies were evaluated for use in the solid state sensing Stonel products. It was concluded that inductive sensing is optimal for discrete position sensing and that the magnetic resistive sensing is optimal for continuous sensing. We design and manufacture our own proprietary solid state sensors to enable full integration with communication protocols and offer customers the greatest value.

Proximity NAMUR sensor EN 60947-5-6



- Used extensively with IS systems (majority of hazardous applications in Europe)
- Various sensing technologies may be used with NAMUR output

The NAMUR sensor provides a changing current with changing valve position instead of a switch output. These sensors are the preferred choice with intrinsically safe (IS) circuits over sensors that provide a switching output.

Proximity NAMUR sensors (IS only!)

Advantages

- Less costly than switching solid state sensors
- Compatible with IS repeater barriers
- Optimal for point-to-point IS monitoring applications
- Can determine “open” circuit or “shorted” circuit with the right barrier

Disadvantages

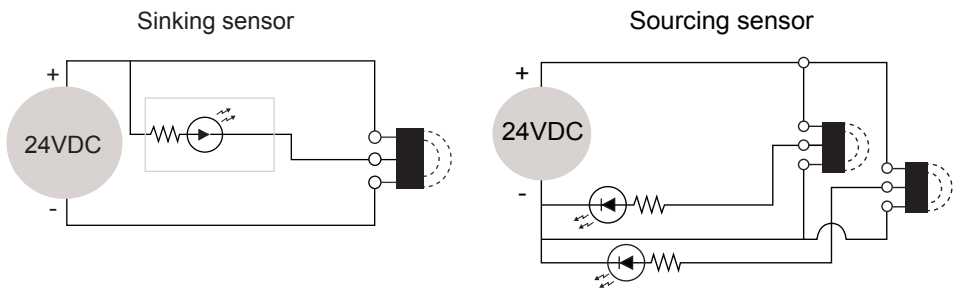
- Not usable in standard monitoring circuits
- Most customers not familiar with sensors
- Need specialized application training

Competitor differentiation

- Must outsource from other manufacturers; standard with Stonel products
- Part of dual module/C-module system with Stonel products
- Less costly

As noted, the NAMUR sensor should be used in an IS circuit. However, because it requires the use of a barrier, it is not suitable for use in non-IS circuits. When using a barrier that is capable of measuring the current, it is possible to detect a short circuit if the current is too high and to detect an open circuit if the current is too low.

Proximity three-wire solid state sensors



- Used to eliminate leakage current and voltage drop problems with solid state switches
- Very common in factory automation applications

Proximity three wire and two-wire solid state sensors are also available. This is the circuit for a three-wire sensor. Although these sensors are much more complex to apply, they offer some advantages over two-wire sensors in applications where no leakage current or voltage drop may be tolerated.

Proximity three-wire solid state sensors

Advantages

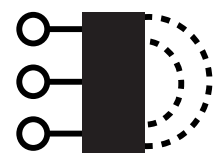
- Eliminate leakage current and voltage drop problems
- Non-arcing, no seal offs required

Disadvantages

- Confusing to apply
- Often miss-wired causing problems

Competitor differentiation

- Stonel products only uses on special applications
- Used by Turck, Effector and Pepperl+Fuchs, but confusing and expensive

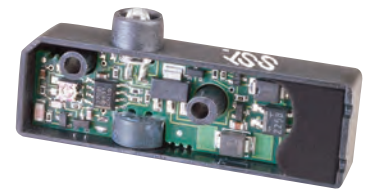


We design and manufacture a three-wire sensor for use with the Foundation Fieldbus 93 I/O module. It is the only three wire sensor at this time that has low enough power consumption to operate with this I/O module.

Proximity solid state two-wire sensors

Advantages

- No moving parts with unlimited life
- 5 year warranty
- Suitable for both AC and DC computer inputs
- Easy to apply; direct replacement for mechanical switches
- Triggers off any metal including nonferrous



Disadvantages

- May not be optimal in intrinsically safe circuits (voltage drop)

Competitor differentiation

- We make all proximity sensors; low cost, high reliability
- We integrate into Eclipse and Hawkeye. Others use reed or mechanical proximity switches

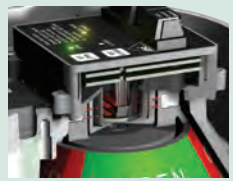
We have selected the two-wire configuration for its solid state sensors because it is the easiest to apply and it most closely resembles a standard switch that is familiar to most end users. It can be used in both AC and DC circuits (up to 250 mA) and is not polarity sensitive. It has the highest warranted cycle life of all of Stonel brand switches/sensors. For IS circuits, the NAMUR sensor should be used.

Stonel dual module system

Features	Benefits
Two (Dual) solid state sensors	Ultra-high reliability
High intensity LEDs	Clearly show position status
Quick set cams with stainless steel targets	Operates in normally open (NO) or normally closed (NC)
Integrated sensors and communication	Minimize costs
Sealed terminal strip and electronics	Prevent contamination and impervious to shock and vibration
No clutter	Easy to wire and setup

This is the dual module shown in a Quartz unit. The dual module system uses the same inductive sensing technology described earlier. It is integrated with the appropriate output electronics and communications into one package for a compact, reliable, and cost effective solution. The dual module technology is available in the Quartz, Eclipse and Prism platforms.

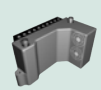
Stonel C-module system



Features	Benefits
Continuous (C) proximity sensing	Eliminates thru-shaft and enables diagnostics
High intensity LEDs	Clearly show position and solenoid status
Solid state position sensing	Ultimate in reliability
Integrated sensing and communication	Minimize costs
SST short circuit protection	Prevents switch burnout with short circuit
SST universal AD/DC solenoid input	Use same unit for entire plant
Sealed terminal strip and electronics	Prevent contamination and impervious to shock and vibration
Push button settings	Quick and precise position setting

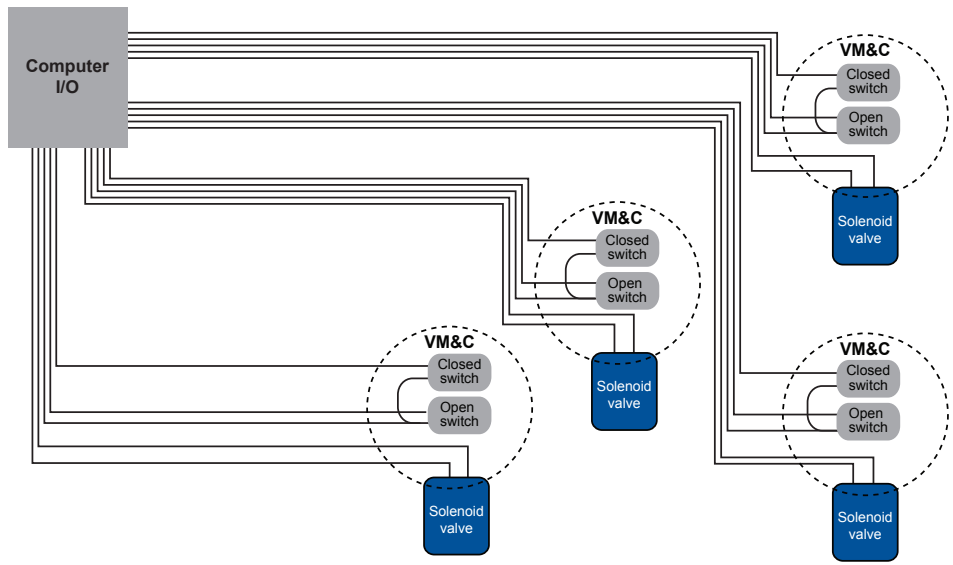
The C-module, shown here on the Axiom AMI, uses magnetic resistive sensing technology. This technology provides for continuous sensing, allowing the open and close positions to be set locally or remotely. The exact valve position is monitored continuously by the C-module to enable the module to have greater flexibility and enable more sophisticated diagnostics. This sensing technology reads the magnetic field direction and is not affected by varying magnetic field strength (within design parameters). Therefore, vibration and non-rotational actuator shaft movement does not alter the position feedback offering accurate rotational measurement even if the actuator shaft/bushing is worn and "wobbling."

Cost/reliability comparisons

Switch type	Cost/trend	Reliability	Life expectancy
Mechanical 	Low/increasing	Good	Good
Reed proximity 	Mid/increasing	Better	Better
Solid state proximity 	High/stable	Best	Best
Dual module 	Mid/stable	Best	Best
C-module 	High/decreasing	Best	Best

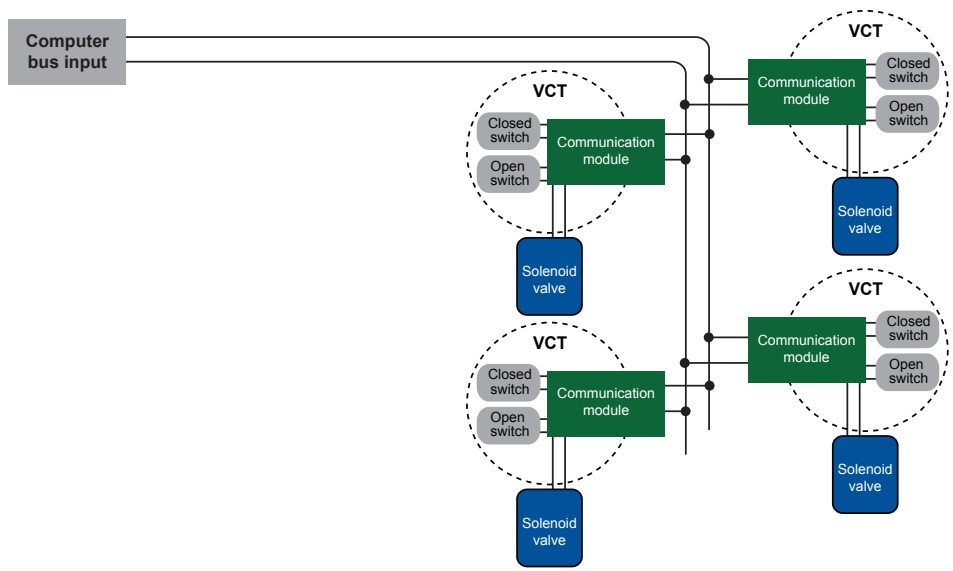
This chart shows a comparison of the available switch and sensor types used in Stonel brand products.

Conventional network with valve monitor and control (VM&C)



For a conventional network with 20 automated valves, 10 wires are needed, spanning the entire distance from the I/O to the field devices.

Bus network with valve communication terminal (VCT)



For an AS-Interface network with 20 automated valves, one pair of wires may span the distance from the power supply and master/gateway to the field devices, dramatically reducing the wire infrastructure costs.

Dual module/C-module options

- Switching and sensors
  - (33) SST switching sensors
  - (44) NAMUR sensors
  - (80) Expeditor (C-module only)

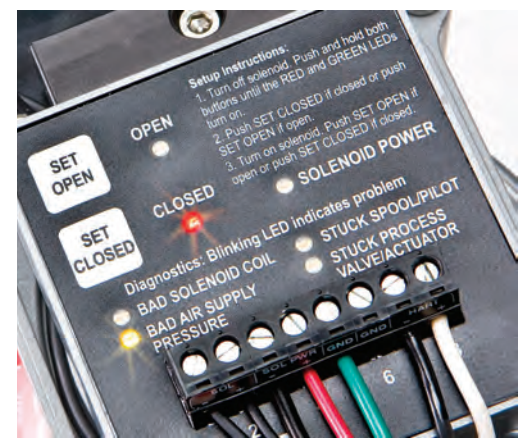
Same solid state sensor/switching electronics as Stonel single proximity switches

- Valve Communication Terminals (VCTs)
  - (71) 4-20 mA with HART diagnostics (C-module only)
  - (92) DeviceNet
  - (93) Foundation Fieldbus
  - (94) FF externally powered
  - (95) Modbus
  - (96) AS-Interface
  - (97) AS-Interface extended addressing

The dual module has the same wiring interface to the control system as the C-module for the same function.

Stonel C-module diagnostic system

- Diagnostics enabled by integrated
  - Pressure sensing
  - Continuous position sensing
  - Current and voltage sensing
- Standard AS-i I/O used to transmit diagnostic information to control system - no additional software or setup required
- Diagnostic alerts and capabilities
  - Low pneumatic supply pressure
  - Malfunctioning solenoid
  - Stuck spool or pilot valve
  - Remote switch setting
  - Identification "winking"
- Diagnostic information also displayed locally



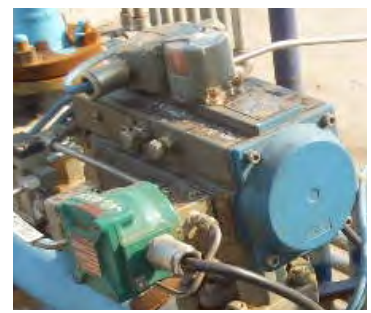
The AS-Interface diagnostic system utilizes the remaining AS-i bits to transmit diagnostic information to the computer. Therefore, no additional software or special set-up is required. We also offer a HART protocol diagnostic model that provides more diagnostic and trending information.

Environment: corrosion resistance

Chemical compatibility (corrosion resistance) chart

- Assists you in selecting Stonel brand products and material options
- Not a substitute for testing of a specific product in your operating environment
- Contact manucaturer technical support for additional assistance

Enclosures are exposed to chemical contamination in typical process environments. In this section chemical compatibility charts illustrate tolerance of ourmaterials of construction to many of the chemicals found in process applications.



See chemical compatibility chart page 18

Chemical compatibility (corrosion resistance)

Chemical	1	2	3	4	5
Acetic acid	A	B	A	B	A
Acetone	A	FC	A	U	B
Acetylene	A	--	A	A	--
Alcohol, amyl-	B	FC	A	A	A
Alcohol, butyl-	B	FC	A	A	A
Alcohol, ehtyl-	B	FC	B	A	B
Ammonia, liquid	A	--	A	A	A
Ammonium hydroxide	B	FC	B	A	B
Beer	A	A	A	A	A
Benzene	B	FC	A	B	U
Boric acid	B	A	B	A	U
Brine	U	B	B	--	A
Bromine	U	FC	U	U	U
Calcium carbonate	U	--	B	A	--
Calcium chloride	B	A	B	A	A
Carbon tetrachloride	U	FC	B	A	A
Chlorine	B	FC	B	--	U
Chromic acid	U	B	U	B	U
Citric acid	U	B	A	A	A
Creosote	B	FC	B	--	--
Ethyl chloride	--	--	A	A	U
Ethylene	A	--	A	--	A
Ethylene oxide	U	--	B	A	A

Chemical	1	2	3	4	5
Fluorine	B	--	A	U	U
Freon (and other similar refrigerant)	B	--	A	A	B
Gasoline	A	FC	A	A	B
Heptane and hexane	A	B	A	A	A
Hydrochloric acid, 10%	U	A[1]	U	A	A
Hydrogen (gas)	A	--	A	--	--
Hydrogen peroxide	A	A	B	B	A
Hydrogen sulfide	B	A	A	A	--
Isopropyl ether	A	A	A	U	A
Jet fuel (JP 4,5,6)	A	--	A	A	B
Kerosene	A	--	A	A	B
Methane	A	--	B	--	--
Methyl chloride	U	FC	A	A	U
Methyl ethyl ketone	B	FC	A	B	U
Methylene chloride	B	FC	A	A	U
Naptha	A	FC	B	A	A
Natural gas	A	--	A	--	--
Nickel chloride	U	FC	B	A	--
Nitric acid (10%)	B	A	A	A	A
Nitric acid (80%)	U	B	B	U	U
Nitrous oxide	U	--	B	--	--
Oils (animal)	A	B	A	A	--
Oil (diesel)	A	A	A	A	A

Chemical	1	2	3	4	5
Oil (mineral)	A	B	A	A	A
Phosphoric acid (85%) (air free)	U	B	U	B	A
Potassium chloride	U	A	B	A	A
Potassium hydroxide (10%)	U	FC	A	A	A
Potassium hydroxide (70%)	U	FC	A	A	A
Potassium phosphate	U	---	A	--	--
Propane (LP gas)	A	A	B	A	B
Soaps and detergents	B	B	A	A	A
Sodium chloride	B	A	B	A	A
Sodium hydroxide (10%) (caustic soda)	U	B	A	A	A
Sodium hydroxide (50%) (caustic soda)	U	FC	B	A	A
Sodium phosphate (monobasic)	U	--	A	A	--
Sulfur dioxide	B	B	A	A	B
Sulfuric acid (7-40%)	U	A	U	A	A
Tannic acid	B	B	B	A	A
Toluol and toluene	A	FC	A	B	U
Turpentine	B	B	B	B	B
Urea	B	A	B	--	B
Vinyl Chloride	B	--	B	--	--
Water, salt	U	--	B	A	A

NEMA Standards Publication 250-1997, "Enclosures for electrical equipment (1000 volts maximum)"

This Standards Publication, as well as all other NEMA publications, available from IHS at 1-800-854-7179.

Environment: enclosure protection

Moisture prevention/reduction

Causes

- Devices are often used outdoors or in damp humid environments
- Enclosures are often watertight but not airtight
- Daily heating and cooling cycles can cause instrument housings to "breathe" which can cause moisture to condense inside the enclosure
- Conduits are often open to the environment and can act as a water pipe to carry water into the enclosure.
- It is also important to protect the electronics by keeping water out during storage and installation.

Process instrument enclosures house electronics and live electrical circuits, and are often used outdoors or in wet humid environments. Water and electricity do not mix. Keeping water away from electronics enhances reliability and improves safety. Water protection is often overlooked during storage and installation.

It is important to seal the conduit entries during storage and installation if they can be exposed to rain or humid conditions. Shipping plugs are often installed to protect the conduit entry threads during shipping and storage, but these typically do not offer much protection from water ingress.

Moisture prevention/reduction

Ingress paths

- Through cover/housing gasket
- Through shaft bushing (if applicable)
- Through conduit entry threads around connectors or cable glands
- Through rigid conduit pipe or flex conduit

The most common source of water entry into instrument enclosures is through the conduit. These are often left open at the other end and can allow water to flow into the enclosure.

The Quartz has two (2) o-rings in the shaft bushing and has been well tested and proven to perform well in wet environments. Products like the Axiom and Eclipse have no shaft to the outside, so they offer even better protection from water intrusion.

Environment: enclosure protection

Moisture prevention/reduction

Prevention techniques

- Flex or rigid conduit
  - Install drip leg
  - Install drain plug
  - Seal all conduit openings

Again, the most common source of water entry into instrument enclosures is through the conduit. The other end should be sealed to prevent water ingress.

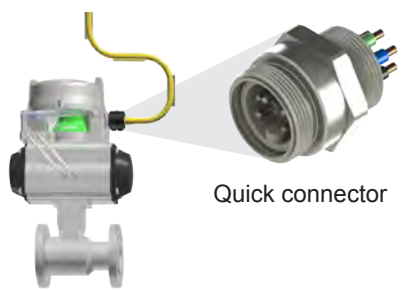
In general purpose applications, drip legs can be installed and a manual valve could be used to drain the leg on occasion. We have even heard of users that install a small solenoid valve here on a timer to drain the drip leg periodically. Of course your solution must follow code and meet hazardous location requirements.

In hazardous locations the drip leg is often drained through a flame arrestor or XP drain plug. The drain plug provides a path for water to weep out but maintains a restrictive flame path to meet hazardous location requirements.

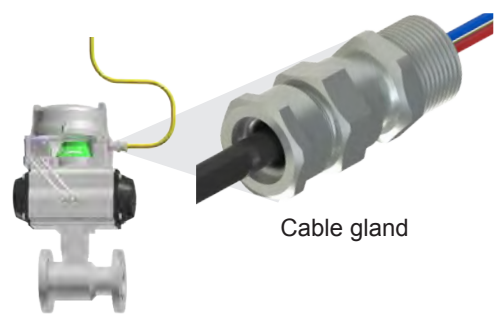
Moisture prevention/reduction

Prevention techniques

- Quick connector or cable gland
  - Ensure threads are sealed
  - Ensure cable gland is sized properly for cable diameter



Quick connector



Cable gland

Environment: enclosure protection

NEMA enclosure standards

NEMA Standards Publication 250-1997, "Enclosures for electrical equipment (1000 volts maximum)"

This Standards Publication, as well as all other NEMA publications, available from IHS at 1-800-854-7179.

Comparison of specific applications of enclosures for outdoor non hazardous locations

	NEMA enclosure guide						
Provides a degree of protection against the following environmental conditions	3	3R*	3S	4	4X	6	6P
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X
Rain, snow, and sleet**	X	X	X	X	X	X	X
Sleet***	…	…	X	…	…	…	…
Windblown dust lint, fibers, and flyings	X	…	X	X	X	X	X
Hosedown	…	…	…	X	X	X	X
Corrosive agents	…	…	…	…	X	…	X
Occasional temporary submersion	…	…	…	…	…	X	X
Occasional prolonged submersion	…	…	…	…	…	…	X

* These enclosures may be ventilated.

** External operating mechanisms are not required to be operable when the enclosure is ice covered.

*** External operating mechanisms are operable when the enclosure is ice covered.

Protecting electronic instrumentation from environmental contamination is critical in process applications. National and international protection standards are described and how Stonel brand products meet the most rigorous enclosure requirements.

NEMA (National Electrical Manufacturers' Association) has established standards for enclosures to provide protection from environmental contamination.

IEC enclosure standards

Ingress protection	IP

Example: **IP 6 7**

Protection against liquids
0: no special protection
1: protected against vertical falling water drops
2: protected against vertical falling water drops when enclosure is tilted at 1
3: protected against sprayed water
4: protected against splashing water
5: protected against water jets
6: protected against heavy seas
7: protected from the effects of temporary immersion
8: protected from the effects of continuous immersion

Protection against solid bodies
0: no special protection
1: protected against solid objects greater than 50 mm
2: protected against solid objects greater than 12 mm
3: protected against solid objects greater than 2.5 mm
4: protected against solid objects greater than 1 mm
5: dust protected
6: dust-tight

The International Electrotechnical Commission (IEC) has established enclosure standards for protection from environmental contamination as shown below. These standards are used widely in Europe, the Middle East, Africa and parts of Asia.

Environment: hazardous areas

National Electrical Code (NEC) 500

Traditional standards used in North America.

Example: **Class I** **Div 1**

Permitted Division	
Division I	gasses or vapors exist under normal conditions
Division II	gasses or vapors are present but are normally contained and can escape only through accident or abnormal operation

Permitted Class	
Class I	gas vapors
Class II	dusts
Class III	fibers

Complete example: **Class I** | **Div 1** | **Grp B, C, D** | **T4**

Example: **Grp B, C, D** **T4**

Temperature Class*	
T1	450°C (842°F)
T2	300°C (572°F)
T3	200°C (392°F)
T4	135°C (275°F)
T5	100°C (212°F)
T6	85°C (185°F)

Permitted Group	
Group A	acetylene
Group B	hydrogen or equivalents
Group C	ethyl ether, ethylene or cylclopropane
Group D	gasoline, hexane, naphtha, benzene, butane, propane, alcohol, acetone, benzol, lacquer, and natural gas
Group E	metal dust
Group F	carbon black
Group G	flour, starch, grain dusts 135°C (275°F) 100°C (212°F)

* Device may be exposed to gases whose ignition temperature is higher than this value.

Complete example: **Class I** | **Div 1** | **Grp B, C, D** | **T4**

This section describes national and international hazard protection standards and the function of third party approval agencies. Stonel brand devices are illustrated in conjunction with these standards and appropriate use in classified areas.

IEC & EU (European) standards

The IEC (International Electrotechnical Commission) markings are as follows:

Explosion Protection	Ex

Example: **Ex** **d**

Type of Protection	
d	flameproof enclosure - contain explosion and quench flame
p	pressurized enclosure - fill with inert gas
ia	intrinsically safe for Zone 0 - limit energy
ib	intrinsically safe for Zone 1 - limit energy
o	oil immersion
s	special protection
e	increased safety - no arcing, sparking or hot surfaces
m	encapsulation - sealed arcing devices or non-arcing
q	sand-filled
nL	nonincendive - limited energy
nA	nonincendive - non sparking
me	encapsulation/increased safety

Complete example:

Ex	d	IIB	T3	Gb

Example: **IIB** **T3** **Gb**

Equipment Protection level (EPL)			
Gas	Applicable zone	Dust	Applicable zone
Ga	0	Da	20
Gb	1	Db	21
Gc	2	Dc	22

Temperature Classification*			
T1	450°C (842°F)	T4	135°C (275°F)
T2	300°C (572°F)	T5	100°C (212°F)
T3	200°C (392°F)	T6	85°C (185°F)

Gas Group Classification	
IIC	acetylene and hydrogen
IIB	diethel ether, ethylene, cyclopropane and others
IIA	gasoline, hexane, butane, naphtha propane, isoprene and many others

* Device may be exposed to gases whose ignition temperature is higher than this value.

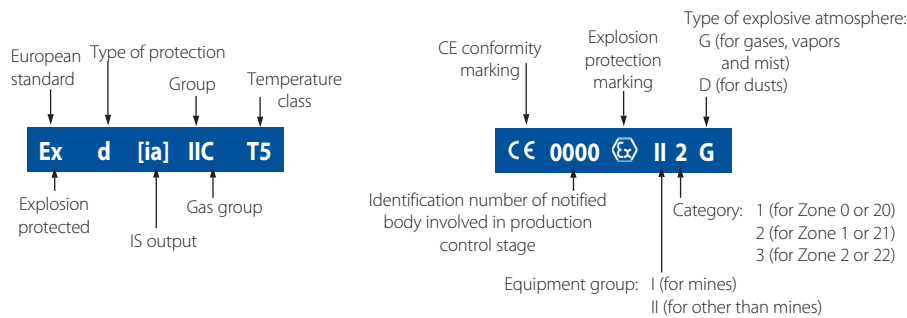
Complete example:

Ex	d	IIB	T3	Gb

ATEX Marking (94/9/EC)

European Union

EU (directive 94/9/EC) - ATEX



* Ambient temperature ranges other than standard (-20° C< Ta < +40° C) must be marked.

European requirements centered around the safety of hazardous area equipment that became mandatory on July, 1 2003. All equipment exported into European member countries must meet the ATEX hazardous and essential health and safety requirements for acceptance. The ATEX markings are in addition to the standard Zone markings and indicate compliance to the new directives.

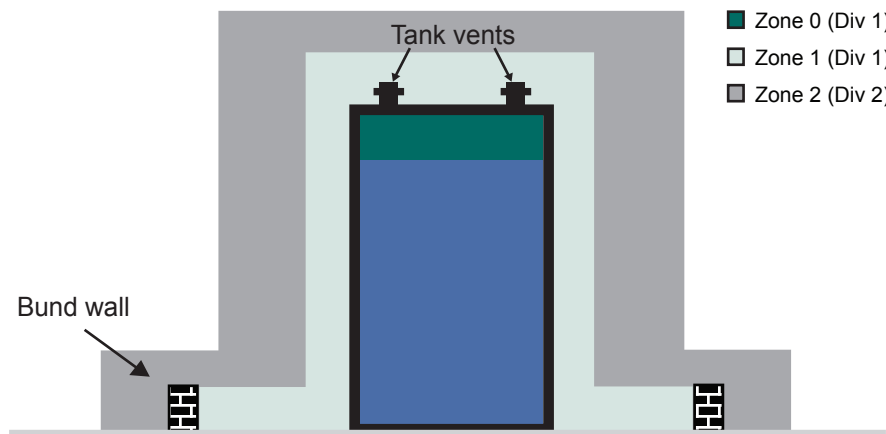
Area classification

	Flammable material Present continuously	Flammable material Present intermittently	Flammable material Present abnormally
IEC/EU	Zone 0	Zone 1	Zone 2
US NEC® 505	Zone 0	Zone 1	Zone 2
US NEC® 500	Division 1		Division 2
CA CEC Secion 18	Zone 0	Zone 1	Zone 2
CA CEC Annex J	Division 1		Division 2

* IEC classification per IEC 60079-10
* EU classification per EN 60079-10
* US classification per ANSI/NFPA 70 National Electric Code® (NEC®) Article 500 or Article 505
* CA Classification per CSA C22.1 Canadian Electrical Code (CEC) Section 18 or Annex J

Area classification example

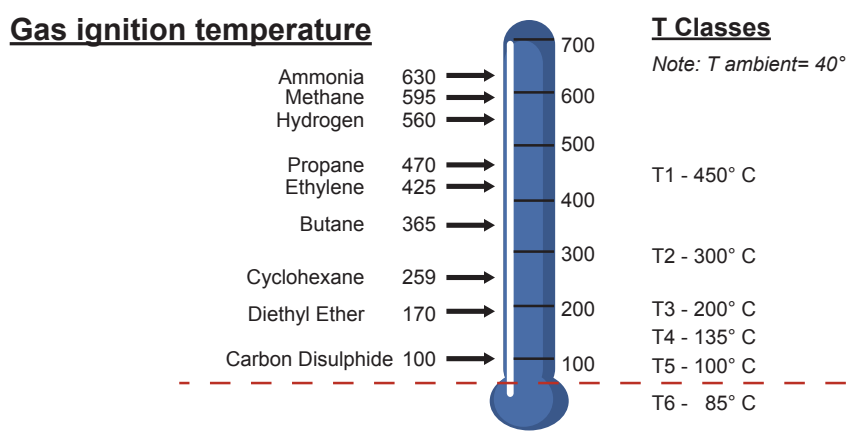
Area classification for a fixed-roof tank venting a heavier-than-air gas



This tank storage of a volatile fuel gives an example of how areas are classified by divisions/ zones. Areas with continuous exposure to high concentrations of the volatile gas vapors under normal conditions is classified as a special Division 1 or Zone 0. Intrinsic safety is the only protection concept allowed by both IEC and NEC standards for this area. Zone 1 or Div 1 is for exposure to the volatile gas under normal conditions and Zone 2 or Div 2 is for exposure to the gases at very low concentrations and/or under abnormal conditions.

Hazardous area temperature classifications

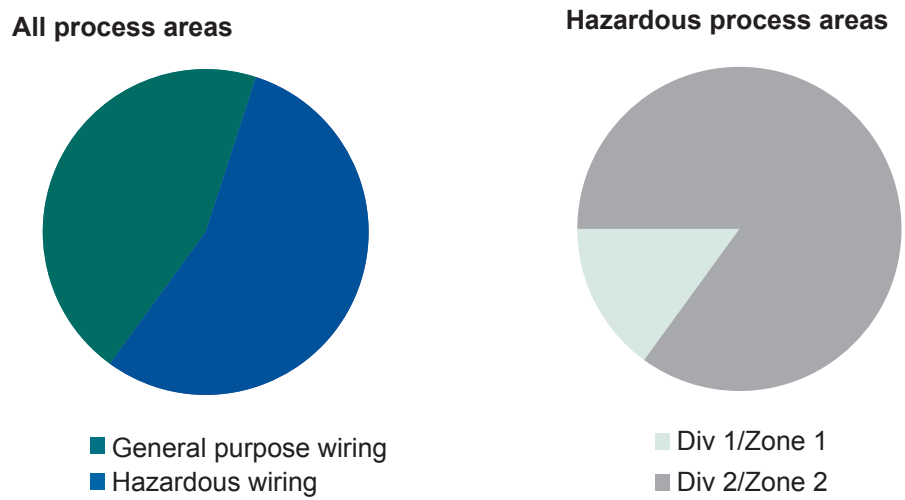
Define maximum surface temperature of field device; Gases may ignite due to thermal conditions. *Stonel brand products are typically T5 or T6*



Temperature classifications are being used increasingly with all hazardous protection concepts. T classes designate the maximum surface temperature a component is expected to have when exposed to a volatile gas. In the case of explosionproof enclosures this is the maximum external temperature of the enclosure. With intrinsically safe rated components this is the max surface temperature components may exhibit under both normal and fault conditions. With nonincendive rated components this is the max surface temperature the components exhibit under maximum normal operating conditions.

Typical area classifications

Typically greater use of hazard protection to assure greater safety



Typical processing plants contain Zone 0, Zone 1/Div 1 and Zone 2 Div 2 hazardous areas and general purpose areas. If the processing plant has significant portions of the plant classified as Zone 1/Div 1 the standard may be to use equipment suitable for this environment throughout the plant in order to eliminate the potential threat of misapplying a lower rated unit in the higher rating area. It is unusual to have electrical instruments and wiring in a Zone 0/special Div 1 area.

Protection compliance

- Trend is toward third party approval before users accept (Manufacturers may use ratings without approvals)
- OSHA (USA) requires electrical apparatus be approved by Nationally Recognized Test Lab (NRTL)

Some third party approval agencies include

- FM Approvals LLC (FM Global)
- CSA International/CSA Group/SIRA (Canadian Standards Organization)
- Brazil - CEPEL, Net Connection Corporation (NCC)
- Physikalisch-Technische Bundesanstalt (PTB)
- Baseefa, SGS Global
- Japan - TIIS

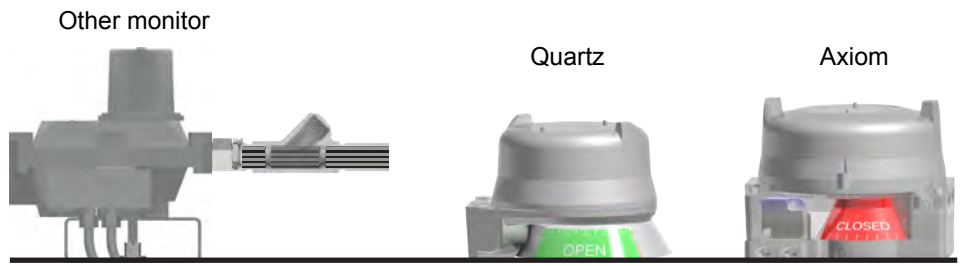
Market	Typical product marking
North America	FM, CSA, UL
Europe	ATEX/Ex, IECEx,
Japan	JIS
India	PESO
Brazil	InMetro
Russia	Gost-R

Most countries have numerous third party testing agencies who will test products per the national standard. Although FM, UL and perhaps CSA are recognized by end users in the USA, OSHA has approved 18 different NRTLs whose marks have the same authority. Increasingly countries around the world are working toward harmonization with the IEC Ex standards with slight variations due to language and unique local wiring requirements.

Hazardous area protection concepts

Seal off requirements

- Used to prevent propagation of ignited gases into and out of enclosure
- Not required with nonincendive devices
- May be required with explosionproof devices in Division 1

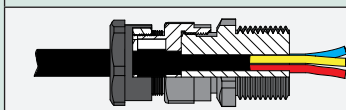
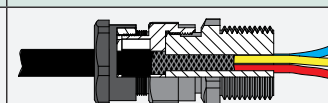


Seal fittings are required in North American applications for explosionproof enclosures to prevent pressures from "piling" into other parts of the conduit system. In IEC based wiring standards the cable gland is used to prevent ignited gases from affecting the outside atmosphere instead of seal fittings. Seal fittings are not required on the Quartz QX or Axiom AX stainless steel enclosures in explosionproof conduit systems.

Hazardous area protection concepts

Cable gland requirements (IEC & ATEX)

- Use of armoured and non armoured cable is country specific
- Glands must be used on all explosion proof equipment
- Prevents propagation of flames and gases
- Zones 1 & 2

Flameproof compound barrier - Ex d (EN/IEC 60079-1)		
Form of equipment protection/cable type ** country specific*	Non armoured cables*	Armoured cables*
		

In IEC/ATEX based wiring standards the cable gland, instead of seal fittings, is used to prevent ignited gases from affecting the outside atmosphere. These devices are third party approved and, unlike seal fittings, prevent both the propagation of flames and gases.

Explosionproof networking

Field enclosures

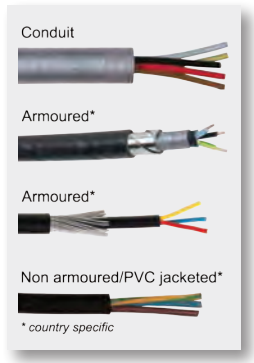
- Must comply with relevant explosionproof standards for area classifications

Field wiring and connections

- Varies significantly depending on code standards (IEC or NEC)
- Rigid metal conduit with approved fittings with NEC; suitable cable with PVC jacket and cable glands at enclosures may be used per IEC
- Metal clad cable with suitable termination fittings for flexibility (NEC)
- Special flexibility provisions not required for IEC
- Quick connectors are not allowed

Field instrument components

- Must be located inside explosionproof enclosures and identified as a complete assembly
- Enclosures may not be opened with circuits energized



Seal fittings are required in North American applications for explosionproof enclosures to prevent pressures from "piling" into other parts of the conduit system. In IEC based wiring standards the cable gland is used to prevent ignited gases from affecting the outside atmosphere instead of seal fittings. Seal fittings are not required on the Quartz QX or Axiom AX stainless steel enclosures in explosionproof conduit systems.

Hazardous areas and control circuits

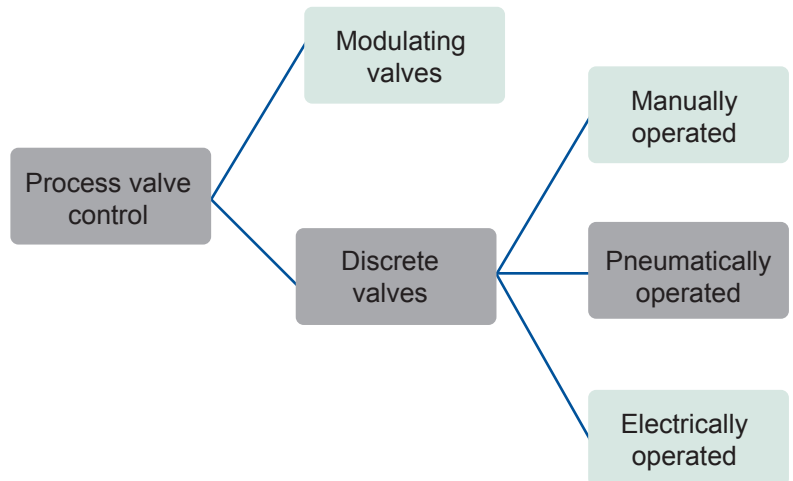
Hazardous area protection for solenoid valves

- Use either explosionproof, intrinsically safe, or nonincendive equipment
- Explosionproof uses enclosure design to contain explosion and cool escaping gases
- Intrinsically Safe (IS) methods limit the voltage and current of the coil; coil also must be designed and approved to be IS apparatus with solenoid diodes
- Nonincendive are constructed to produce a non-sparking device that may be used with low cost enclosures (only Div 2/Zone 2)
- Coil temperature is limited

Different protection methods can be used for solenoid valves depending on the application.

Pneumatic control

Discrete actuator control

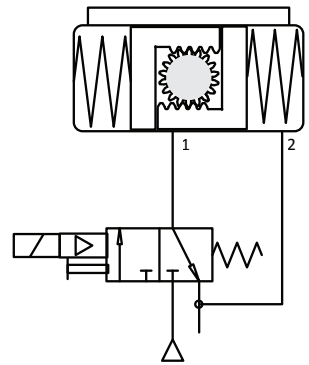


Although we offer products to monitor all types of process valves the primary focus is on monitoring and control of pneumatically operated discrete (on/off) valve systems. In this section the more popular pneumatically operated discrete valves are described along with the typical control options.

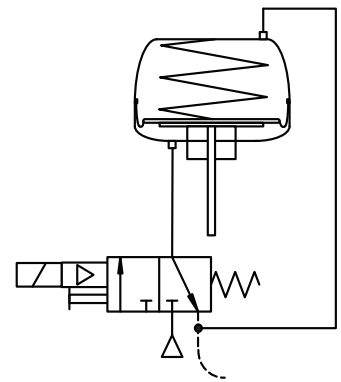
Modulating vs discrete

	Modulating	Discrete (On/Off)
Control type	Positioner	Solenoid valve and monitor
Operation	Precise control	Simple open or closed
Relationship to valve	Intimate; characterized	Generic
Cost	10% of value package	30% of value package
Key value features	• Exact control in PID loop • Reliable operation	• Low initial cost • Reliable when operated
Advanced features	• More diagnostics • "High end" communication • Loop control in positioner • Zero bleed pneumatics	• Electronic sensing • Basic low cost communication • Integrated solenoid • Push button settings
Typical price	$1,500	$500

Single-acting spring return actuator and pilot valve



Quarter-turn actuator with pre-determined fail state



Linear actuator with pre-determined fail state

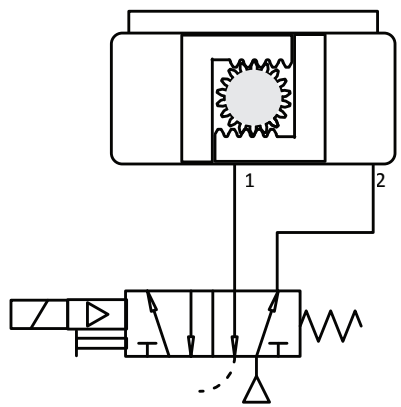
These pneumatic actuators represent actuators that are designed to fail in a predetermined position.

When energized, pneumatic pressure operates actuator pistons against springs. When de-energized, springs force pistons back with air exhausting.

On loss of electrical signal and/or air pressure actuator will return to the “fail safe” position.

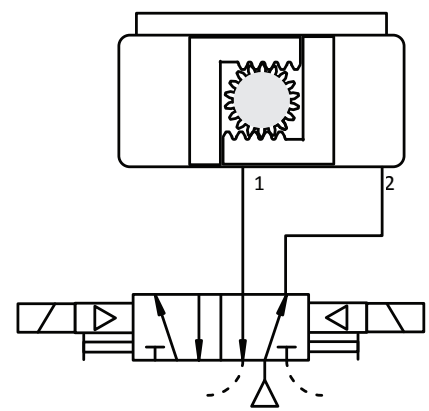
Rebreather systems may be used to port exhausted air into the spring chamber in order to prevent ingestion of contaminants from the environment.

Double-acting with spring return pneumatic pilot valve



Quarter-turn actuator with pilot valve determined fail state

Double-acting with shuttle spool pneumatic pilot valve

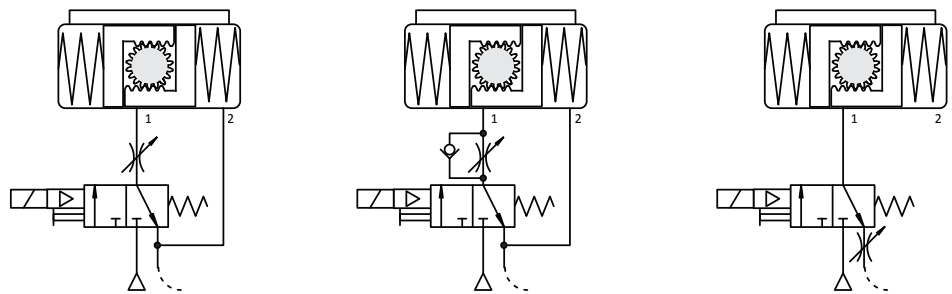


Quarter-turn actuator with fail- in-last position

The spring return pilot valve is used for another type of fail position operation. When energized, pneumatic pressure pushes actuator pistons out with air exhausting; when de-energized pistons are forced back with air exhausting opposite side. On loss of electrical signal the actuator will be pneumatically driven to “fail-safe” position. On loss of pneumatic signal the actuator will remain in last position.

The shuttle spool pilot valve is designed for fail-in-last position. When one solenoid is momentarily energized pilot valve spool shuttles to opposite position operating actuator in conventional double-acting fashion. Momentarily operating second solenoid shifts pilot spool back which reverses operation of double-acting actuator. Actuator stays in last position on loss of electrical power or air.

Flow restrictor options



Restricted open and closed

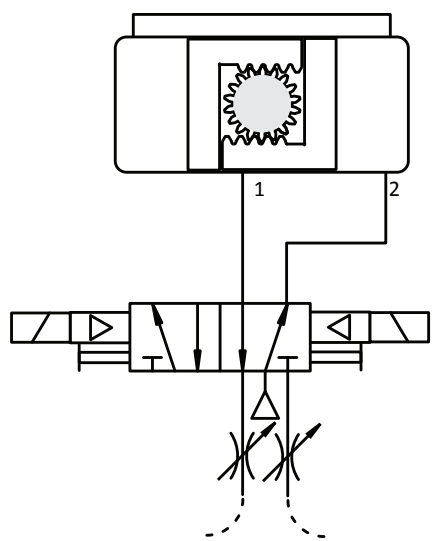
Restricted closed

Restricted close (no rebreather)

Spring return actuators may have their speeds controlled by the use of flow restrictors.

These restrictors may be used in various ways to reduce air flow for desired closure and/or opening speed.

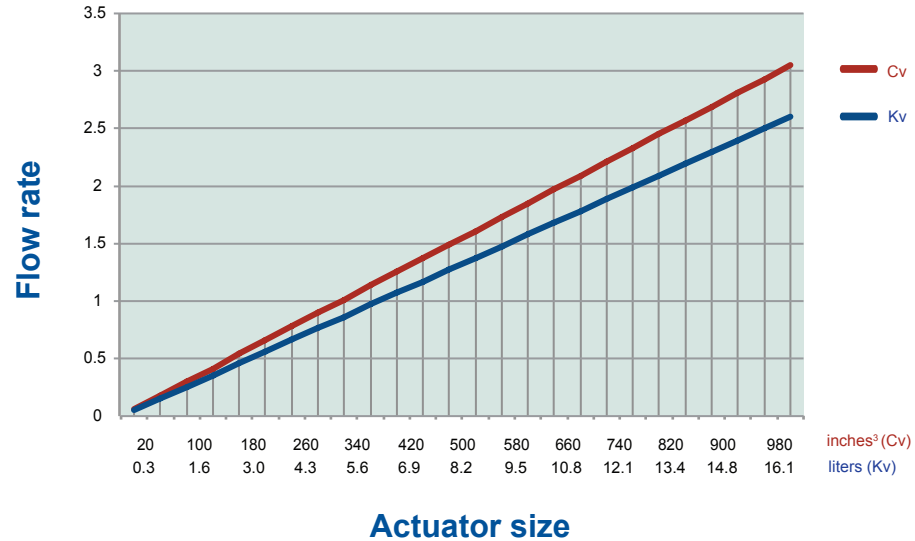
Flow restrictor options



Restricted open and closed

Air low and actuator speed

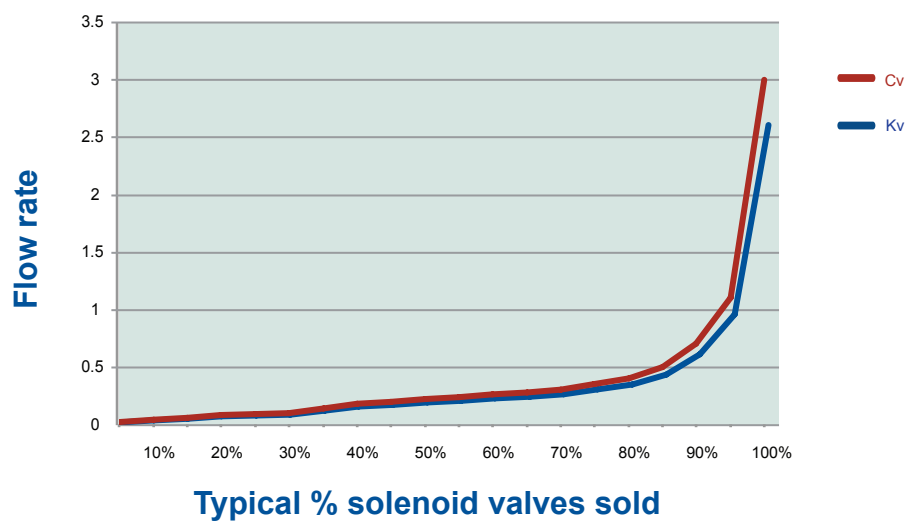
Solenoid valve flow rate to operate actuator in less than two seconds



The graph shown gives an approximation of the pneumatic control valve size that is needed to operate various sizes of actuators for 2 second open or 2 second close operation at 75psi (5 bar). Other factors which affect flow requirements and will significantly affect actuator operation times are:

- Actuator spring force
- Valve torque requirements
- Air pressure at the actuator
- Actuator port sizing
- Fitting and air line sizes

% of solenoid valves sold operating actuator in less than two seconds (typical 1/4 turn discrete valves)



Actuator sizes sold can vary significantly depending on type of process application. A rough estimate is that 90% of pneumatic quarter-turn actuators will operate in 2 seconds (either full open or full closed) with a Cv of 0.7 (Kv of 0.6) operating at 75 psi (5 bar).

Another significant break point is 1.2 Cv (Kv of 1.0) where approximately 95% of actuators in typical applications will operate in less than 2 seconds at 75 psi (5 bar).

Intermediate control

Axiom Expeditor capabilities

Fill control

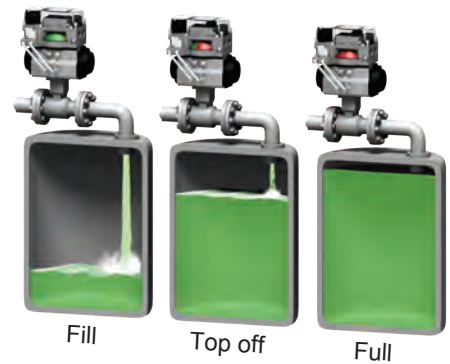
Intermediate position partially closes valve to reduce flow as the full level approaches.

- Fill tanks and hoppers rapidly and accurately

Flow dampening

Allows valves to close using multiple steps.

- Prolongs valve and piping life
- Improves process flow performance
- Inhibits water hammer



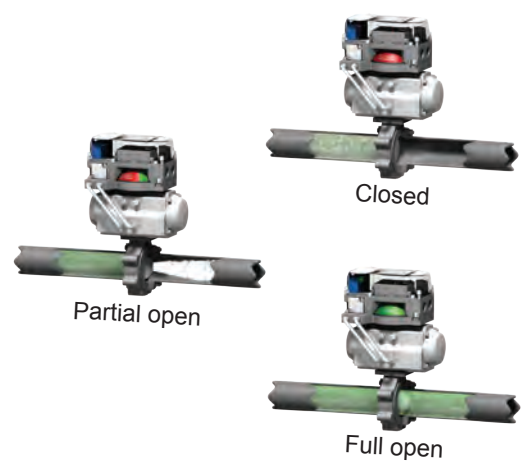
With expanded control and monitoring capabilities, the Axiom Expeditor offers unparalleled value in batch processing applications. Fill control, flow dampening and thermal shock reduction are examples of applications where the Axiom Expeditor may improve your plant operation.

Axiom Expeditor capabilities

Thermal shock reduction

Prevent thermal shock by partially opening a standard discrete valve.

- Gradual heating minimizes potential damage to steam lines
- Especially critical in applications
  - CIP (clean-in-place)
  - SIP (steam-in-place)



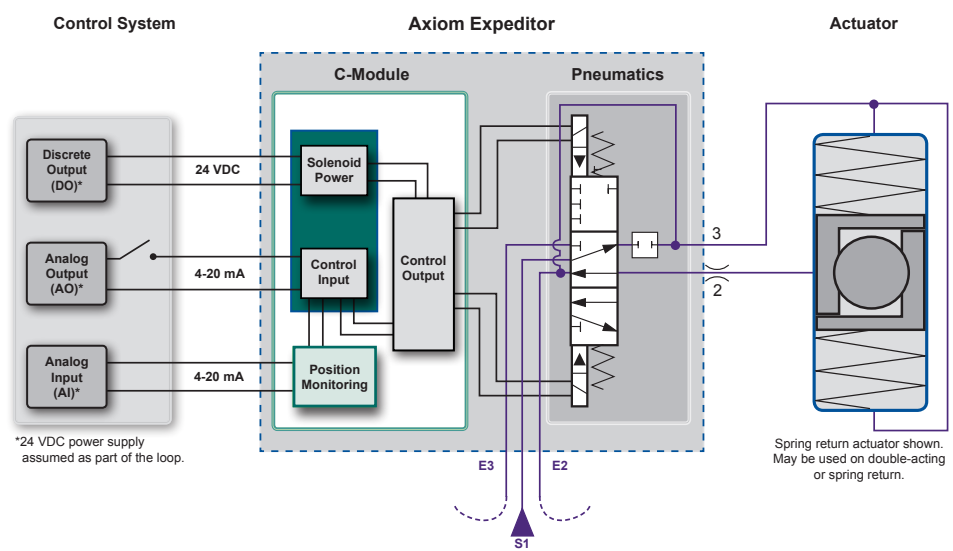
Axiom Expeditor set-up

- Calibration performed simply with onboard instructions
  - Unit under power up conditions may be programed in less than 15 seconds
  - Actuator stroking is performed during set-up and calibration
- Automatically detects actuator speed for proper calibration
  - Full stroke less than 1 second requires speed controls
  - Too rapid of operation causes set point overshoot

Calibration may be performed quickly and easily using the Axiom Expeditor's readily accessible membrane control pad. By simply following the on-board instructions, with the unit powered up, all set-up procedures may be performed in a few easy steps and the actuator evaluated for proper stroke timing.

During set-up, as mentioned above, the Axiom Expeditor automatically gages the speed of the actuator to determine if flow restrictors are needed. If full stroke is less than one second, flow restrictors (included with each Expeditor from the factory) are required to assure smooth, consistent intermediate control operation.

Axiom Expeditor operational diagram



Notes

Process networking

Notes

Overview

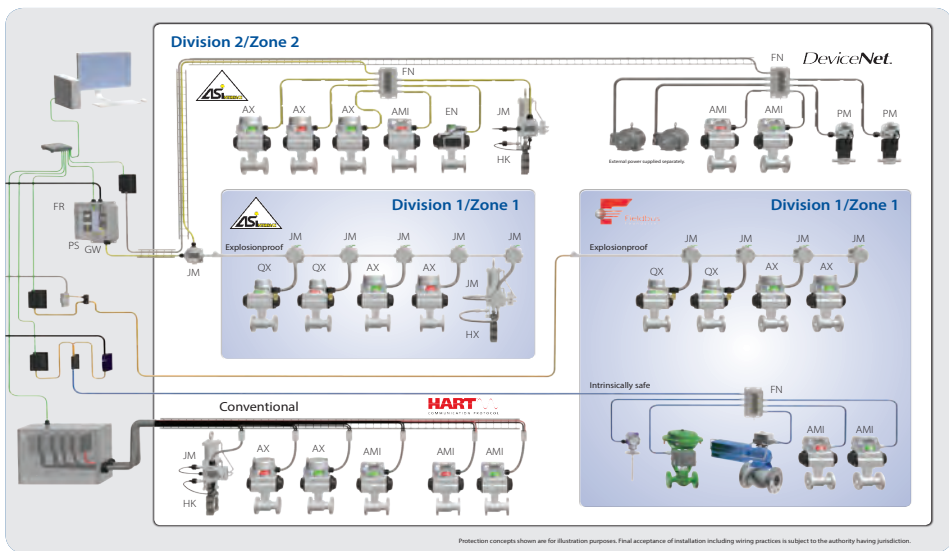
Process networking benefits include

- Significantly reduced installation costs by allowing many devices to communicate over a common set of wires
- Improved process diagnostic data from network enabled devices and instruments

In this section we will discuss what makes up these networks and cover some basic terminology.

Standardized communication networks are linking intelligent field devices to enterprise systems to offer unparalleled benefits to the process industries. Users are experiencing dramatic reductions in installation costs, reduced maintenance and commissioning costs, and improved process performance.

Hazardous area networking guide



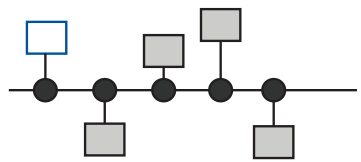
Networking communications

Characteristics

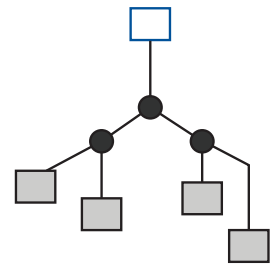
- Digital signals transmitted over a wire or non-wire medium
- Multiple devices attached to the same medium
- Devices may both send and receive messages
- Devices are typically intelligent

Topology

Trunk and drop



Tree or chicken foot



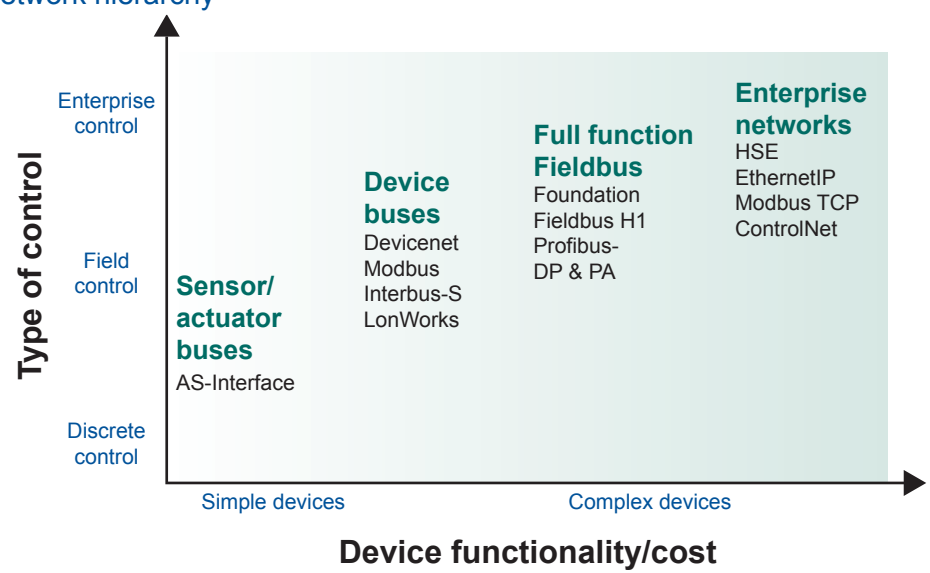
Network protocol

- Fully defines the hardware and software characteristics and procedures used on a particular network
- Devices operating on a common protocol must conform to the defined characteristics and follow the specified procedures for communication.
- Open Systems Interconnection (OSI) model used as a framework to define.

Topologies

- Trunk and drop and tree are common topologies used in process networks.

Network hierarchy



Enterprise networks Ethernet with TCP/IP is the de facto standard for linking computer control and business systems together.

Fieldbus networks The most popular protocol at this level is Foundation Fieldbus (H1).

Device bus networks These offer the functionality to connect both analog and discrete instruments into the process control architecture. Modbus, DeviceNet, and Profibus are popular device bus protocols used in the process industries.

Sensor/actuator networks AS-Interface is the dominant protocol used for discrete applications throughout the world in the process industries. It offers dramatic installation savings, is simple to install, integrates conveniently into most other higher level protocols, and is easy to maintain.

Protocol selection criteria

Protocol(s) selection

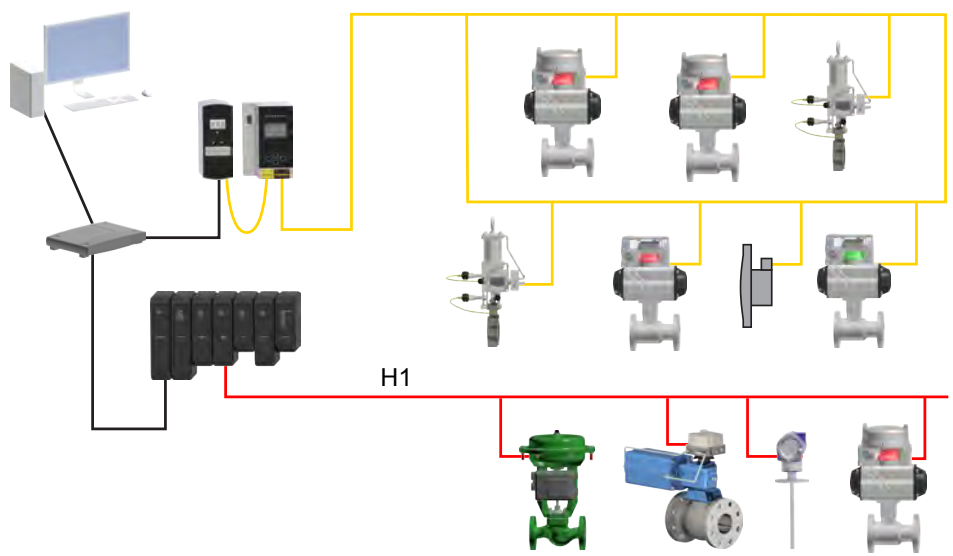
Options

- AS-i
- Fieldbus Foundation
- DeviceNet
- MODBUS
- PROFIBUS

- Instrument functionality
- Instrument availability
- Instrument cost
- Control architecture compatibility
- Process suitability
- Compatibility with protection concept(s)
- Instrument geographic dispersion
- Technology migration

Protocol selection Each of these network protocols have specific strengths and weaknesses. It is important to consider these criteria when selecting the optimal network structure for your project.

Bus network architecture



Optimized process control architecture An optimized network may consist of two or three communication protocols which seamlessly and economically link sophisticated process instruments and simple, discrete devices into the process control architecture. This diagram illustrates a fieldbus and sensor bus being directly attached to the process control/ enterprise system. Although one higher level protocol may be capable of directly connecting all of the field devices with the control architecture, area classifications, reliability, and economic considerations make the layered approach preferable.

AS-i Trade Organization
(ATO)
16101 N. 82nd Street
Suite 3B
Scottsdale, AZ 85260
USA
Tel: 480-368-9091
Fax: 480-483-7202
www.as-interface.net

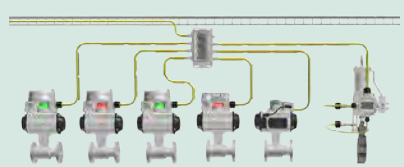
AS-Interface overview

- Ideally suited for actuators and proximity sensors
- Designed for mission critical applications
- Over 20,000,000 installed field devices

Actuator Sensor Interface, or AS-Interface, was developed by a group of sensor manufacturers and introduced into the market in 1994. Since that time, it has become the de facto standard for discrete sensors in process industries throughout the world.

AS-Interface technology has been standardized in EN 50295 and IEC 62026-2. There are over 400 different products available from 50+ vendors. And, as of this writing, there are estimated to be over 20,000,000 installed nodes (field devices) throughout the world. Which makes AS-i one of the most widely used industrial bus networks in the world.

AS-Interface



Features	Benefits
Simple electronics and communication	Reliable, robust performance
Power and data over 2-wire, unshielded cable	Easy to use and flexible for retrofits
Free choice of network topology	Easy to install with minimal cost
Up to 124 devices per master/gateway	Dramatic cost savings
Complements higher level networks	Use with existing control architecture
Adopts to most DCS/PLCs	Fast installation and easy retrofits
Easy to understand	Reduced training time
Easy to program and maintain devices	Reduced maintenance costs

AS-Interface is a versatile, low cost alternative to traditional hard wired I/O. It can replace traditional point-to-point wiring with a better, more flexible solution that is easier to install, operate and maintain and easier to re-configure.

This network is easy to install, easy to troubleshoot and a very powerful tool used to communicate data to process instruments.

AS-Interface updates

- 31 devices per network
- 5 ms scan time
- 124 inputs and 124 outputs

- 62 devices per network
- Analog profiles
- Additional diagnostics

- 62 devices per network up to 8DI or 8DO
- Fast analog
- Serial profile

AS-Interface has continued to improve over the years and the spec has been revised carefully, to allow for improvements without adversely affecting current users or products that are older versions. These versions are forward and backward compatible.

2.0-The first version of AS-i that had significant usage in the process industries. It featured 31 devices per segment and only discrete device profiles were possible (4 bits per device).

2.1-This version enabled up to 8 bits of discrete I/O and analog I/O profiles. It established an optional extended addressing feature (A/B slaves) allowing up to 62 devices per segment.

3.0-The latest version. It allows new device profiles for greater flexibility.

AS-Interface vs. conventional

Installation cost comparison (calculated per field device)		
	Conventional	AS-Interface
Valve monitor and solenoid	$510	$610
Conduit and wiring	$700	$300
I/O (Conventional); Gateway (AS-i)	$200	$100
Installation labor	$500	$200
Total installed cost	$1,910	$1,210

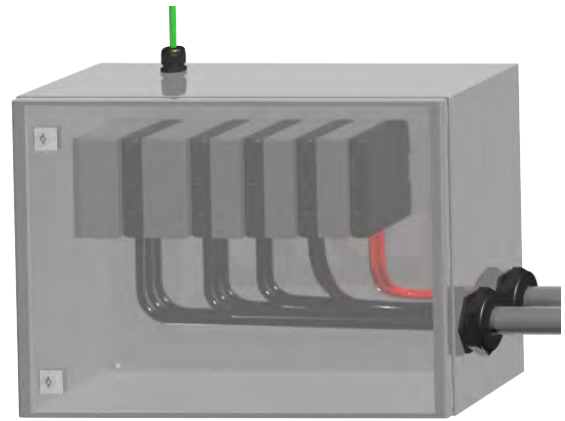
Total installation savings
$700 per valve or 37%

While the device itself costs a bit more, dramatic cost saving are made possible by reducing the amount of wire and terminations needed. The example shows costs per valve assuming a network of only 10 valves. Greater cost savings are possible if more than 10 devices are networked.

Users get better performance and easier troubleshooting, while in the end costing less than if the devices were wired using conventional point-to-point wiring.

AS-Interface

Conventional



AS-Interface saves money!

AS-Interface cuts project costs by

- Eliminating I/O cards
- Saving cabinet space
- Drastically reducing required cable and conduit

AS-Interface saves time!

AS-Interface cuts project time by

- Reducing engineering time
- Reducing installation time due to
  - Wiring
  - Labeling
  - Commissioning
  - Testing

Additional savings come from the reduction of space in the I/O cabinets.

Reducing the amount of wires in the I/O and marshalling cabinets from 5 wires per device to 2 wires per network eases installation and documentation efforts and costs.

AS-Interface signal

- Exceptional noise immunity
- Performs reliably even in strenuous environments
- Maximum scan time of 5 milliseconds for 31 devices (.125 milliseconds/device for discrete; multiple scans for analog or 4 x .125 milliseconds = .5 milliseconds)

Master call

0	SB	A4	A3	A2	A1	A0	I4	D3	D2	D1	D0	PB	1
ST													EB

ST ... Start bit
SB ... Control bit
A4, .., A0 ... Address bits
D3, .., D0 ... User data

Slave response

0	D3	D2	D1	D0	PB	1
ST						EB

PB ... Parity bit
EB ... End bit

The AS-Interface utilizes Alternating Pulse Modulation (APM) with Manchester II coding and decoding. This minimizes electromagnetic emissions and is highly tolerant of electromagnetic interference. AS-Interface networks are recommended for "mission critical" applications.

The AS-Interface messages are very short, which enables great speed. The master command is followed by the slave's response, then the master sends a command to the next address. This all happens very fast. A network of 31 devices will complete all communication in less than 5 ms. (> 200 times per second!!!!) Single-bit parity check and bit repetition is used for error detection. Incorrect messages are identified and repeat requested by the master/gateway.

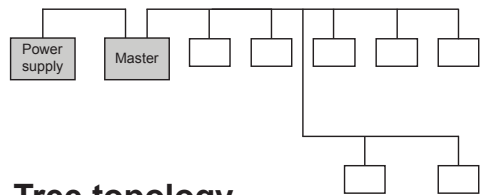
AS-Interface addressing

- Each field device has a defined address
- Field device addressed off-line with hand held
- Field device addressed on-line by master
- Addresses are unique on each string (set of devices on one master)
- Standard addressed from 1 to 31; Extended addressing 1a to 31a and 1b to 31b (62 devices!)

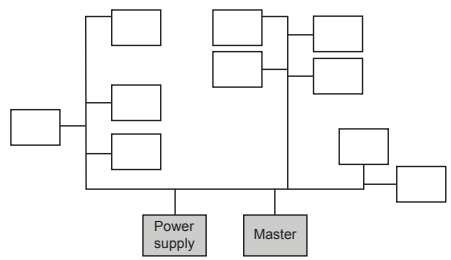
Each field device has a defined address. The address is set off-line by the master/gateway or by a hand held addressing device. Automatic on-line addressing is available for field device replacements.

AS-Interface topologies

Linear with spur topology



Tree topology



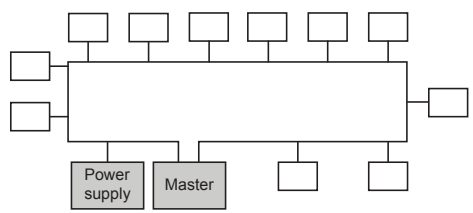
AS-Interface is capable of supporting any topology. Any combinations of star, ring, tree and linear are possible.

The only limit is total cable length. AS-i is limited to 100 m (328 ft) of total cable length, including all cable carrying the signal. We have some tools that can allow for much longer networks that will be discussed a few pages later.

Utilizing a topology that makes efficient use of cable can be very beneficial.

AS-Interface topologies

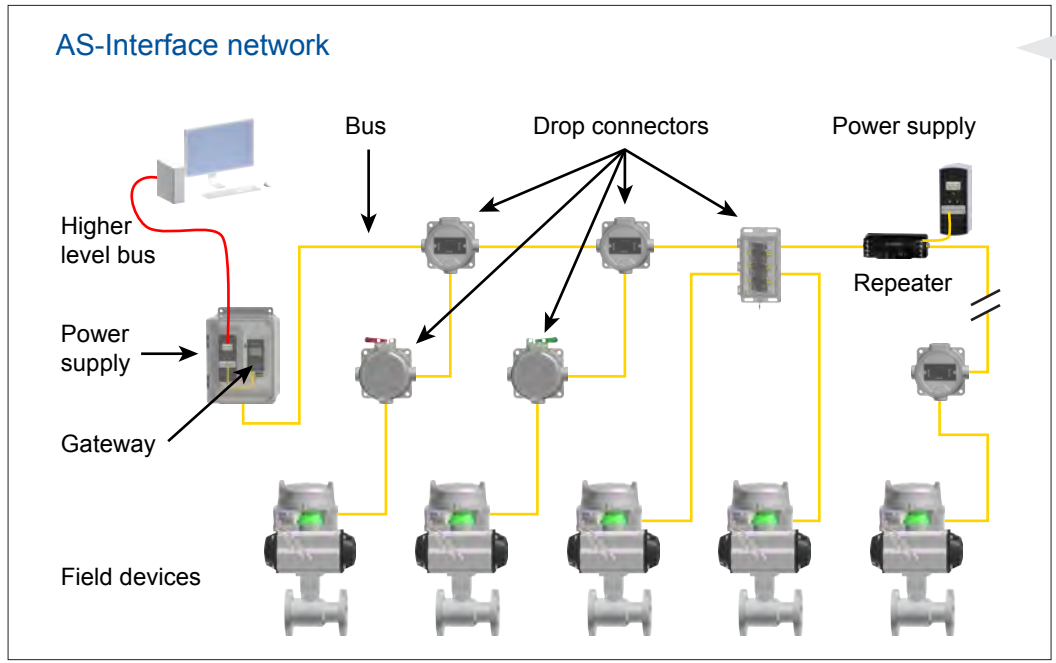
Ring topology



AS-i is one of the few networks that can support a ring topology.

The benefit of a ring is that a wire break in the ring will not disrupt communication with the devices on the network.

A repeater cannot be used in the ring to extend the length of the ring itself.



All of the wire shown in yellow is included in the 100 m cable budget.

A repeater can be used to add an additional 100 m of total cable length.

Stonel brand AS-Interface gateways

These gateways provide an easy method to integrate AS-i to virtually any PLC or DCS system

- Durable stainless steel housing
- Graphical display
- Duplicate address detection
- Available in
  - Profibus-DP
  - Modbus
  - DeviceNet
  - Ethernet … and more
- ETL approved for Class I Div 2 in NEMA 4 enclosure

The AS-Interface master/gateway controls and operates the sensor bus network. All of the slaves (field devices) respond to the master and rely on the master for control of the network. Gateways perform all of the same functions as the master and, additionally, interface with higher level bus networks.

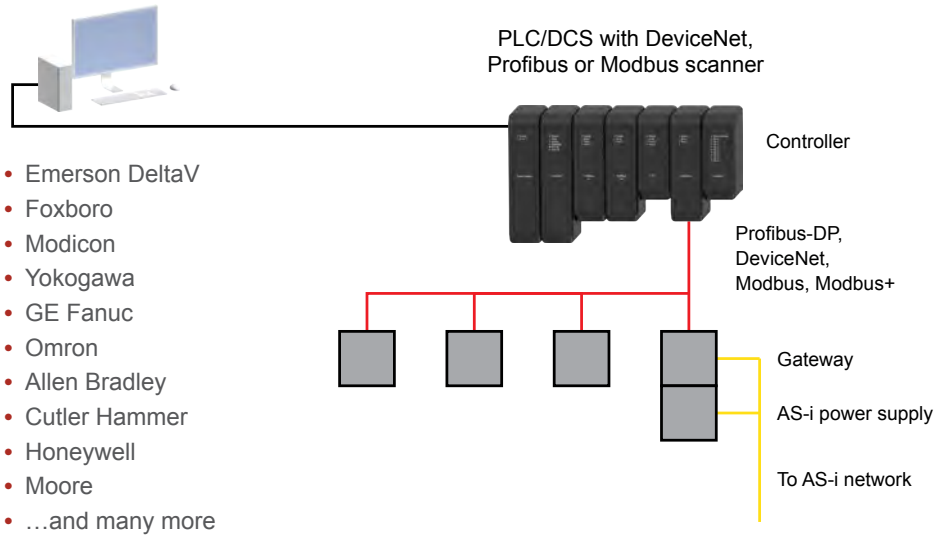
Several of our new dual channel stainless steel gateways are available with a feature that simplifies design and saves money. These dual channel gateways can operate 2 AS-Interface networks with a single 30 VDC power supply.

Stonel brand PLC AS-i masters

- PLC AS-i master for Allen Bradley SLC dual channel
- AS-i master for Allen Bradley CompactLogix / MicroLogix
- AS-i master for Allen Bradley ControlLogix – dual Channel

Some PLC/DCS manufacturers have AS-i I/O cards that fit into the backplane. This makes for a very easy integration of the data into the PLC/DCS.

Networking AS-Interface



- Emerson DeltaV
- Foxboro
- Modicon
- Yokogawa
- GE Fanuc
- Omron
- Allen Bradley
- Cutler Hammer
- Honeywell
- Moore
- …and many more

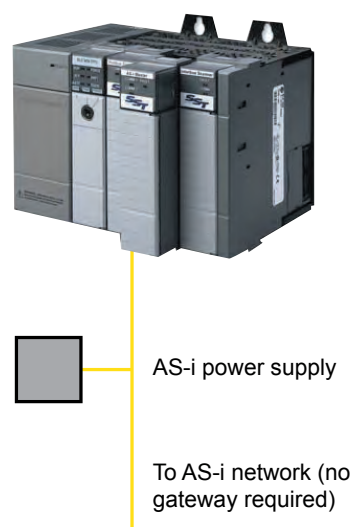
Many PLCs and DCSs have communication cards available that utilize protocols such as Profibus, ProfiNet, DeviceNet, Modbus, Modbus+, Ethernet, etc. The appropriate AS-Interface gateway would simply act as a node on the higher level network.

The benefit of this arrangement is that the gateways can be located near the devices in a local cabinet. In many cases this makes it much easier to work within the 100 m AS-i cable budget.

Also having the gateways out in the field gives users a remote access point to see data and check diagnostics without having to bother the DCS/PLC.

PLC/DCS with AS-Interface scanner

- Allen Bradley
- Siemens
- Emerson DeltaV
- Modicon
- SquareD
- GE Fanuc
- Wago
- Beckhoff
- Omron
- Mitsubishi



Many DCS/PLCs have AS-Interface scanners available, which enable direct connection without an AS-Interface gateway.

This makes for easy integration into the DCS/PLC control system.

Stonel brand AS-i power supplies

Power supplies

- Provide voltage and current to AS-Interface network (30.5 VDC) (Decoupled to prevent signal interference)
- Available in 2.8 and 8.0 amp and dual channel 4.0 amp
- 1 required for each AS-i network and 1 for each repeater
- 2.8 amp FM and CSA approved for Class 1 Division 2 hazardous locations

AS-i REQUIRES the use of a special power supply to enable data to be carried on the power wires. The power supply must be 30.5 VDC and have data decoupling.

Stonel brand AS-i network extension tools

Repeater

- Allows extension of network by 100 m (328 ft)
- Requires additional power supply
- Allows devices on both sides of the repeater
- No more than 2 repeaters in series (total of 300 m or 984 ft)
- DIN or direct mount
- Also available in JM, FieldRack and FieldBlock enclosure

AS-i cable budget: 100 meters (328 feet) total length of cabling may be used for each master/gateway.

Additional length of 100 meters for each repeater is possible with limit of no more two repeaters in series. Parallel repeaters can be used to cover a vast area of the plant floor. The rules governing repeater placement are very straightforward. No segment shall contain more than 100 m of total cable length. No more than 2 repeater hops from any device to the master. Each repeater requires a separate AS-Interface power supply.

Stonel brand AS-i extension tools

AS-i network terminator

- Extend AS-i networks beyond 100 m
- Passive termination improves signal quality
- Cannot use loop topology

AS-i network tuner

- Extend AS-i networks beyond 100 m
- Active adjustable termination improves signal quality
- Cannot use loop topology

The AS-i terminator is a passive device that can be placed near the end of a segment to extend the AS-i network up to 200 m without repeaters. The terminator places a specially designed impedance at the end of the AS-i segment which serves to optimize the signal and therefore increase the network length.

The tuner is a device that actively looks at the network signal and determines the best impedance level to optimize the signal. It also has diagnostic LEDs to show signal level quality. The AS-i tuner can allow networks to extend up to 300 m without repeaters and has diagnostic LEDs.

Please note that it is important that voltage drop be considered when extending networks with these new tools.

Stonel brand AS-i wiring

- Two-wire unshielded - untwisted 16 gauge (2x1.5 mm^2)
- Length of 100 meters (330 feet)
- Additional length of 100 meters per repeater (maximum of 2 repeaters)
- Total length of 300 meters or 984 feet

The vast majority of all process applications use AS-i round cable. Factory automation applications often use a specially designed flat cable.

AS-Interface drop connectors			
	Passive	Protected	Switched protected
Double drop, (1-2)	Available		
Multi drop (1-4, 1-6)	Available		
Trip @ 240 mA, single drop (1-1)		Available	
Multi drop, DIN (1-4, 1-6)		Available	
Trip @ 240 mA, single drop (1-1)			Available
Multi switched drop, DIN (1-4, 1-6)			Available

Drop connectors are used to split the wires out to "drops" down to the field devices. There are 3 types available passive, protected, and switched, in many different form factors.

Passive drop connectors can be used for branching circuits. There is no current limiting in the passive drop connectors.

Protected drop connectors have short circuit protection. These devices detect short circuits by monitoring current. If current is exceeded, it will take the drop off-line. Protected drop connectors are designed such that only one device can be located downstream from the protected drop.

Switched drop connectors typically have the same short circuit protection scheme, but also have an integral disconnect switch to remove power from the drop.

AS-Interface drop connectors

Junction module (JM)

- Rated for Class I & II, Div 1 & 2; No sealoffs
- Houses tees or disconnect switch
- Lockout tag out feature on disconnect switch

FieldBlock (FN)

- Anodized aluminum enclosure is durable and corrosion proof
- Suitable for use in heavy washdown and submersible applications with NEMA 4, 4X and 6 ratings
- Multiple connector or cable gland options conveniently interface with flexible wiring systems
- Compact design minimizes space requirements

The JM offers a compact watertight enclosure for drop connectors and other components to be used in general purpose and hazardous locations. The disconnect switch is a great tool to disconnect power from a device, allowing maintenance to be performed in hazardous locations.

FN provides a durable enclosure to enable drop connectors to be located in the field, near the devices. This is especially useful in maximizing the efficiency of the AS-i cable.

Stonel brand AS-i handheld addressing unit

Handheld addressing unit

- Simple operation
- Low cost
- Convenient for use in the shop or in the field

The handheld addressing unit is the easiest way to set addresses in an AS-i device.

For new installations, set the address of devices before adding them to the network. This makes the network configuration a snap

For existing installation, use the handheld to pre-address replacements to ensure they get the correct one. This also makes replacing devices very easy.

Stonel brand AS-i VCTs

Valve Communication Terminal (VCT)

4DI/2DO

- 2 integral proximity sensors (DI) with LED
- 2 auxiliary inputs (DI)
- 2 solenoid outputs (4 watts total power)

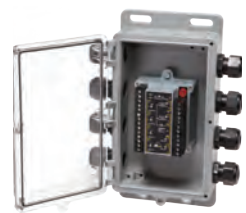
AS-Interface watchdog

We have many different platforms of valve communication terminals for virtually every on/off valve application. While the devices look very different and are designed for different applications, the device profile is the same.

Stonel brand AS-i I/O Modules

Discrete I/O modules

- 4DI / 4DO module with solenoid outputs (4 watts total)
- 4DI / 4DO module with 2 relay outputs
- Available in JM or FieldBlock enclosures
- Available in JM with integral solenoid valve



These modules allow users to connect conventional discrete I/O points to the AS-i network. These are often used to monitor and control knife gate valves, electric actuators and more.

Stonel brand AS-i analog modules

Analog input modules

- 4 analog inputs (4-20 mA) or (4) thermocouple inputs
- 16 bit resolution .1%
- LED indication (power status and input status)
- DIN rail mount available in IP20 or IP65
- Requires AS-i 2.1 version master!

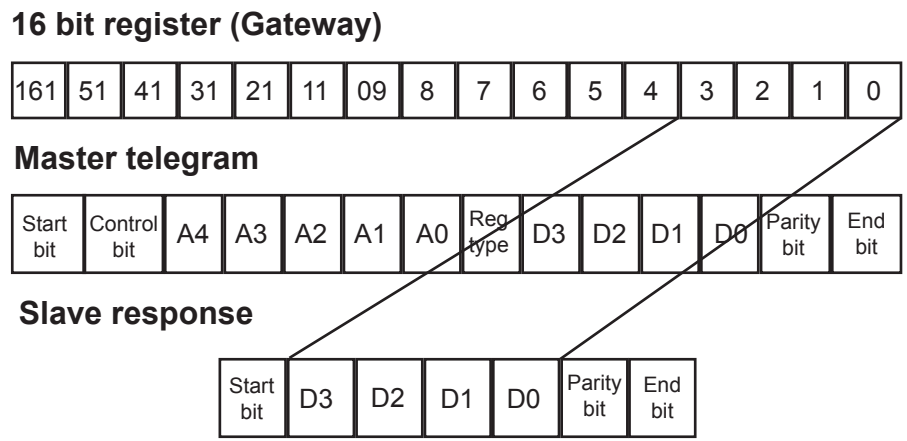
Analog output modules

- 4 analog outputs (0-20 mA)
- 16-bit resolution .1%
- LED indication (power status and input status)
- DIN rail mount available in IP20 or IP65
- Requires AS-i 2.1 version master!

If using a version 2.1 or later AS-i master you can now monitor and control analog 4-20 mA devices like transmitters and positioners with AS-i. These provide high resolution analog feedback and control to conventional 4-20 mA instruments using AS-i.

AS-Interface analog

- 16-bit analog values from a 4-bit data packet
- 7 scans per analog channel
- Timing: 4 channel analog input device 7 x 4 x 5 ms = 140 ms



The analog signals from the module are broken up into packets and sent to the master/gateway. There the signal is reassembled and stored in a table to be read by the PLC/DCS. The 16-bit signals are updated several times per second.

Stonel brand AS-i commissioning kit

- Commission devices (set address)
- Commission networks (configure addresses, test communication)
- Troubleshoot and diagnose network problems
- Test AS-Interface devices (read inputs, force outputs)
- A must for bench testing AS-i VCTs

This kit is a great tool for workshops that need to assemble and test AS-i automated valve packages.

It can also be used to troubleshoot and test for network master communication problems.

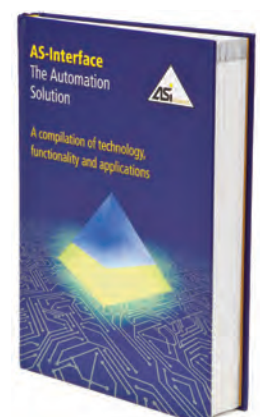
AS-Interface network layout and design tips

- Buy 100 m spools of wire. Use this to confirm that your network does not exceed 100 m
- Use repeaters to extend cable length
- Use passive drop connectors for branching circuits
- Use short circuit protection for field devices
- Remember, only 1 AS-i device per protected drop

Follow these simple rules for a trouble-free installation. Contact us for assistance with product selection and network design tips. Our network experts have many years of experience designing and assisting with the installation of networks in process plant environments.

Want to learn more about AS-i

- AS-Interface *The Automation Solution* book
- Order part # AC462014A
- $40 list each



This is a great reference manual to learn more about the development of AS-i protocol and the inner workings of the signals and message structure.

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Fax: 734-922-0027
www.odva.org

DeviceNet overview

DeviceNet is a versatile, low cost alternative to traditional hard wired I/O.

- Powerful promotion by Allen Bradley and ODVA

DeviceNet™

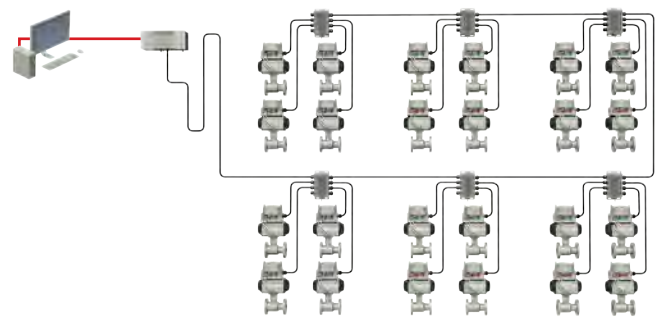
DeviceNet benefits

- Installation cost savings: over 30%
- Dramatic I/O and wiring space reduction
- Field devices easily added or removed
- Flexible structure for easy installation and operation

DeviceNet can replace traditional point-to-point wiring with a better, more flexible solution that is easier to install, operate and maintain and easier to re-configure.

DeviceNet protocol

- Trunk with drop topology
- Up to 64 addressable nodes (62 field devices)
- Signal and 24 VDC power in same cable
- Selectable data rates (125k, 250k, 500k)
- 120 ohm terminator at each end of the trunk



DeviceNet is based on CAN (Controller Area Network) technology originally developed by Bosch to replace expensive wire harnesses with low cost network cable in automotive applications. The fast response and high reliability of the CAN system makes it ideal for "mission critical" applications.

The DeviceNet protocol uses a trunk wiring network that may directly connect to field devices containing analog as well as discrete information.

DeviceNet protocol - power and signal

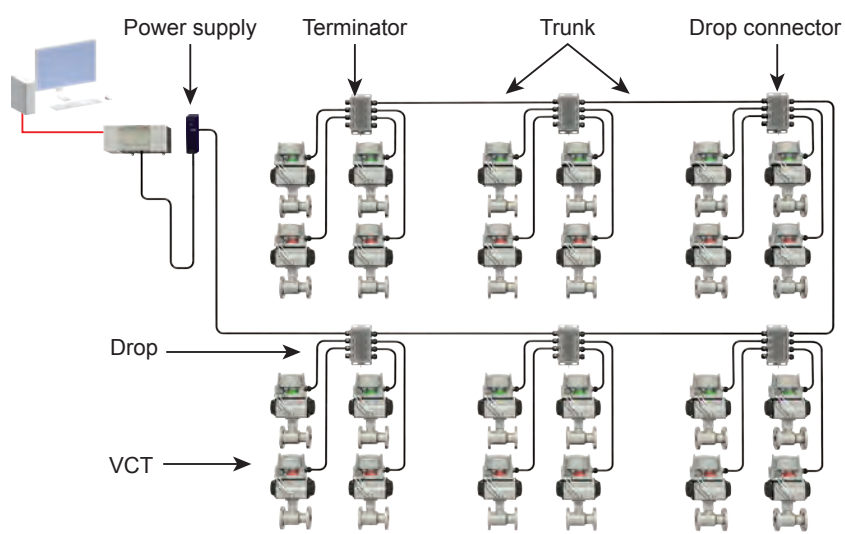
- Two twisted pair
  - Signal pair: low loss, high velocity with foil shield
  - Power pair: up to 8 A capacity with foil shield
  - Overall braid with drain wire
- Sensors and low power outputs can be powered directly from bus
- Opto-isolation for self-powered devices
  - e.g. drive, PLC, weigh scale, etc.
- Multiple power supplies can be used
  - Used for additional power or as backup

DeviceNet has high noise immunity, and the communication electronics are available with wide temperature ranges, making the protocol desirable for industrial and process automation.

Systems may be installed in hazardous environments by using acceptable explosionproof wiring or power limited wiring practices with nonincendive or explosionproof enclosures. Plug-in connectors are readily available for heavy washdown, general purpose environments.

DeviceNet protocol (cable length)			
Trunk cable length			
Baud rate	125 K	250 K	500 K
Thick	500 m	250 m	100 m
Flat	400 m	200 m	75 m
Thin	100 m	100 m	100 m
Drop cable length			
Baud rate	125 K	250 K	500 K
Maximum	6 m	6 m	6 m
Cumulative	156 m	78 m	39 m

DeviceNet network



In a DeviceNet system, up to 62 valve communication terminals, process instruments, etc. may be connected via drops or branches on a trunk network.

Power and signal are carried over the four-wire network. Each device has its own address and it may have several I/O points. Any discrete or analog instruments may be connected into the network provided it is DeviceNet compatible. Conventional field devices may also connect into the network via our DeviceNet VCTs and I/O modules, which have provisions for auxiliary inputs and outputs.

DeviceNet masters/scanners

- Allen Bradley PLCs
- Emerson DeltaV
- GE Fanuc
- Modicon
- Many others

DeviceNet power supplies

- 24 VDC (+/- 1%) power for DeviceNet networks
- 3.8 and 8.0 amp versions available
- Make sure the power supply has its own current limit protection (fuse).
- DeviceNet requires a power supply to have a rise time of less than 250 mS to within 5% of its rated output voltage.
- The power supply must be sized correctly to provide each device with its required power.
- The power supply should only be used to power the DeviceNet network.

Many PLCs and DCSs have communication cards available that communicate with DeviceNet.

DeviceNet requires the use of a 24 VDC power supply that meets the terms of the DeviceNet specification. A standard 24 VDC power supply may function but we recommend using a power supply that has the DeviceNet Conformance checkmark.

Multiple power supplies can be installed on a DeviceNet network, but no section of cable should have more current flowing than the appropriate rating.

When using multiple power supplies on a network; break the V+ wire between the power supplies. This effectively isolates the power supplies from each other.

Stonel brand DeviceNet cable

- Thick wire (trunk cable)
- Thin wire (drop cable)
- Flat cable

The vast majority of all process application use DeviceNet round cable. Factory automation applications sometimes use a specially designed flat cable.

Typically the thick cable is used for the trunk and the thin cable for the drops.

DeviceNet drop connectors

- Direct mount passive drop connectors
  - Easy wiring
  - Direct mount type for JM or in customer's enclosure
- Multi-drop passive drop connectors
  - Easy wiring
  - DIN rail mount for FieldRack or in customer's enclosure
- Junction Module (JM)
  - Rated for hazardous locations
  - Houses tees or I/O Modules
- FieldBlock (FN)

Drop connectors are used to split the wires out to "drops" down from the trunk to the field devices. The three types are passive, protected, and switched. They are available in many different form factors.

- Passive drop connectors are used for branching circuits. There is no current limiting in the passive drop connectors.
- Power protected drop connectors have short circuit protection in the V+ drop. * These devices detect short circuits by monitoring current in the V+ line. If current is exceeded, it will take the drop offline. Only one device can be located downstream from the protected drop.
- Switched drop connectors have the same short circuit protection scheme as mentioned above, but also have an integral disconnect switch to remove power from the drop.

* DeviceNet does not allow short circuit protection in the communication wires.

Stonel brand DeviceNet components

Valve Communication Terminal (VCT)

- 2DI/2DO/1AI
  - 2 integral proximity sensors (DI) with LED indication
  - 2 solenoid outputs (4 watts total power)
  - 1 analog input (4-20 mA)
- Predefined output fail state

We have many different platforms of valve communication terminals for virtually every on/off valve application. While the devices look very different and are designed for different applications, the device profile is the same.

DeviceNet components

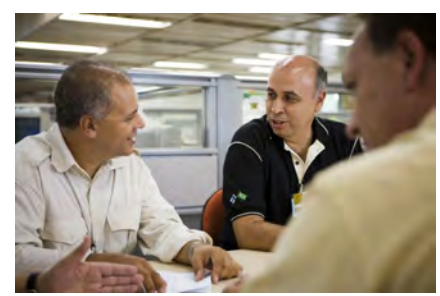
I/O modules

- 2DI / 2DO / 1AI module with solenoid outputs (4 watts total)
- Available in JM or FieldBlock enclosures
- Available in JM with integral solenoid valve

These modules allow users to connect conventional discrete I/O points to the DeviceNet network. These are often used to monitor and control knife gate valves, electric actuators and more.

Network layout and design

- Determine # of devices per segment
- Determine cable length and cable routing
- Determine drop connector method
- Select 24 VDC power supply, size network based upon current load
- The DeviceNet cable must by grounded at only one location
- Connect the network shield and drain wire to an earth ground using #8 AWG wire up to a maximum 3 m (10 ft) in length.
- Also connect the V-conductor (black wire) of the network trunk cable and the DC ground of the power supply to this ground connection.



Follow these simple rules for a trouble-free installation. Contact us for assistance with product selection and network design tips. Our network experts have many years of experience designing and assisting with the installation of networks in process plant environments.

DeviceNet device configuration

- Electronic Data Sheet (EDS) file from vendor or web
  - Standardized ASCII file format
  - Provides description of device attributes: name, ranges, eng. units, data type, etc.
  - Public attributes from device profiles
  - Vendor specific attributes
- Set device baud rate and MAC ID

These .eds files can be downloaded from the vendors website or requested by e-mail. Some PLC/DCS have a built-in library of .eds files.

Stonel brand DeviceNet commissioning kit

- Commission devices (set address, baud rate)
- Test DeviceNet devices (read inputs, force outputs)
- A must for bench testing DeviceNet VCTs

This kit is a great tool for workshops that need to assemble and test DeviceNet automated valve packages.

DeviceNet gateway configuration

- Get EDS file from vendor
- Set MAC ID
- Determine gateway mapping for I/O

These gateways provide an easy method to integrate AS-i to virtually any PLC or DCS system

DeviceNet applications

- Gateway AS-Interface networks into many legacy systems where distance to PLC or CPU over 100 to 200 feet
- Use DeviceNet I/O or VCT where devices scattered over long distances (hundreds of feet between units)
- Use DeviceNet I/O retrieving other process variables (discrete and analog)

MCCs (Motor Control Centers) are commonly controlled and monitored by DeviceNet.

DeviceNet troubleshooting steps

- Walk the network to determine the actual layout (make a sketch)
- Check # of nodes
- Check cumulative drop length
- Check individual drop lengths
- Check total trunk length
- Check the termination location and measure the terminators
- Check the power supply cable length and wire size
- Check total power load and its distribution points

Try to distinguish, as soon as possible, a device problem from a media problem.

Try to reduce the system to the smallest size, which still exhibits the problem. Start by removing nodes, drops, or lengths of trunk.

Use substitution where possible to rule things out.

DeviceNet troubleshooting steps

- Use an OHM meter to check resistance between CAN_H and CAN_L when idle. This should be about 60 ohms (two 120 ohm terminators in parallel). This value may be as low as 50 ohms if there are many nodes attached.
- Make sure all wires are well attached to the right places.
- The V+ level, relative to V-, should always be between 11 to 25 volts.
- Check for one (and only one) earth ground of the V- and shield.
- Measure the 24 V at the middle and ends of the network.

A common source of problems is the incorrect setting of baud rates and node addresses. Always verify the nodes address and baud rate before installing it on a network.

We recommend baud changes on a separate, point-to-point only connection.

Fieldbus Foundation
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Austin, TX 78759-5316
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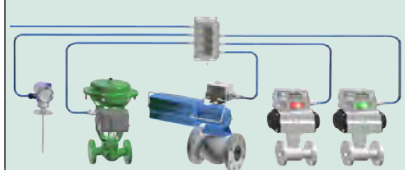
Fax: 512-794-8893
www.fieldbus.org

Foundation Fieldbus overview

- Supported by most process instrument companies
- Designed as the digital bus (LAN) replacement for the 4-20 mA standard
- Well promoted in North America as the “Process Bus”

Foundation Fieldbus



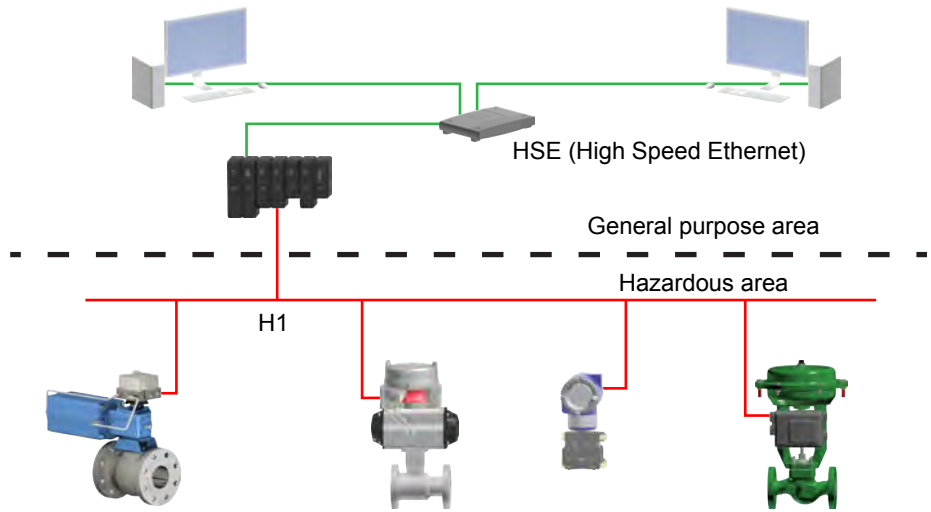
Features	Benefits
Available for both analog and discrete devices	Flexibility
Intrinsic safety wiring	Reduces costs in hazardous environments.
Field devices may control segment (LAS)	Frees up space in central controllers.
Time stamping of control parameters performed in field devices and coupled to control data	Optimizes operating performance
Standardized function blocks for control and I/O	Speeds setup
Span most process systems with long bus length	Bus 1900 m (6,175 ft); spurs up to 120 m (390 ft)

Foundation Fieldbus H1 level has been designed as a digital replacement of the 4 to 20 mA standard in the process industries.

Foundation Fieldbus is also a LAN (Local Area Network) for instruments used in both process and manufacturing automation with built-in capability to distribute the control application across the network.

The primary advantage of Foundation Fieldbus is its ability to have very long distance runs with higher level instrumentation devices. Where these long distances are required, significant savings may result in wiring costs. It also provides greater controllability and process information.

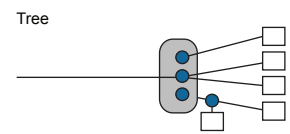
Foundation Fieldbus networks

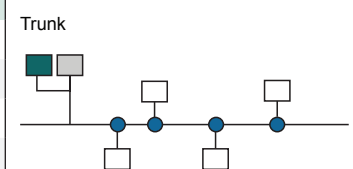


Foundation Fieldbus has two main levels. HSE for interconnecting control systems using an Ethernet physical layer and H1 for interconnecting field devices using a different physical layer. The network may consist of up to 16 instruments connected to a two-wire bus. This translates into significant savings over conventional point-to-point wiring due to less expensive wiring, reduced space, and greater flexibility. In control loops, Foundation Fieldbus offers greater controllability and transfers control to the field for better reliability.

Foundation Fieldbus H1 physical layer

- Transmission speed - 31.25 Kbits/sec
- Topology
  - Tree
  - Trunk



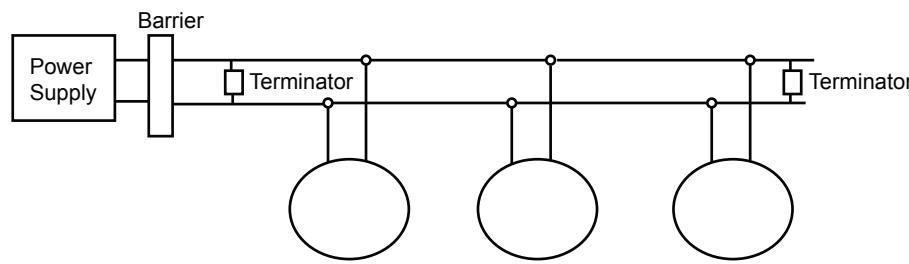


Foundation Fieldbus		
Physical layer		
Bus power/device	15 mA to 25 mA typical	
Bus voltage	Must operate from 9 to 32 VDC	
Cable length	1,900 meters (6,234 ft) total	
Drop (spur) length	# of devices	Max length
	15 to 16	60 m
	13 to 14	90 m
	2 to 12	120 m

Foundation Fieldbus has a number of rules that should be followed when constructing the physical layer. Those rules should be adhered to in order to maintain system performance.

Foundation Fieldbus physical layer

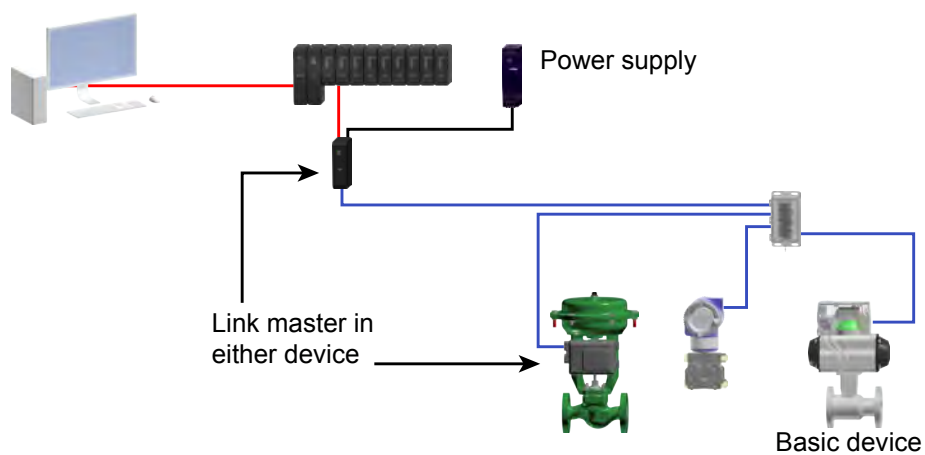
- May be used in intrinsically safe applications
- Number of devices distance, barrier, device dependent
- Standardized IEC 61158-2
- Terminators should be used on the trunk at the end of each segment (Used to prevent distortion and signal loss)



The physical wiring is also fully compatible with intrinsic safety (IS) or nonincendive wiring standards and may be used in hazardous, as well as general purpose areas. In hazardous areas standard explosionproofing or power limited concepts may be used, as well as IS concepts, offering greater cabling design flexibility.

Device types

- Link Master device (LM) - capable of becoming the Link Active Scheduler (LAS)
- Basic device - not capable of becoming the Link Active Scheduler (LAS)

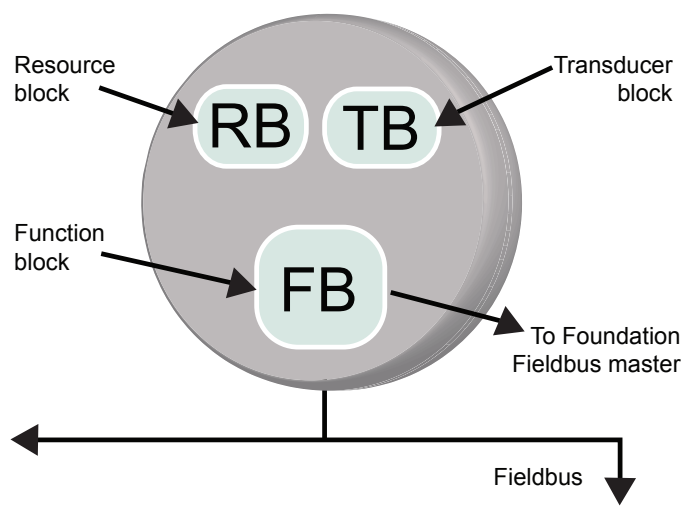


One of the devices on the Foundation Fielbus segment must be a Link Active Scheduler (LAS) or link master. This device manages the communication network. There may be multiple link masters on the same bus. If the active LAS fails, another link master may take over the LAS function, allowing the operation of the fieldbus to continue.

Link active scheduler

- Must have one per segment
- May have one device on segment designated as backup
- Issues compel data message (highest priority activity)
  - Sends message to device
  - Device receives compel data message
  - Device then “publishes” its data
  - Other devices configured to receive the data (called “subscribers")
- Maintains live list
  - Periodically sends probe node messages to addresses not on the live list
  - Broadcasts changes to all devices
- Issues pass token for unscheduled communication

Field device configuration



With Foundation Fieldbus, the user is able to interconnect the function blocks and schedule the running of the blocks to create control algorithms.

The control may reside in the field devices rather than in the centralized controller depending on the capability of the field device.

User layer

Resource blocks

RB

- Includes read-only information that helps define the device
  - Manufacturer name
  - Model number - materials of construction
  - Device options
- There may also be configurable parameters (device dependent)
  - Mode (e.g., automatic or out of service)
  - Security and access limiting features (e.g., write locks)
  - Alarm options

Transducer blocks

TB

- Interface to sensors used to measure variables
- Device calibration information
- Sensor data
- Configurable mode (automatic or out of service)
  - To perform calibration routines, most devices require that the block is out of service

Function blocks

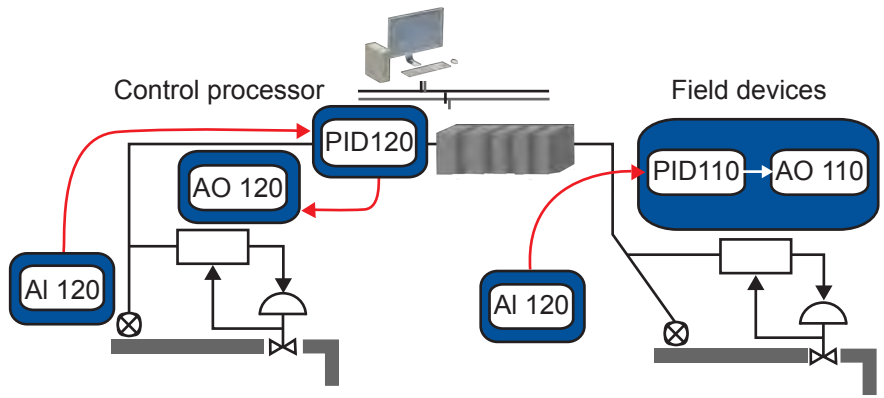
FB

21 function blocks specified for basic and advanced process control

Function block	
Examples	Symbol
Analog Input	AI
Analog Output	AO
Bias	B
Control Selector	CS
Discrete Input	DI
Discrete Output	DO
Manual Loader	DD
Proportional/Derivative	PD
Proportional/Integral/Derivative	PID
Ratio	RA

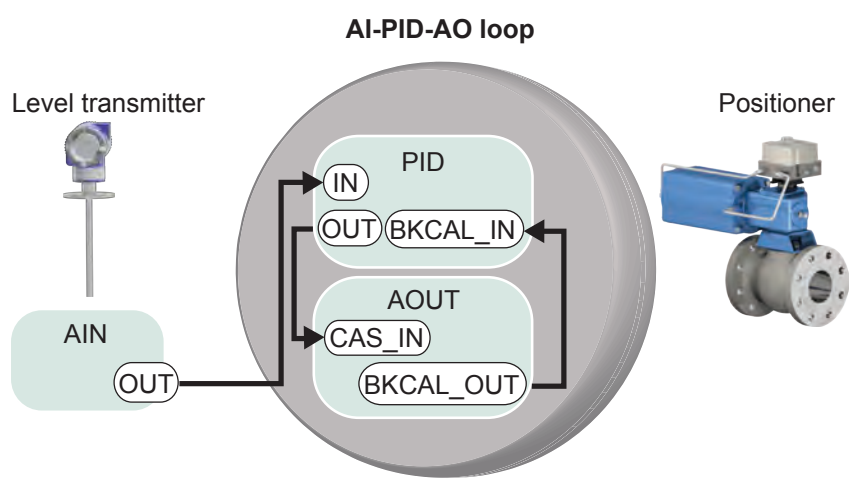
These blocks can be executed in host or field device.

Function block execution



Function blocks are supported in control processor or field devices; the choice is yours!

Consumer producer access (peer-to-peer)



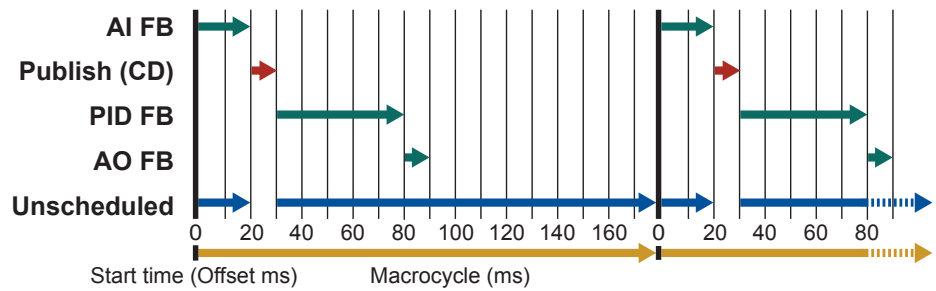
This examples shows the PID (Proportional Integral Derivative) block running in the field instrument. This decreases the amount of network traffic improving the cycle times of the network.

Function block scheduling

- Time required to execute each function block
- Network communication traffic
- Unscheduled time for Acyclic functions: alarms, maintenance and diagnostic information, trend information, configuration and downloads

Exec. time (ms)

20 Scheduled function block exection (AI)
10 Scheduled communication (CD)
50 Scheduled function block execution (PID)
10 Scheduled function block execution (AO)



This example shows the schedule timing for a simple PID control "loop" which includes (1) transmitter and (1) valve positioner. In this case the PID function block resides in the positioner. This allows the user to save time in the macrocycle by reducing the amount of scheduled network traffic. More devices added to this segment may cause the macrocycle time (loop time) to be increased.

Device description

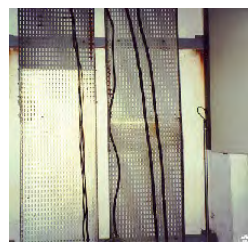
- Key element that enables interoperability
- Used to describe
  - Standard block parameter
  - Supplier unique parameters
- Allow any compliant host to interoperate these parameters
- Available from vendor or Fieldbus Foundation
- DDs for devices tested with host system typically included in release

The best place to get latest Foundation Fieldbus DD files is www.fieldbus.org. The Fieldbus Foundation maintains a repository of all DDs that have passed FF interoperability testing.

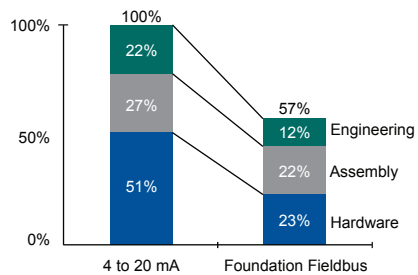
Wiring and installation savings

- Elimination of instruments with multivariable monitoring from single insertion
- Enabled instrument diagnostics
- Reduced building infrastructure
- More process flexibility
- Greater process optimization

Before



After



Reducing the amount of wires in the I/O and marshalling cabinets from 5 wires per device to 2 wires per network eases installation and documentation efforts and costs.

Additional savings come from the reduction of space in the I/O cabinets.

Fieldbus host systems (masters)

- Emerson DeltaV
- Honeywell
- Invensys
- Yokogawa
- Smar
- Allen Bradley
- Softing

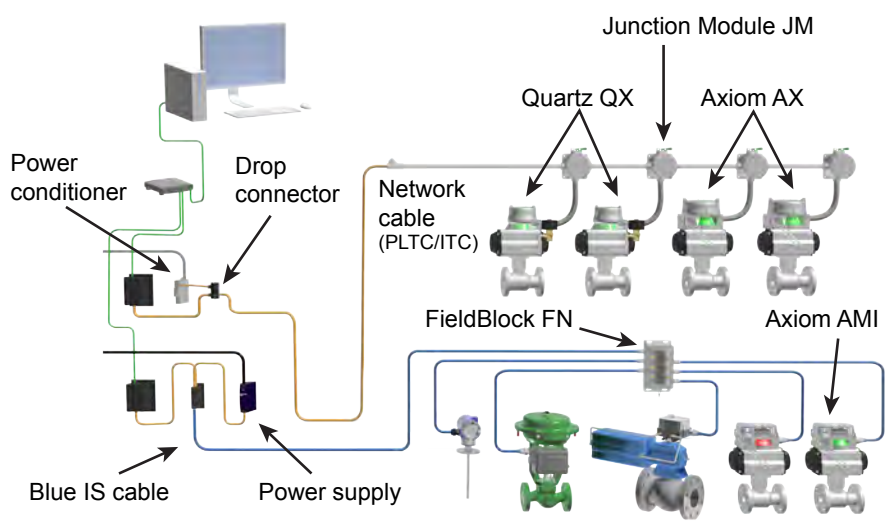
Foundation Fieldbus economic analysis

Installation cost comparison (calculated per field device)		
	Conventional	Foundation Fieldbus*
Computer I/O; master/gateway	$70	$160
Conduit, cable tray, wiring and fittings	$1,400	$290
Valve monitor/VCT and pneumatic valve	$315	$1,025
Switch protected drop connector	NA	$160
Installation and commissioning labor	$600	$250
Power supply	$50	$30
Total installed cost	$2,435	$1,915

Total installation savings
$520 per device

* Foundation Fieldbus is not directly comparable. Analog instruments may require less adder over conventional 4 to 20 mA instruments making this system cost effective when combining analog and discrete field instruments on the same segment. Functionality for Foundation Fieldbus devices is also significantly greater, offering increased diagnostic and operational capabilities.

Stonel brand Foundation Fieldbus products



When using our VCT module and integrating it into the Foundation Fieldbus (FF) network illustrated, there are significant savings. This system consists of 16 automated valve systems located in a cluster approximately 200 feet from the I/O rack. Each of the automated valves is located 20 feet apart in the cluster.

Stonel brand Foundation Fieldbus products

Power supply

- Meets IEC 61158-2 specifications
- 0.35 amps of power

Cable

- Designed for use in standard process applications
- PLTC, ITC
- 18 AWG shielded
- 100 m or 300 m lengths
- Also available in IS blue

Foundation Fieldbus REQUIRES the use of a special power supply/power conditioner to enable data to be carried on the power wires. These are typically 19 VDC – 24 VDC.

Foundation Fieldbus drop connectors			
	Passive	Protected	Switched protected
Double-drop, (1-2)	Available		
Multi-drop, DIN (1-4, 1-6)	Available		
Trip @ 40 mA, single-drop (1-1)		Available	
Multi-drop, DIN (1-4, 1-6)		Available	
Trip @ 40 mA, single-drop (1-1)			Available
Multi-switched drop, DIN (1-4, 1-6)			Available

Drop connectors are used to split the wires out to “drops” down to the field devices. There are 3 types available: passive, protected, and switched, in many different form factors.

Passive drop connectors can be used for branching circuits. There is no current limiting in the passive drop connectors.

Protected drop connectors have short circuit protection. These devices detect short circuits by monitoring current. If current is exceeded, it will take the drop off-line. Protected drop connectors are designed such that only one device can be located downstream from the protected drop.

Switched drop connectors typically have the same short circuit protection scheme, but also have an integral disconnect switch to remove power from the drop.

Foundation Fieldbus I/O module (bus powered outputs)

2 discrete inputs, DI (Stonel brand solid state sensors or special low power dry contacts) *

- Power available < 1 mA @ 6.5 VDC
- On current is .045 mA

2 discrete outputs, DO

- Power output is 2 mA @ 6.5 VDC

Total current consumption is 16 mA

* *Discrete inputs are not galvanically isolated from FF. Optocouplers may be needed if input device is not local.*

These modules allow users to connect conventional discrete I/O points to the Foundation Fieldbus network. These are often used to monitor and control knife gate valves, electric actuators and more.

Foundation Fieldbus I/O module (externally powered outputs)

2 discrete inputs, 2 DI (Stonel brand solid state sensors or special low power dry contacts) *

- Power available < 1 mA @ 6.5 VDC
- On current is .045 mA

2 discrete outputs, 2 DO

- 4 watts power combined or individual
- 24 VDC power

1 analog (4-20 mA) input ,1 AI

- 10-bit resolution (0.1%)

1 analog (4-20 mA) output ,1 AO

- 10-bit resolution (0.1%)

Total communication current consumption is 16 mA

* *Discrete inputs are not galvanically isolated from FF. Optocouplers may be needed if input device is not local.*

These modules allow users to connect conventional discrete and analog I/O devices to the Foundation Fieldbus network. These are often used to monitor and control knife gate valves, electric actuators, as well as 4-20 mA positioners and transmitters.

These Foundation Fieldbus I/O modules have a 4 to 20 mA input and a 4 to 20 mA output which are powered from the supplemental 24 VDC supply bus.

Savings may result from connecting the 4 to 20 mA device directly to the Stonel I/O instead of running wires back to I/O at the controller.

A 4 to 20 mA instrument may be conveniently wired directly into our I/O module. With a conventional system the control would need a 200 foot run back to the controller.

Foundation Fieldbus relay module (externally powered)

2 DI same as I/O module

1 AI and 1 AO same as I/O

2 relay outputs

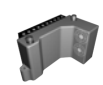
- Fused for 2 A @ 125/250 VAC
- Interlocking
- Independent

Total communication current consumption is 16 mA

These modules allow users to connect conventional discrete and analog I/O devices to the Foundation Fieldbus network. These are often used to monitor and control electric actuators, as well as 4-20 mA positioners and transmitters.

Valve Communication Terminals (VCTs)

Stonel Foundation Fieldbus	
VCTs	
Configuration	2 discrete inputs (solid state sensing) 2 discrete outputs with 4 watts maximum (externally powered "94")
	or
	2 discrete outputs for piezo valving (bus powered "93") Current consumption under 16 mA
Special features	Watchdog function (predetermined output communication fail state)



We have many different platforms of valve communication terminals for virtually every on/off valve application. While the devices look very different and are designed for different applications, the device profile is the same

Optimal applications

- When using process control loop applications utilizing analog functions
- When information from control elements is critical
- When control in the field is desired
- In IS applications
- Discrete applications using FF
  - Lower number of discrete inputs interspersed with analog control instruments
  - Extremely long runs of discrete inputs
  - IS applications

Foundation Fieldbus is commonly used for analog devices like transmitters and positioners. Although the cost/benefits are not as powerful, there are several applications where it is desirable to use this protocol for discrete monitoring and control.

Network layout and design

- Determine # of devices per segment
- Determine cable length and cable routing
- Determine drop connector method
- Select FF power supply or power conditioner
- Size network based upon current load and network traffic time

Device configuration

- Often done via FF host interface (master)
- National Instruments configuration with PCMCIA host
  - Good for bench testing and network configuration planning

Follow these simple rules for a trouble-free installation. Contact us for assistance with product selection and network design tips. Our network experts have many years of experience designing and assisting with the installation of networks in process plant environments.

Profibus Trade Organization
(PTO)
16101 N. 82nd Street
Suite 3B
Scottsdale, AZ 85260
USA
Tel: 480-483-2456
Fax: 480-483-7202
www.profibus.org

Profibus-DP and PA overview

- Introduced in 1989
- Leading open fieldbus system in Europe
- German Standard (DIN 19245), European Standard (EN 50170)
  - IEC Standard (one of eight bus networks)
- Supported by over 1,000 companies
  - (PTO; Profibus Trade Organization)
- Over 20,000,000 installed nodes

PROFIBUS

Profibus originated in the European market and has become a worldwide standard because of its performance attributes.

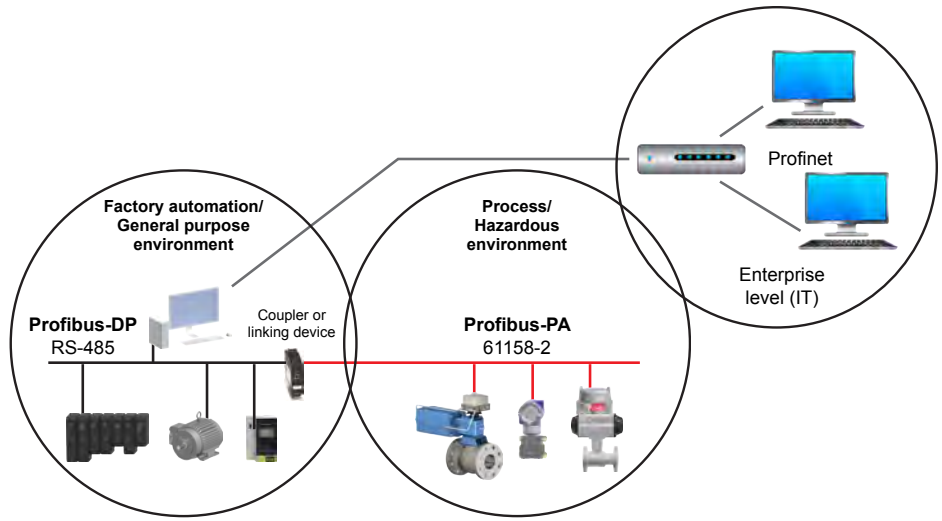
Profibus levels

- Profinet - ethernet with similar profibus user layer
- Profibus-DP (Distributed Peripherals) - communication between a master (PC or PLC) and slaves (remote I/O, field devices)
- Profibus-PA (Process Automation) - similar to DP with IEC 61158-2 physical layer

Profibus consists of several variations which are designed for use in special applications. The two Profibus versions most commonly used are Profibus-DP (Distributed Peripherals) and Profibus-PA (Process Automation).

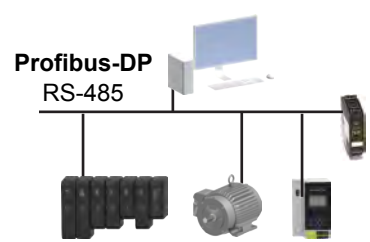
Profibus-PA was developed to connect directly into Profibus-DP and may be used in intrinsically safe applications. DP uses the RS485 physical layer while PA uses the IEC 61158-2 physical layer designed primarily for process applications.

Profibus networks



Profibus-DP features

- High speed data access capable of handling time critical functions. It takes about 1 millisec to handle 1024 I/O points over 32 devices at the 12 Mbit/sec rate.
- Networks up to 32 devices (up to 126 with repeaters) on a 4-wire network; (2-wires for signal and 2-wires for power).
- Trunk network may extend up to 4,000 feet (1220 meters) per segment.
- Interfaces readily into newer control systems.
- Used extensively throughout Europe with support in North America.

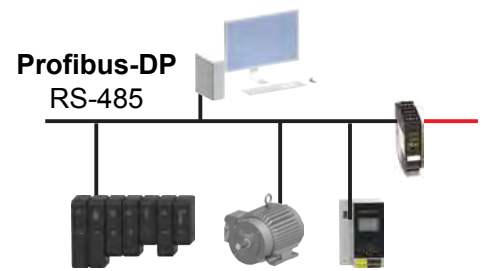


Dramatically cuts wiring costs and commissioning over conventional applications.

The high speeds are possible due to the efficient mapping of the data from the data link layer directly to the user layer by means of the SRD service of the data link layer.

Profibus-DP communication

- Communication occurs on a peer-to-peer basis for data communication or on a multi-cast basis for control commands.
- Cyclic polling may also be used for data communication between the master and its designated slaves.
- DP also offers acyclic communication services for the parameterization, operation, monitoring, and alarm-handling of intelligent field devices.



These acyclic services may be handled in parallel to data transfer with the master taking some additional time to carry out this function. Acyclic extended functions are optional.

Profibus-DP device configuration

- A GSD file (Electronic device data sheet) is used for configuration of a DP devices. This computer file describes the characteristics of a device type in a precisely defined format.
- An EDD (Electronic Data Description) file can also used to describe each device.

Vendors provide specific GSD files to users. The system simply reads the GSD file for each device and automatically configures the bus system using this information.

.edd files, also provided by vendors, are read by the engineering tools to simplify the Profibus systems configuration, commissioning, and maintenance.

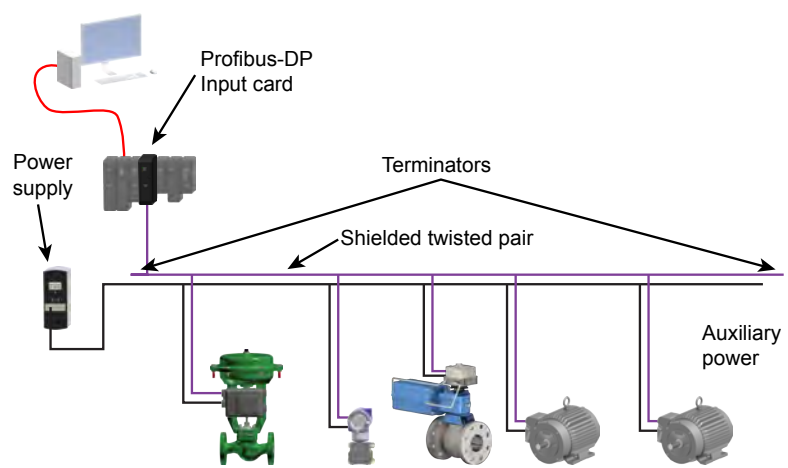
Profibus-DP physical layer

- Physical layer RS-485
- Trunk topology
- Up to 32 devices per segment
- Up to 126 devices with 4 repeaters
- May select From various speeds

Profibus-DP				
Physical layer				
Baud rate (kbits/s)	9.6-93.75	500	1,500	12,000
Cable length (meters)	1,200 m	400 m	200 m	100 m

Profibus-DP uses the RS485 physical layer with a unique data link layer and a direct data link mapper connecting the data link layer directly to application functions.

Profibus-DP physical layer



- Auxiliary power is required for field instruments
- Two pair of separately shielded cables may also be used to supply signal and power

Profibus-DP devices are often powered locally, where the Profibus-DP cable carries only the communication.

Terminators are needed with Profibus-DP. They require access to points with in the device so they are often located within the devices themselves or are part of the connector used to mate with the device.

Profibus-DP does not allow drops or spurs when used at the fastest speeds. So for factory automation applications zero drop length connectors are used. In most process application the speeds can be lower to allow drops for more convenient wiring and reduced cable budget.

Profibus-DP data link characteristics

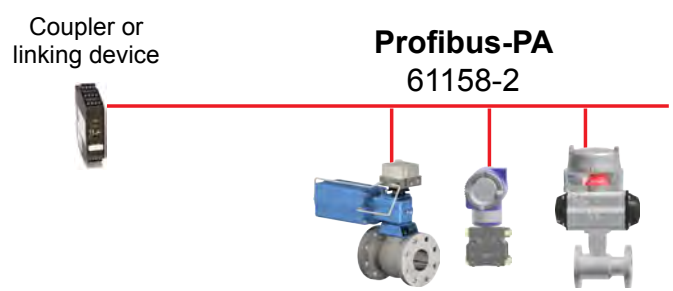
- Bus access methods
  - Masters on same segment
  - Token passing (multi-master system possible)
  - Master to slaves - - cyclic polling
  - Multicast for special control commands (synchronization)
  - Peer-to-peer for asset management and set-up
- Bus operating states
  - Operate: cyclic transmission of I/O data
  - Clear: inputs are read, outputs remain in secure state
  - Stop: diagnostics and parameterization (no I/O read)
- Slave may carry up to 246 bytes of I/O date with low bit overhead
- Other functions
  - Dynamic activation of individual slaves
  - Synchronization of I/O
  - Watchdog control of DP slave detects assigned master failure

Profibus uses a medium access control which includes token-passing for multi-master applications and the master slave interaction. Networks may be multi-master, multi-master with slaves, or single-master with slaves. In a multi-master network the token is passed to each master in a predetermined time frame. The master with the token is active and communicates with other masters or accesses its assigned slaves.

Communication occurs on a peer-to-peer basis for data communication or on a multi-cast basis for control commands. Cyclic polling may also be used for data communication between the master and its designated slaves. DP also offers acyclic communication services for the parameterization, operation, monitoring, and alarm-handling of intelligent field devices.

Profibus-PA

- Must be attached to Profibus-DP by a segment coupler or linking device
- Uses physical layer, IEC 61158-2 which may be used in intrinsically safe applications
- Uses function blocks

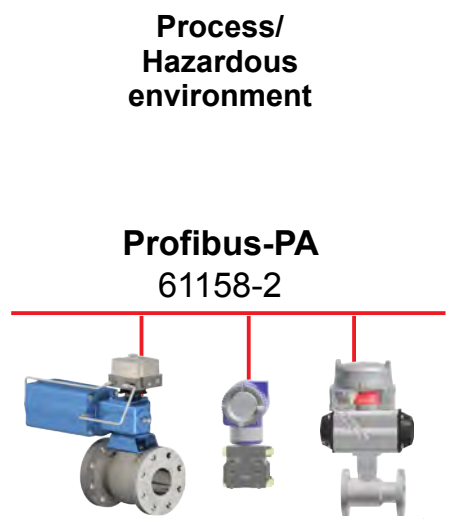


Profibus-PA was designed as a substitute for HART and 4 to 20 mA signal transmission in the process industries. It uses function blocks designed around process industry requirements and uses the IEC 61158-2 physical layer, making it compatible with intrinsic safety circuits.

Profibus-PA links to the control architecture via Profibus-DP with a segment coupler or link as shown. Segment couplers are signal converters that adapt the RS-485 signals to the 61158-2 signal level. They are transparent from the bus protocol point of view. If segment couplers are used, the baud rate on the DP (RS-485) segment must be restricted to 45 Kbits/sec. The segment coupler also injects power into the PA network for the segment instrumentation.

Profibus-PA physical layer

- Using segment coupler
  - PA segment transparent to DP segment
  - DP segment limited to 45 Kbit/sec (PA segment runs at 31.25 Kbit/sec)
- Using linking device
  - Slave on DP segment; master on PA segment
  - DP segment speed not limited
- All PA segment parameters established by IEC 61158-2 standards (same as FF H1)



Segment couplers are signal converters that adapt the RS-485 signals to the 61158-2 signal level. They are transparent from the bus protocol point of view. If segment couplers are used, the baud rate on the DP (RS-485) segment must be restricted to 45 Kbits/sec. The segment coupler also injects power into the PA network for the segment instrumentation.

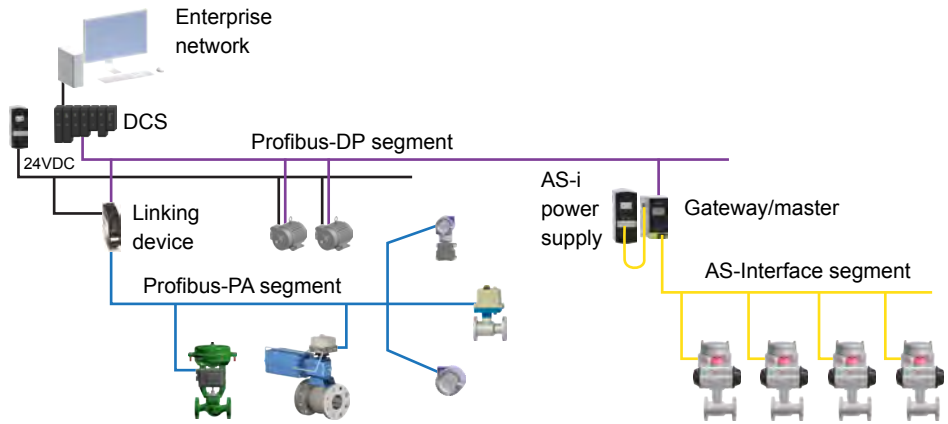
Profibus-PA other parameters

- All data access same as DP with segment coupler
- Link master uses cyclic polling for data transfer and acyclic polling for diagnostics (similar to DP)
- Limited function blocks are used similar to FF however
  - Block data not time stamped (system synchronization)
  - Functions executable only in master device not in the field

Links are independent slaves on the DP network which represent all devices connected to the 61158-2 segment. When PA segments are connected using links there is no limit to the baud rate on the DP segment which enables faster overall bus network performance.

The measured values and status of the PA devices are transmitted cyclically, with high priority between the DCS and the measuring transducers using the DP basic functions. This provides timely transfer of values into the control system. Asset management parameters are transmitted with low-priority, acyclic DP functions.

Profibus-DP with AS-Interface



- Seamless transmission of data from AS-i into control system.
- Up to 32 separate networks on DP backbone
- Optimized for specific applications

Profibus-DP is very commonly used as a companion bus with AS-Interface.

Profibus applications

- Profibus-DP is widely used in process as a communication bus for drives, motors, pneumatic valve islands, and to connect AS-i gateways to a DCS or PLC.
- Profibus-DP is widely used in factory automation, very strong in Europe.
- Profibus-PA is very strong in European process industries and is growing rapidly in North America.

Profibus-DP is recognized as a high performance bus network capable of transmitting thousands of I/O point information in less than a few milliseconds. For that reason it has been used extensively for fast response control applications such as turbine servos and variable speed drives.

The Modbus Organization
PO Box 628
Hopkinton, MA 01748-0628
USA
Tel: 508-435-7170
www.modbus.com

Modbus overview

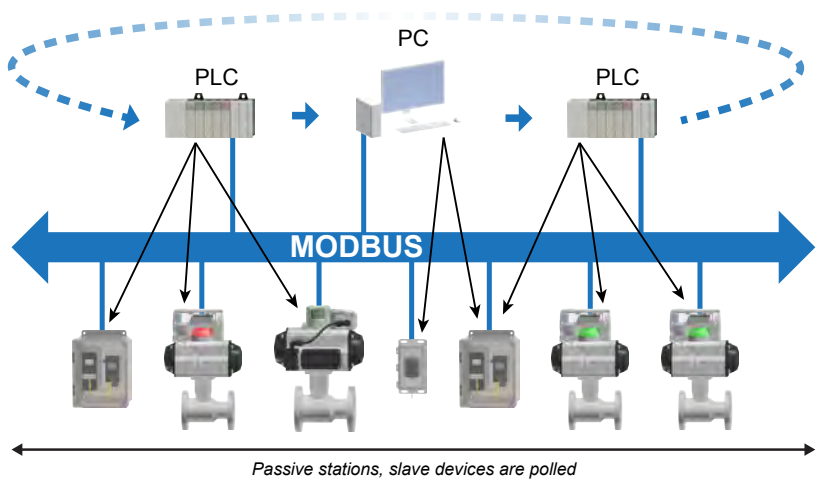
- Recognized as the de facto standard for connecting remote I/O to traditional DCS processors
- Originated from Schneider/Modicon
- Many PLCs capable of communicating via Modbus protocol
- Most process software contains modbus drivers for convenient interfacing to field devices

MODBUS

Modbus, developed by Schneider/Modicon, has been the defacto standard for interfacing remote I/O and PLCs into the process DCS system for the past 15 years. Because of this strong history, most legacy control systems interface conveniently with the Modbus standard.

Numerous actuator and instrument manufacturers support the protocol, therefore, it is used extensively as a "fieldbus" network as well. The following discussion focuses primarily on the protocol use for field networking purposes.

Modbus system function



Modbus features

Protocol has been proven in thousands of "mission critical" process applications over the last 20 years.

- Capable of supporting both simple discrete devices as well as sophisticated analog applications.
- May be supported without additional training since most plants are already using the protocol extensively.
- Popular among instrument manufacturers for a wide variety of applications.
- Uses master/slave polling.

Modbus uses serial communications

Signal line parameters	RS-232	RS-422	RS-485
Maximum number of drivers	1	1	32
Maximum number of receivers	1	10	32
Maximum cable length Max. Transmission speed (Modbus)	50 ft 115.2 Kb/s	4000 ft 115.2 Kb/s	4000 ft 115 Kb/s

Modbus features

- Interfaces conveniently into most existing plant control architectures.
- Networks up to 32 devices on a 4-wire network (2-wires for signal and 2-wires for power).
- Trunk network may extend up to 4,000 feet (1220 meters) per segment.
- Dramatically cut wiring costs and commissioning over conventional applications.

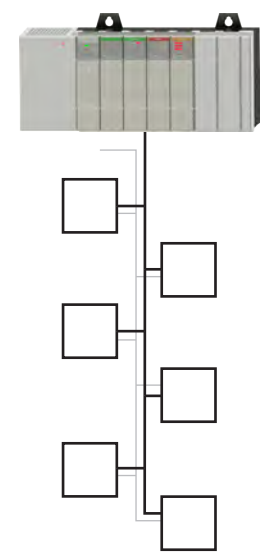
Data transmission speeds

- Standard values typically range from 1.2 Kbits/s to 57.6 Kbits/s
- Data transmission speed selection must be uniform in all devices connected to the same string

Modbus RS485 field cabling

- Use 18 or 20 gauge shielded twisted pair for signal
- Use 16 gauge or heavier for power (may be run in same conduit with shielded signal cable)
- RS232 converted to RS485 may not be multi-dropped
- Minimum total termination resistance of 60ʊ is required on signal cable

Modbus masters and slaves must have supplemental power!



Modbus devices are often powered locally, where the Modbus RS485 cable carries only the communication.

Terminators are needed with Modbus RS485. They are placed across the communication wires at each end of the trunk.

Message frame – data field

- Master to slave query: contains information for slave to take action upon
- Slave response contains data requested

Message frame (data field)					
Start	Address	Function	Data	CRC Check	End
T1-T4	8 bits	8 bits	n x 8 bits	16 bits	T1-T4

Master to slave query: contains information for slave to take action defined by function code (register addresses, quantity of items to be handled, count of data bytes in field)

Slave Response: contains data requested by the master query

Message frame – function codes

Message frame (function codes)		
FC	Description	Address range
01	Read output status	0001-9999
02	Read input status	10001-19999
03	Read multiple registers	40001-49999
04	Read input registers	30001-39999
05	Single bit/coil write	0001-9999
06	Single register write	40001-49999
15	Multiple bit/coil write	0001-9999
16	Multiple register write	40001-49999

Start	Address	Function	Data	CRC check	End
T1-T4	8 bits	8 bits	n x 8 bits	16 bits	T1-T4

These function codes define the type of transaction for the query.

Modbus drop connectors

- Direct mount passive drop connectors
  - Easy wiring
  - Direct mount type for JM or in customer's enclosure
- Multi-drop passive drop connectors
  - Easy wiring
  - Din Rail mount for FieldRack or in customer's enclosure
- Junction Module (JM)
  - Rated for hazardous locations
  - Houses tees or I/O modules
- FieldBlock (FN)

Drop connectors are used to split the wires out to "drops" down from the trunk to the field devices. There are 3 types available: passive, protected, and switched, in many different form factors.

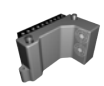
Passive drop connectors are used for branching circuits. There is no current limiting in the passive drop connectors.

Power protected drop connectors have short circuit protection in the V+ drop. These devices detect short circuits by monitoring current in the V+ line. If current is exceeded, it will take the drop offline. Only one device can be located downstream from the protected drop.

Switched drop connectors have the same short circuit protection scheme as mentioned above, but also have an integral disconnect switch to remove power from the drop.

Modbus components

- Valve Communication Terminal (VCT)
- 2DI/2DO/1AI
  - 2 integral proximity sensors (DI) with LED indication
  - 2 solenoid outputs (4 watts total power)
  - 1 Analog input (4-20 mA)
- Modbus watchdog



We have many different platforms of valve communication terminals for virtually every on/off valve application. While the devices look very different and are designed for different applications, the device profile is the same.

Modbus components

- I/O modules
- 2DI / 2DO / 1AI module with solenoid outputs (4 watts total)
- Available in JM or FieldBlock enclosures
- Available in JM with integral solenoid valve

These modules allow users to connect conventional discrete I/O points to the Modbus network. These are often used to monitor and control knife gate valves, electric actuators and more.

Modbus device configuration

- Set address
- Set baud rate
- Set device framing

Modbus commissioning kit

- Commission devices (set address, baud rate)
- Test modbus devices (read inputs, force outputs)
- A must for bench testing modbus VCTs

Use Stonel brand ModbusADR software.

This kit is a great tool for workshops that need to assemble and test Modbus automated valve packages.

Applications for Modbus protocol

- Gateway AS-Interface networks into most legacy systems where distance to PLC or CPU over 100 to 200 feet
- Use Modbus I/O or dual module where few devices scattered over long distances (hundreds of feet between units)
- Use Modbus I/O in an electric actuator network for retrieving other process variables (discrete and analog)
- When the customer wants it directly in the field device!

Modbus is suited for process applications where up to 31 devices may be connected over a 4,000 foot span into an existing control system. The RS485 version is used for multi-drop field applications with other versions, RS232 and RS422, relegated to point-to-point installations. Since many PLCs and DCSs are available with a Modbus scanner card, this is an easy way to network field Devices and is quite popular in the process industries.

Modbus RS485 field devices must be separately powered since the signal wire pair does not transmit sufficient power. Signal wires may be shielded twisted pair. An additional 16 gauge pair is recommended for power transmission and may be run in the same tray or conduit with the shielded twisted signal pair.

HART overview

HART protocol

- HART (Highway Addressable Remote Transducer)
- Developed by Rosemount in the mid 1980s for use with smart instrumentation
- Became an open protocol / HART User group was formed in 1990
- Bidirectional communication protocol that provides for data transfer between smart instrumentation and a host system
- Typically used over a 4-20 mA input or output
- Wireless

HART® COMMUNICATION PROTOCOL

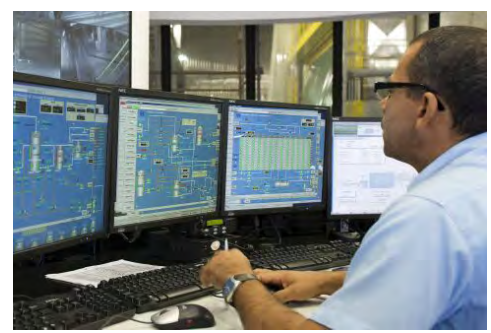
The HART (Highway Addressable Remote Transducer) protocol is a global standard communication protocol for sending and receiving digital information across analog wires between smart devices and DCS/PLC control or asset management system.

HART has undergone continuous development, up to, and including automation products with built-in WirelessHART communication.

HART technology offers a convenient and reliable solution for plant operators to receive the benefits of intelligent devices with digital communication. Many industrial instruments in operation today use traditional 4-20 mA analog wiring, HART technology allows the users to access additional information while maintaining the 4-20 mA analog signal.

HART applications

- Device configuration
- Device diagnostics
- Device troubleshooting
- Accessing additional data provided by smart instrument



HART technology is very easy to use and very reliable when used for commissioning and calibration of smart devices. It also provides an excellent solution for monitoring continuous online diagnostics.

Device testing, diagnostics and configuration has never been easier!

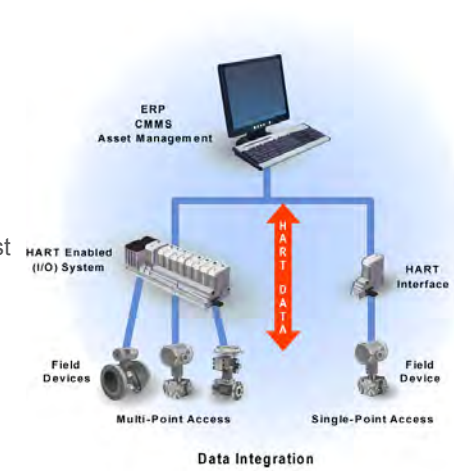
HART benefits

- Increase plant uptime
- Integrate devices and systems for detection of previously undetectable problems
- Detect device and/or process connection problems real time
- Minimize the impact of deviations by gaining new, early warnings
- Avoid the high cost of unscheduled shutdowns or process disruptions
- Capture performance trend data for predictive maintenance diagnostics

HART features

The standard features of HART technology include

- Compatibility with standard 4-20 mA analog wiring
- Simultaneous transmission of digital data
- Simplicity through intuitive menu-driven interfaces
- Ease of implementation for maximum “upfront” cost effectiveness
- Broad product availability, with compatible devices and software applications from most process automation providers



Source: HART Communication Foundation

How HART works

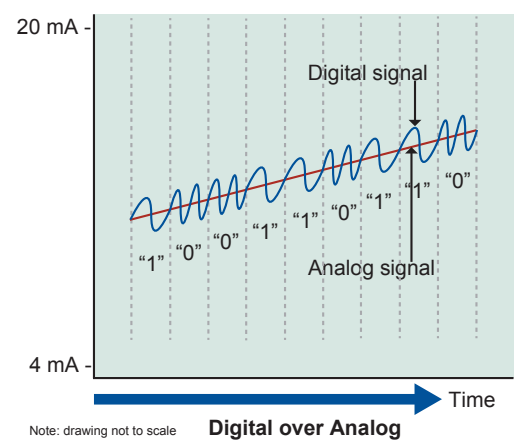
- Enables two-way field communication and makes it possible for additional information to be communicated via the 4-20 mA signal.
- Communicates at 1200 bps without interrupting 4-20 mA signal; allows host application (master) to get two or more digital updates per second from field device.
- Master/slave protocol; field device only speaks when spoken to by a master.
- Uses standard instrumentation wire with standard wiring and termination practices.

HART COMMUNICATION PROTOCOL

HART communication occurs between the two HART-enabled devices, typically a smart field device and a control or monitoring system.

How HART works

- Uses two simultaneous communication channels
  - 4-20 mA analog signal
  - Digital signal
- 4-20 mA signal communicates primary process value
- Additional device information communicated using HART digital signal superimposed on analog signal
- Makes use of Bell 202 Frequency Shift Keying (FSK) standard to superimpose digital communication signals on top of the 4-20 mA analog (AI or AO) signal



Note: drawing not to scale

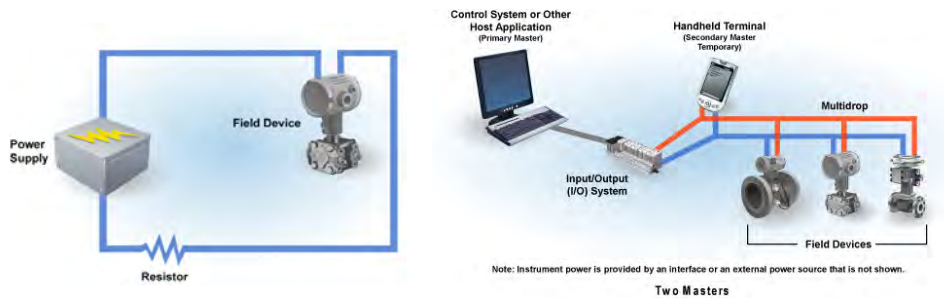
Digital over Analog

HART emerged in the late 1980s and was based on the same technology that brought the caller ID feature to analog telephony.

Together, the two communication channels provide a low-cost and very robust complete field communication solution that is very easy to use and configure.

How HART works

- The HART protocol can be used in various modes, point-to-point or multi-drop configurations.

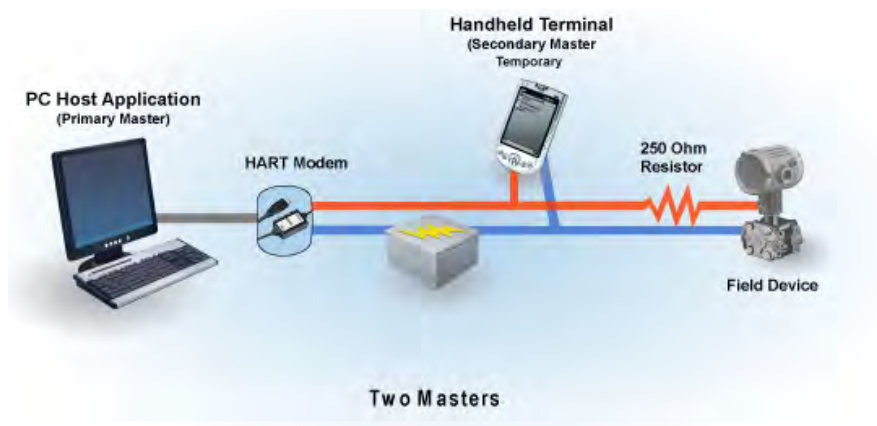


Source: HART Communication Foundation

Communicating information to/from smart field instruments and DCS/PLC or asset management systems.

How HART works

- HART has provision for up to two masters (primary and secondary)



Source: HART Communication Foundation

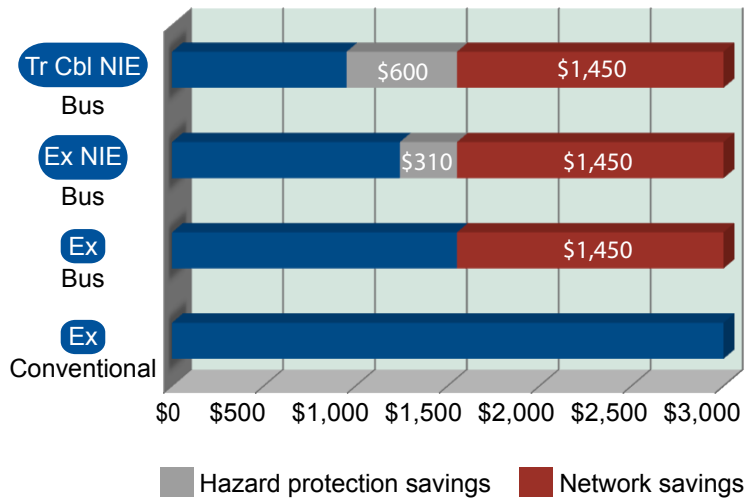
This allows secondary masters, like handheld communicators, to be used without interference to communications to/from the primary master.

Notes

Hazardous area networking

Overview

Save by using hazardous optimized bus networks



Significant savings may be realized by converting conventional valve monitoring and control systems to a valve communication solution. This is possible through the use of bus networking combined with optimized protection concepts. The following will review how to optimize your protection concepts in conjunction with your bus network given the hazardous ratings of your plant environment.

Protection concepts and network protocols

Protection concepts and network protocols		
Area classification	Protection concepts	Network protocol
Class I & II Division 1 Gas Zone 1	Explosionproofing	Most networks
	Intrinsic safety (Zone 0, 1)	Foundation Fieldbus
		Profibus-PA
Class I & II Division 2 Gas Zone 2	All Division 1 concepts	Division 1 networks
	Nonincendive equipment	Most networks
	Tray cable systems	Most networks
	Nonincendive field wiring	Foundation Fieldbus
		Profibus-PA
		AS-Interface

The protection concept should be selected in combination with the desired bus network given the hazardous area rating of the process.

Optimize protection concepts to reduce costs and increase safety

Protection concepts

Options

- Ex
- Ex + NIE
- Tr Cbl + NIE
- IS

- Area classification compatibility
- Overall reliability
- Cost effectiveness
- Maintainability
- Flexibility
- Personnel safety
- Ease of understanding
- Instrument availability
- Protocol compatibility

Different protection concepts may be used in the plant's hazardous areas depending on a number of parameters. Each of those parameters should be considered and many of them are not necessarily directly quantifiable, however they should all be considered to optimize overall performance.

Ex

Area classifications (NEC)
Class I groups A, B, C, D
Divisions 1 & 2

Class II groups E, F, G
Divisions 1 & 2

Area classifications (IEC)
Ex d IIC, IIB, IIA Zones 1 & 2

Explosionproof/flameproof

Basic concept

- Contain ignition inside conduit and enclosures
- Cool gases to prevent ignition outside of containment vessels

Advantages

- Well understood in North America
- Unlimited power for instrumentation/bus circuits

Disadvantages

- Deterioration in conduit and/or housing can degrade protection
- Enclosures may not be opened with circuits energized
- Bulky conduit and enclosures are expensive, space consuming and inflexible

This concept is used extensively throughout the world and relies on robust wiring and conduit systems to contain any possible explosions. It is recommended when it is not desirable to limit power and the area has extensive Zone 1/Div 1 areas.

NEC references
Field enclosures: articles 501.2, 501.3, 501.5, 501.6, and 501.7

Field wiring: articles 501.4, 501.5, 501.11, and 501.14

Connections: articles 501.4, 501.5, 501.12, and 501.13

Field instrument components: articles 501.3, 501.6, 501.7, and 501.10

IEC references
Field enclosures: IEC 60079-1

Field wiring: IEC 60079-14

Explosionproof networking

Field enclosures

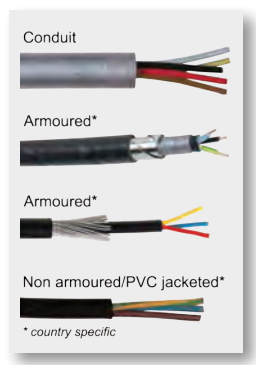
- Must comply with relevant explosionproof standards for area classifications

Field wiring and connections

- Varies significantly depending on code standards (IEC or NEC)
- Rigid metal conduit with approved fittings with NEC; suitable cable with PVC jacket and cable glands at enclosures may be used per IEC
- Metal clad cable with suitable termination fittings for flexibility (NEC)
- Special flexibility provisions not required for IEC
- Quick connectors are not allowed

Field instrument components

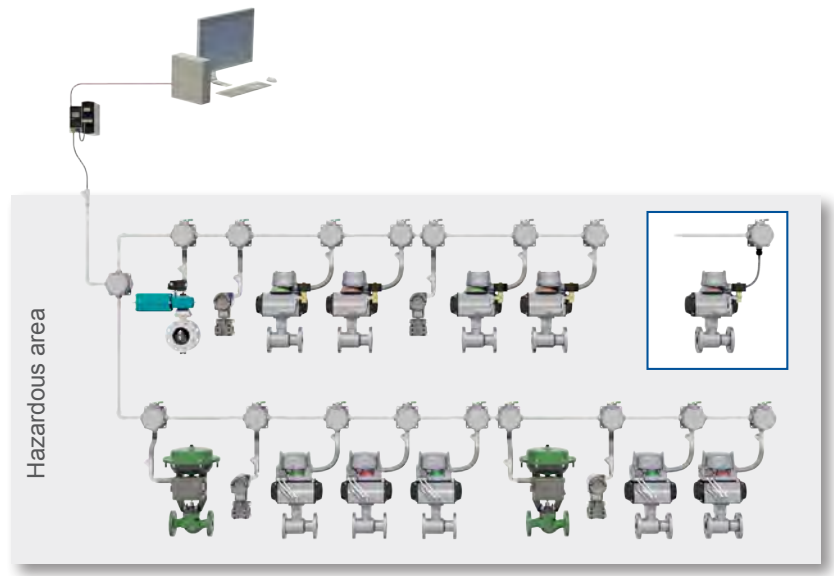
- Must be located inside explosionproof enclosures and identified as a complete assembly
- Enclosures may not be opened with circuits energized



Field devices must be approved for the particular area and wired in using approved fittings, seal fitting and conduit systems. IEC typically relies on a cable gland sealing the entrance of the instrument enclosure with a flexible cable enabling greater wiring flexibility than conduit systems used in North America.

Ex

Network (Division 1 and 2)



When using an explosionproof system all instrument enclosures must be fully rated and be fitted with proper seals/cable glands. Most North American applications require hard conduit with approved fittings while IEC based systems have greater flexibility with cabling. Since enclosures cannot be opened or maintained it is recommended that each instrument have a switched protected drop connector with appropriate sealing to enable flexibility in maintaining the system.

Network economic analysis

Installation cost comparison (calculated per field device)

	Conventional	AS-Interface	Foundation Fieldbus*
Computer I/O; master/gateway	$70	$50	$160
Conduit, cable tray, wiring and fittings	$1,600	$350	$380
Valve monitor/VCT and pneumatic valve	$520	$620	$1,100
Switched protected drop connector	NA	$170	$170
Installation and commissioning labor	$800	$350	$350
Power supply	$50	$30	$60
Total installed cost	$3,040	$1,570	$2,220

* Foundation Fieldbus is not directly comparable. Analog instruments may require less adder over conventional 4 to 20 mA instruments making this system cost effective when combining analog and discrete field instruments on the same segment. Functionality for Foundation Fieldbus devices is also significantly greater, offering increased diagnostic and operational capabilities.

Savings are dramatic when using a network vs conventional point to point wiring. In this instance costs are reduced nearly by 50% using AS-Interface.

Ex

Stonel brand components

- Axiom AX series
- Quartz series with aluminum covers
- JM (Junction module) series with aluminum covers

Axiom AX

Quartz

JM

We have an extensive array of explosionproof approved product for both conventional and networking applications. The Axiom AX and Quartz QX are suitable for most gas groups in Zone 1/Div 1 areas for monitoring/communication and control. The JM series has become an important addition to networks in hazardous areas with its switched drop connection, I/O module and repeater/power conditioner options enabling convenient maintenance and retrofitting with existing field applications.

Ex + NIE

Area classifications (NEC)
Class I Groups A, B, C, D
Division 2

Class II Groups E, F, G
Division 2

Area classifications (IEC)
Ex nA IIC, IIB, IIA Zone 2

Explosionproof with nonincendive equipment

Basic concept

- Used as part of an explosionproof system in Div 2/Zone 2 areas.
- All instruments rated as Nonincendive equipment
- Nonincendive components must not create arcs or sparks (solid state) or arcs are contained within an hermetically sealed chamber
- Components surface temperatures must not exceed max temperature ratings for area

Advantages

- Lower cost enclosures and may be non-metallic
- Less space consumed for wiring and no seal offs required
- Enclosures may be opened with circuits energized
- Substantial electric power for instrumentation

Disadvantages

- Circuits have electric shock hazard (may not be manipulated while energized)
- Division 2/Zone 2 areas only

Nonincendive devices may be installed as part of an explosionproof system in Zone 2/ Division 2 areas. In these areas wiring system requirements may be relaxed with greater flexibility and lower costs. Since combustibles are only present under abnormal conditions and devices do not cause ignition under maximum normal operating conditions fewer precautions are needed to assure safe operation.

NEC references
Field Enclosures: Articles 501.2, 501.3, 501.5, 501.6, and 501.7

Field Wiring: Articles 501.4, 501.5, 501.11, and 501.14

Connections: Articles 501.3 (B)(6), 501.4, 501.12, and 501.13

Field Instrument Components: Articles 501.3, 501.6, 501.7, and 501.10

IEC references
Electrical Apparatus: 60079-15

Electrical Installations: 60079-14

Field enclosures

- Rated at least NEMA 4 or 4X
- Electrical components have no arcs or sparks (solid state) or arcs contained within an hermetically sealed chamber
- Non-metallic enclosures must withstand high impact tests after the effects of aging
- Surface temperatures of components must not exceed 80% of the thermal ignition temperature of the exposed volatiles

Field wiring and connections

- Div 1/Zone 1 wiring may be used
- Liquidtight may be used in NEC where flexibility required
- Seal fittings not required with nonincendive devices
- Quick connectors are allowed

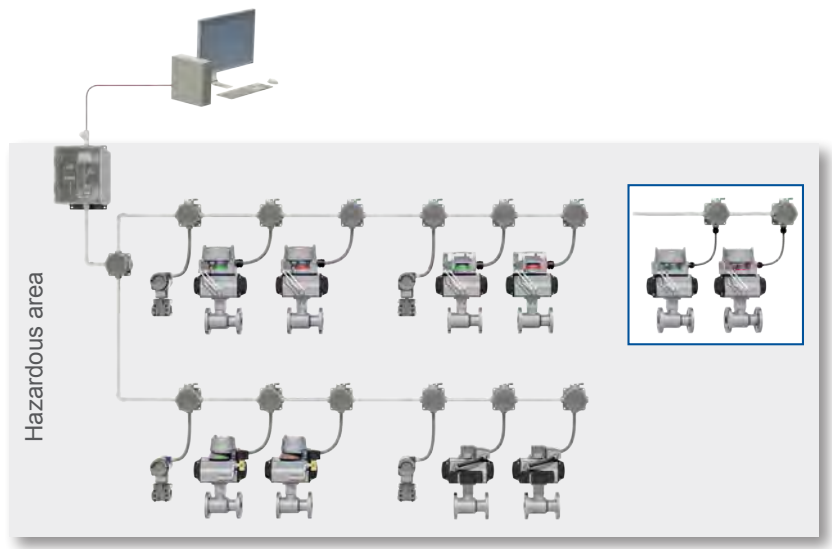
Quick connector requirements

- Power removed from the circuit before plugging and unplugging (warning label must be present)
- Current not exceed 3 amps @ 120 VAC
- Cord listed for hard usage with receptacle and plug (locking and grounding type)

Greater flexibility and robust enclosure requirements along with freedom to use quick connectors make this concept desirable in Zone 2/Div 2. When using quick connectors it is important to follow special guidelines noted.

Ex + NIE

Network (Zone 2)



Hard conduit systems may be used with less rigorous wiring practices and physical protection requirements than explosionproof systems thus dramatically reducing installation costs and increasing flexibility. As with explosionproof applications switched drop connectors are recommended to enable field instruments to be disconnected or reconnected into the network. Unlike explosionproof applications, nonincendive enclosures may be opened while circuits are energized but wiring may not be manipulated.

Network (Div 2, Zone 2 only)

Installation cost comparison (calculated per field device)

	Conventional	AS-Interface	Foundation Fieldbus*
Computer I/O; master/gateway	$70	$50	$160
Conduit, cable tray, wiring and fittings	$1,400	$290	$290
Valve monitor/VCT with pneumatic valve	$510	$590	$1,120
Switched protected drop connector	NA	$160	$160
Installation and commissioning labor	$600	$250	$250
Power supply	$50	$30	$30
Total installed cost	$2,630	$1,370	$2,010

* Foundation Fieldbus is not directly comparable. Analog instruments may require less adder over conventional 4 to 20 mA instruments making this system cost effective when combining analog and discrete field instruments on the same segment. Functionality for Foundation Fieldbus devices is also significantly greater, offering increased diagnostic and operational capabilities.

Any contemporary bus network may be used with this protection concept. With the AS-i protocol dramatic savings are realized over conventional installations and greater communication bandwidth permits the use of diagnostics.

Ex + NIE

Stonel brand valve communication and control (VC&C) components

- Quartz, Eclipse EN, Axiom AMI VCTs
- Hawkeye with I/O

Most of our valve communication and control and process networking products are approved as nonincendive. Since most switching systems and communication modules are solid state or hermetically sealed these components qualify as being nonincendive and are inherently safer than standard mechanical components with open arcing contacts even when used in explosionproof applications.

Stonel FieldLink process networking components

- FieldBlock (FN)
- JM (Junction module)
- Power supplies

Tr Cbl + NIE

Area classifications (NEC)
Class I Groups A, B, C, D
Division 2

Class II Groups E, F, G
Division 2

Area classifications (IEC)
Ex nA, IIC, IIB, IIA Zone 2

Tray cabling with nonincendive equipment

Basic concept

- Limited power to circuit of less than 100 watts to minimize ignition and shock hazard (PLTC) or current limited from 3 to 5 amps with maximum of 150 VAC (ITC)
- Utilize special cabling (PLTC or ITC) in cable trays or with general support structures

Advantages

- Significant power for bus networks
- Low cost wiring and instrumentation enclosures
- Limited shock and ignition hazard (Class 2 circuits)
- Suitable for all bus networking protocols
- Easy to understand and apply

Disadvantages

- Little knowledge of PLTC or ITC wiring concepts
- Suitable for Division 2 only

Tray cabling is now accepted in North America similar to IEC based countries. PLTC was an earlier concept requiring a Class 2 power supply but now with the adoption of ITC a special power supply is no longer required as long as it meets the parameters of ITC.

NEC references
Field Enclosures: Article 501.3 (B)(4)

Field Wiring: PLTC - Article 725 (26 to 71)

ITC - Article 727

Connections: Articles 501.3 (B)(6), 501.4, 501.12, and 501.13

Field Instrument Components: Articles 501.3, 501.6, 501.7, and 501.10

IEC references
Electrical Apparatus: 60079-15

Electrical Installations: 60079-14

Field enclosures (same as NIE)

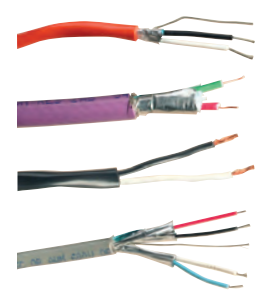
Field wiring

- ITC (Instrument Tray Cable) power limited to 150 volts and 5 amps
- PLTC (Power Limited Tray Cable) max of 100 W and 60 V (uses Class 2 power supply)
- For use with cable tray systems
- Must have 2 inch separation or mechanical barrier from higher power circuits
- May be used as open wiring mechanically protected by angles, struts or other mechanical means or supported by messenger wire
- May be used as open wiring where cable complies with metal clad or follows Div 2 Ex wiring rules (liquidtight etc.)

Connections

- Approved Ex fittings
- Quick connectors with special provisions
- Compression fittings installed to avoid stress at the cable terminations

Field instrument components (same as NIE)



Generally ITC or PLTC cabling must be supported in some manner so that excessive stress is not put on the cabling.

Tr Cbl + NIE

Network economic analysis

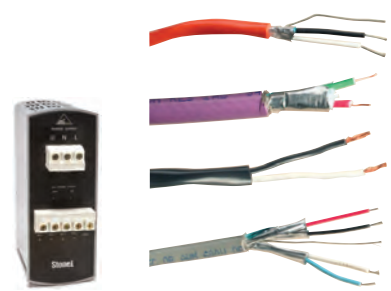
Installation cost comparison (calculated per field device)			
	Conventional	AS-Interface	Foundation Fieldbus*
Computer I/O; master/gateway	$70	$50	$160
Conduit, cable tray, wiring and fittings	$750	$160	$160
Valve monitor/VCT with pneumatic valve	$510	$590	$1,120
Switched protected drop connector	NA	$100	$100
Installation and commissioning labor	$500	$150	$150
Power supply	$50	$30	$30
Total installed cost	$1,880	$1,080	$1,720

* Foundation Fieldbus is not directly comparable. Analog instruments may require less adder over conventional 4 to 20 mA instruments making this system cost effective when combining analog and discrete field instruments on the same segment. Functionality for Foundation Fieldbus devices is also significantly greater, offering increased diagnostic and operational capabilities.

When constructing a network it is ideal to use the tray cabling concept for the main bus trunk and to use nonincendive equipment and wiring practices for each of the drops. This also allows for a smooth transition to more protective wiring near the field device.

Stonel brand components

- FieldRack
- Power supplies (Class 2 approved)
- JM
- FieldBlock
- Quartz, Axiom, Prism, Eclipse EN
- Hawkeye with I/O VCTs
- Wire (ITC and PLTC rated)



Tray cabling qualified for PLTC and ITC is readily available from us and a number of other suppliers. Along with special power supplies from us this new practice is easily applied and readily available for process applications.

IS

Area classifications (NEC)
Class I Groups A, B, C, D
Division 1 & 2

Class II Groups E, F, G
Division 1 & 2

Area classifications (IEC)
Ex ia IIC, IIB, IIA Zones 0, 1 & 2

Compatible protocols
Foundation Fieldbus and Profibus-PA

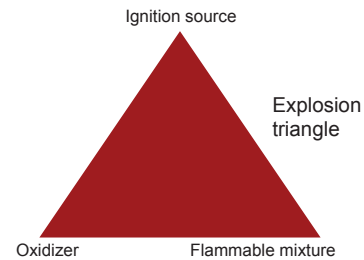
Intrinsically safe circuits

Basic concept

- Prevents ignition of gases
- No ignition under normal or abnormal conditions
- Limit electrical energy input and energy storage
- Provide over voltage and short circuit protection

Advantages

- Low cost wiring and instrumentation enclosures
- No shock hazard
- Instruments may be serviced while hot



Disadvantages

- Limited power delivery holding maximum number of devices per string to 4 or 5
- Use of barriers drops available voltage to instruments
- Communication protocols limited to those with physical layer 61158-2 (Foundation Fieldbus H1 and Profibus-PA)

Intrinsic safety is required for electric wiring and instrument applications in Zone 0/Div 1 continuous exposure applications and other applications where hazard protection is ultra critical. IS circuits eliminate the source of ignition, rather than contain it as done in explosionproof protection concepts.

NEC references
Field enclosures: Articles 504.10, 504.30 (A)(3), and 517.64

Field wiring: Articles 504.2, 504.30, 504.50, 504.7, and 504.80

Connections: Article 504.80

Field instrument components: Articles 504.2, 504.4, and 504.10

IEC references
Electrical apparatus: 60079-11, 60079-27 (FISCO and FNICO)

Electrical installations: 60079-14, 60079-25, 61158-2

Network (Divisions 1 & 2; Zones 0, 1 & 2)

Field enclosures

- NEC - NEMA 4 or 4X; IEC - IP 54 minimum
- General purpose
- Other more robust enclosures may be used

Field wiring

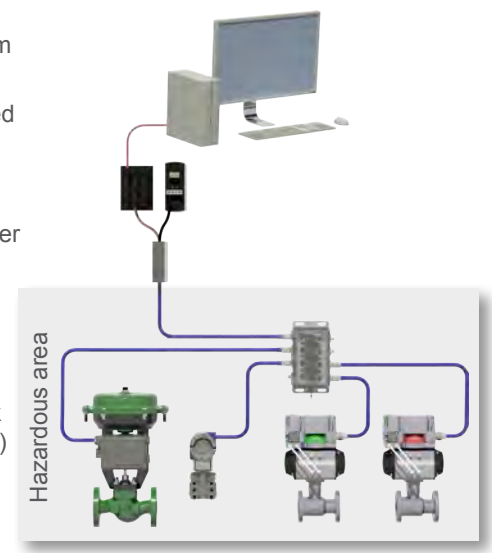
- General purpose cabling
- IS barriers to limit voltage and current under fault conditions
- Cable capacitance may need to be evaluated

Connections

- General purpose connections apply (quick connectors may be used without limitation)

Field instrument components

- Must be IS approved or simple



Generally there are few restrictions on enclosures and wiring provided electrical apparatus are protected from the environment. However, strict guidelines must be followed with energy storage and current and voltage parameters in the components and the circuits under both normal and abnormal (fault) conditions.

IS

Devices

Simple devices do not require approvals

- Must not generate nor store more than 1.2 V, 0.1 A, .25 mW (Examples: RTDs, TCs, LEDs, Diodes)

IS apparatus

- Require approvals
- Given “entity parameters” (Examples: transmitters, positioners, solenoid valves)

Although many apparatus (simple switches) may be used without special considerations in an IS system, care must be taken to make sure apparatus will work properly at the very low energy levels prevalent in IS circuits.

Matching entity parameters

Matching entity parameters		
Intrinsically safe apparatus		Associated apparatus
Lowest Vmax in segment	>	Voc (open circuit voltage)
Lowest Imax in segment	>	Isc (short circuit current)
Lowest Pmax in segment	>	Pt (power transfer)
Total of Cdevices + Ccable	<	Ca (allowed capacitance)
Total of Ldevices	<	La (allowed inductance)
Additional consideration		
Max normal operating current total	<	Nominal barrier current levels

IS barrier parameters (associated apparatus) must match device requirements in the field circuit (intrinsically safe apparatus) when using the entity concept as shown in the table. Barriers are typically limited to 60 mA and 1.2 w for hydrogen environments.

In order to determine if the system will function properly after entity parameter matching has been performed, the barrier’s nominal current levels should be greater than the maximum normal operating current levels. Also, the voltage drop across the barrier should allow enough voltage to the segment components to be above operating parameters at peak current levels.

IS

Bus network

Utilize entity concept

- Entity parameters of barrier and field devices must match
- Cable inductance and capacitance considered concentrated and must be considered
- Barriers typically limited to 60 mA and 1.2W for hydrogen; restricting number of field devices

Utilize FISCO model (Fieldbus Intrinsically Safe Concept)

- Device entity parameters for inductance and capacitance eliminated
- Cable inductance and capacitance not considered concentrated so not added to calculations
- Barriers typically limited to 100 mA and 1.8W; hydrogen enabling use of more field devices

Conventional point-to-point wiring

use Entity concept

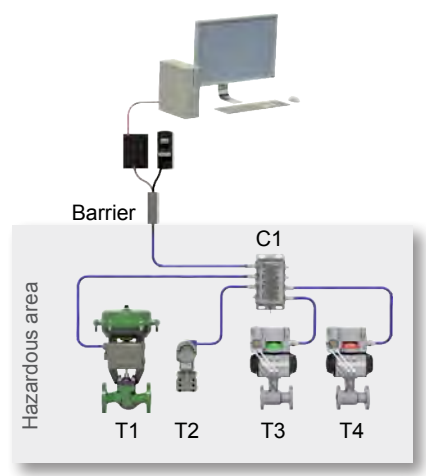
Bus network wiring

use Fieldbus Intrinsically Safe concept (FISCO)

After extensive testing by PTB in Germany it was determined that the IEC 61158-2 physical layer bus networks allowed greater flexibility while meeting ignition restriction limits for fieldbus implementations. As a result the FISCO IS model was developed. The FISCO model has been accepted universally and is now used as the de facto IS standard for Foundation Fieldbus and Profibus-PA networks, both of which use this physical layer.

FISCO application example

Tag	Vmax V	Imax mA	Pmax W	Inom mA
T1	24	250	2	24
T2	28	220	2	24
T3 (VCT)	26	250	2.4	16
(Piezo)	26	230	2.1	-
T4 (VCT)	28	220	2.2	16
(Piezo)	26	220	2.1	-
C1	24	220	2	0
	Voc V	Isc mA	Po W	Inom mA
Required	24	220	2	80
Barrier selected	13	208	1.9	100



When using the FISCO model, device entity parameters for inductance and capacitance are considered negligible (Must be less than .01 mH and .005 µF respectively). Cable inductance and capacitance are not considered concentrated so are not added to the calculations (R loop must be from 15 Ω to 150 Ω/km; L must be 0.4 to 1 mH/km and C must be 0.045 to 0.2 µF/km). Maximum cable lengths are limited to 60 m for drops and 1km for trunk in IIC (groups A & B) and 5km trunk in IIB (groups C & D).

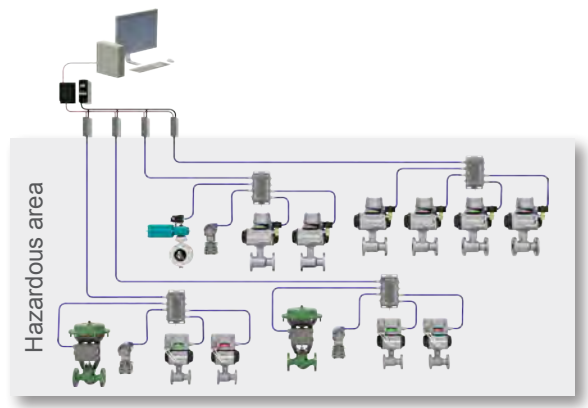
Field devices with IS approvals per FISCO must be used. (FISCO approved devices may be used in systems using the entity concept but not vice versa.)

As illustrated IS FISCO barriers are typically limited to 100 mA and 1.8 w for hydrogen environments providing more flexibility for instruments using this concept.

IS

Multiple barrier/repeater on same H1 segment

- Single host and LAS controls several spurs
- Single power supply
- Barrier/repeaters enhance signal and provide IS protection
- Field devices matched to individual barrier/repeaters



In this example multiple barriers are used providing the nominal current and power requirements while only requiring one host (one segment). As a result total segment costs may be reduced significantly.

Bus network protocols

- Use 61158-2 physical layer (FF H1 or Profibus-PA)
- May use FISCO devices with entity concept but not entity approved devices with FISCO

Fieldbus Foundation

PROFIBUS

Only two bus protocols are able to be used with the IS protection concept.

IS

Network economic analysis

Installation cost comparison (calculated per field device)

	Conventional	Foundation Fieldbus
Computer I/O; master/gateway	$70	$50
Barriers	$100	$190
Conduit, cable tray, wiring and fittings	$600	$220
Valve monitor/VCT and pneumatic valve	$560	$1,060
Protected drop connector	$0	$70
Installation and commissioning labor	$350	$150
Power supply	$10	$30
Total installed cost	$1,690	$1,770

When comparing conventional IS applications to applications using Foundation Fieldbus(FF) IS installations, initial costs are comparable. This comparison is valid for discrete communication and control only. Analog instruments may require less adder over conventional 4 to 20 mA instruments making this system cost effective when combining analog and discrete field instruments on the same segment. Functionality for Foundation Fieldbus devices is also significantly greater, offering increased diagnostic and operational capabilities

Stonel brand components

- Passive drop connectors
- Foundation Fieldbus valve communication terminals (VCTs)
- Foundation Fieldbus I/O modules approvals

We offer a full array of IS devices for both conventional and networking applications. Many robust explosionproof platforms may have IS components if users require this durability in their process environments while using IS systems.

Area classifications (NEC)
Class I Groups A, B, C, D
Division 1

Class II Groups E, F, G
Division 2

Area classifications (IEC)
Ex nL IIC, IIB, IIA Zones 0, 1 & 2

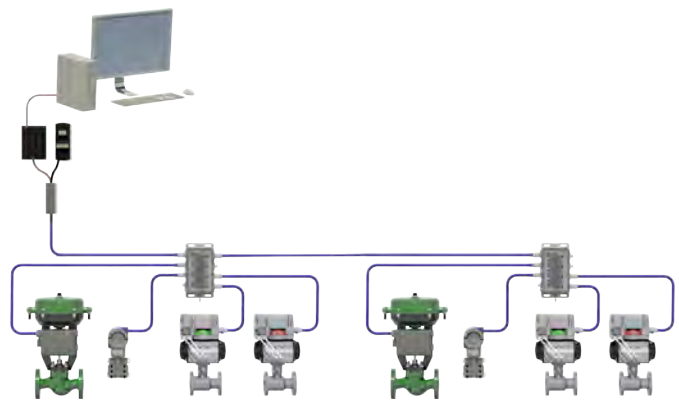
Compatible Protocols
Foundation Fieldbus H1 and Profibus-PA

NEC references
500.2, 501.4

IEC references
60079-27, 60079-15

FINICO highlights (NEC variant of nonincendive field wiring)

- Similar to IS but used in Zone 2/Div 2 applications
- Allows typically twice the current levels as IS – twice the number of devices
- Device input parameters are considered negligible and cable inductance is not concentrated (Same parameters as FISCO)

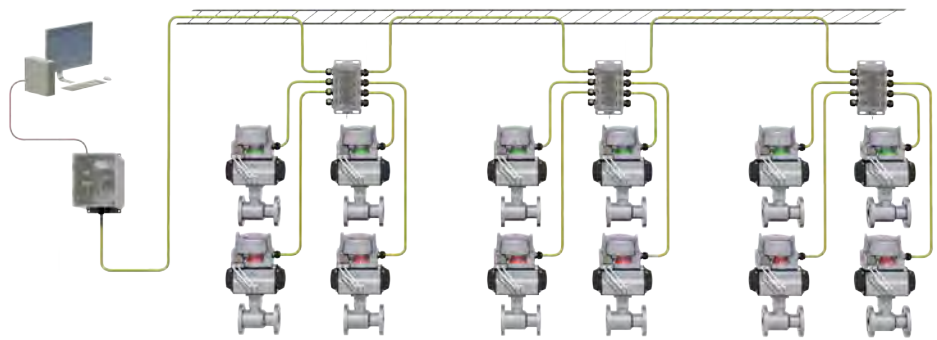


Fieldbus nonincendive concept enables more devices to be used in Zone 2/Div 2 areas using the same basic parameters and analysis as FISCO.

Optimized Hazard Protection (Zone 2/Div 2)

Optimized AS-i network in Zone 2/Div 2

- ITC or PLTC for trunk with voltage and current limited power supply (less than 100 watts; 3.0 amps max and 31 volts max)
- Nonincendive AS-i VCTs (Li = 0 & Ci = 0)
- Switched protected drop connectors (Short circuit current max of 240 mA)



This AS-i network has optimized the protection concepts to offer a low cost, flexible, safe system. The trunk will deliver up to 2.8 amps of current at full rated power or 30.5 VDC with each drop providing up to 200 mA at the same voltage which is sufficient to provide the nominal power for up to 30 AS-i Stonel VCTs on the same segment. Should a fault occur at the device, voltage and current will be limited to no more than 240 mA @ 30 VDC which is below the ignition energy level for most gases (Hydrogen excluded).

Valve diagnostics

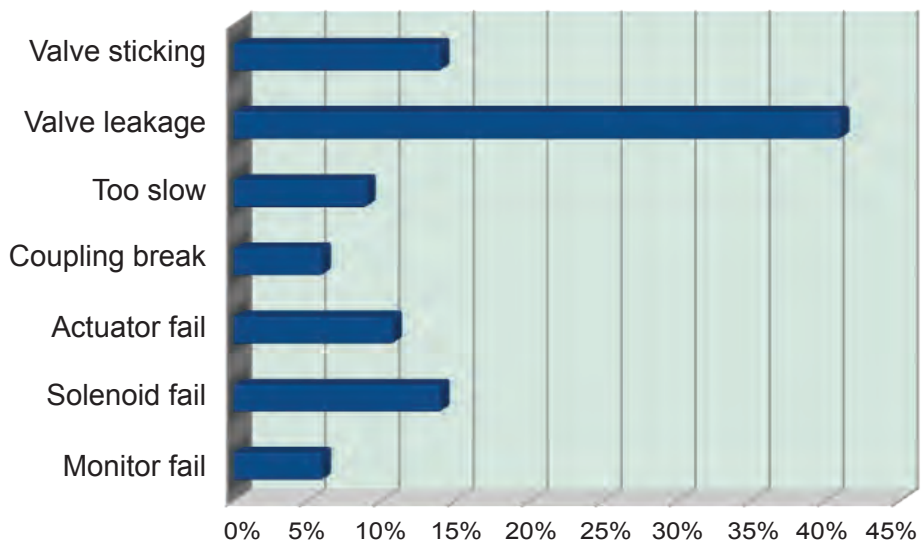
Overview

Savings when diagnostics implemented

- Greater process uptime resulting from fewer unpredictable valve failures
- Faster, lower cost maintenance by locating valve problem sources more quickly
- Optimized by performing maintenance only where it is needed

Stonel valve communication terminals (VCTs) with diagnostic capabilities provide a window into the automated valves' performance providing vital clues on automated valve performance. As a result, significant savings may be realized by lowered maintenance cost and greater operational up time.

Valve failure causes



Valve failure causes are based on our studies performed with process users in the last five years.

Axiom diagnostic systems

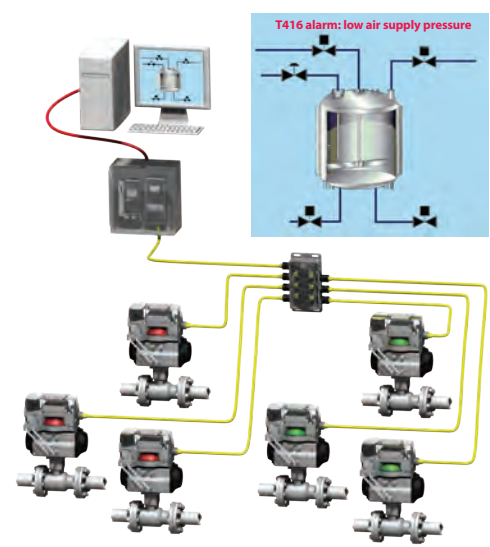
Features	Benefits
Air supply pressure alert	Prevent actuator malfunction
Determine solenoid condition	Reduce spool repair maintenance time
Local trouble-shooting display	Speed repair and reduce maintenance time
Monitor pneumatic valve operation	Identify problem cause and enable rapid repair
Identify problem with valve/actuator	Isolate problem to valve/ actuator assembly and not to control/monitor
Winking	Quickly identify valve/actuator locally
Remote switch setting	Speed initial set-up and reduce time to access

Remote switch setting Open and closed limit switch settings may be made with on-board push buttons or remotely through the control system.

Field identify with "winking" To positively confirm the field device identity, the control room may initiate the "wink" function that flashes both open and closed LEDs without affecting valve operation.

Axiom AS-Interface with diagnostics option

- Uses standard AS-i with Rev 2.1 or greater
- Map directly to operating software
- May be mixed with standard AS-i units
- Simple to integrate and install
- Cost effective option on Axiom 96 model



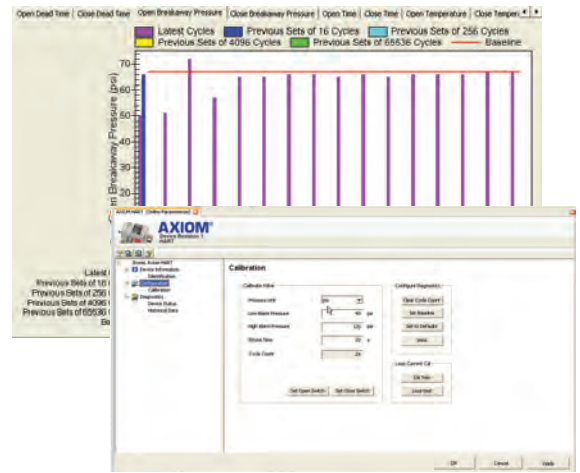
Electrical connections The Axiom with AS-Interface diagnostics uses standard (1-31) addressing with a 4DI/4DO profile to maximize the diagnostic data available via the network. Diagnostic units may be integrated on the same network as other AS-Interface devices.

Control system interface Interface up to 31 Axiom units into your control system. Communication bits may be mapped into standard DCS or PLC as desired. No special software is required. See tour FieldLink program for information about the cost saving benefits and easy installation of the AS-Interface protocol.

HART COMMUNICATION PROTOCOL

Axiom HART

- Offers comprehensive predictive diagnostics
- Trending data for open and closed
  - "Dead" time
  - Stroke time
  - Position offset
  - Pressure levels (torque requirement
- Controllable air pressure alarms
- Electronic circuit temperature
- Data is stored onboard for over 1 million cycles



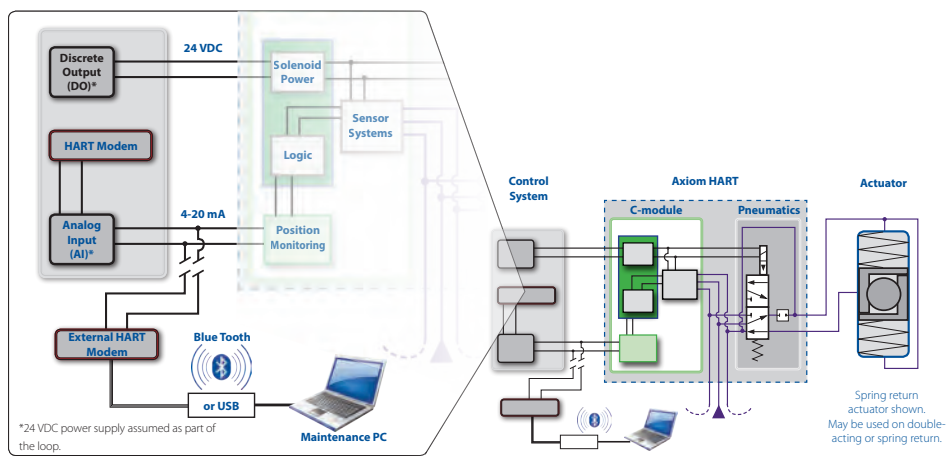
Excessive valve torque changes Open and closed breakaway actuator differential pressures are measured and compared to baseline levels during each operation. This enables operators to observe unusual pressure/torque level trends, which may ultimately lead to a malfunction.

Erratic valve/actuator performance Total travel time and dead time (time between energizing and initial actuator movement) are measured during each operation and recorded. This gives maintenance staff additional clues on potential automated valve problems.

Valve/actuator end-stop changes Exact valve position is continuously measured and may be used to determine if changes have occurred at end-of-travel.

Axiom HART

Easy control system integration



System connections Two, two-wire connections attach to the control system to provide discrete solenoid control and continuous position monitoring. A standard 24 VDC discrete output (DO) powers and controls the solenoid valve. A conventional 4 to 20 mA analog input (AI) provides continuous exact valve position feedback into the control system.

HART signal The HART communication signal is overlaid on the 4 to 20 mA analog position monitoring input.

Axiom HART

Software integration

Integrates DCS asset management systems using

- EDDL (Electronic Device Description Language)
- FDT/DTM (Field Device Tool/Device Type Manager)

Most DCS vendors use one or both of these technologies, which provides open access to device intelligence and allows easy use of all features and benefits available from the Axiom HART device.

fdtCONTAINER

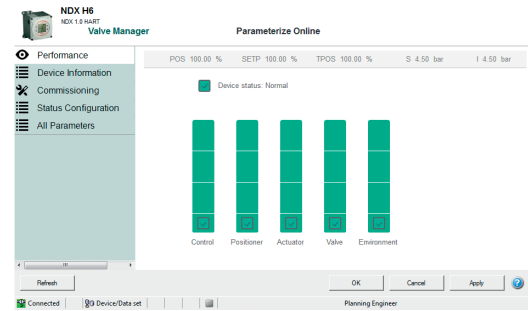
Software

Benefits

- Manage multiprotol field networks and devices from many manufacturers
- View standard and device specific parameters, eliminating vendor specific tools

Features

- Field device configuration
- Field device on-line monitoring
- Field device on-line diagnostics
- DTM catalog management



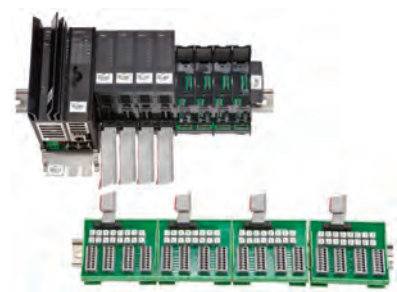
fdtCONTAINER is a device and asset management software solution based on open FDT technology. This tool can be used to manage device regardless of communication protocol. Open FDT technology allows you to select best in class devices.

Multiprotocol support, fdtCONTAINER can be used to manage devices with HART, Profibus-PA, Foundation Fieldbus, DeviceNet, AS-Interface, ProfiNet, etc.

HART Gateway and USB modem

Gateway features

- Interfaces up to 128 devices to fdtCONTAINER; 16 cords of 8 I/O channels
- Stand-alone; designed to work in place of multiplexers
- Much faster communication than multiplexer
- Convenient ethernet connection allows stand-alone use or tie it into the plant network



USB modem features

- USB 1.1 and 2.0 compatible
- Convenient minigrabber connections

This HART gateway interfaces up to 128 HART devices to fdtCONTAINER. The rack can be configured with up to 16 cards of 8 I/O channels.
This modem enables the transfer of HART data to a windows PC. It enables easy point-to-point connection between fdtCONTAINER and DTM enabled HART devices

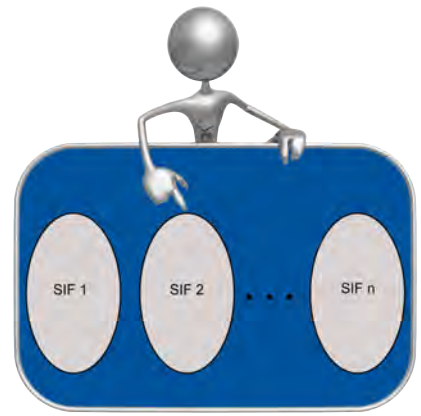
Safety instrumented systems

Key standards

- IEC - 61508: general standard for functional safety of electrical/ electronic/programmable electronic safety related systems
- IEC – 61511: functional safety related systems for the process industry sector.

Overview

- A Safety Instrumented System (SIS) is implemented as part of a risk reduction strategy.
- The primary focus is to prevent catastrophic accidents resulting from abnormal operation.



The purpose of a Safety Instrumented System (SIS) is to reduce the risk of a process failure which may cause damage to personnel and/or assets. This is done in part by using monitoring and control hardware that is specifically designed and approved for this purpose and that will force the process to a safe state when a hazardous event is detected.

An example would be to close a valve to stop material flow when a hazardous condition is sensed. This function would consist of a sensor to sense a hazardous condition, a Logic Solver, and a Final Element consisting of a process valve, an actuator, a valve monitor, and a solenoid valve.

Definitions

SIS – Safety Instrumented System

- An automatic system to reduce the level of risk when a hazard condition occurs. An SIS can be made up of several SIFs.

SIF – Safety Instrumented Function

- A safety function with a specified safety integrity level which is necessary to achieve functional safety (IEC 61511).

SIL – Safety Integrity Level

- A number from one to four that defines the required risk reduction an SIF needs to lower risk to an acceptable level. SIL 1 is the least stringent and SIL 4 is the most stringent. Typically SIL 4 is not used in process control.

If a process requires SIL 4, the process should be redesigned.

Definitions

Logic solver

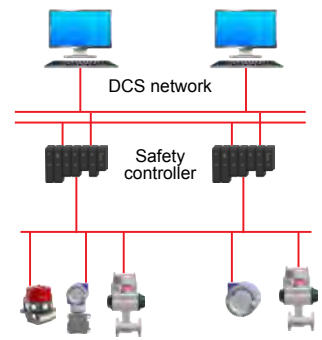
- A logic device, like a PLC, that accepts inputs and generates outputs but is designed and approved to IEC 61508. A logic solver is separate from the process PLC or DCS and contains the logic to perform the SIF.

Proof test

- A test to uncover undetected failures within the SIF that would prevent the safety function. An example would be to completely cycle an emergency shutdown valve to make sure all elements are still operational.

Partial Stroke Test (PST)

- A test in which a valve is moved off its open seat (typically to 85% Open), checked for functionality, and opened up again. A PST is performed between proof tests to make sure the major elements of a SIF are still operational. This will decrease the average PFD without shutting down the process like a proof test will.



Definitions

MTBF – Mean Time Between Failure

- The statistical approximation of how long a number of units will operate before a failure can be expected.

PFD – Probability of Failure on Demand

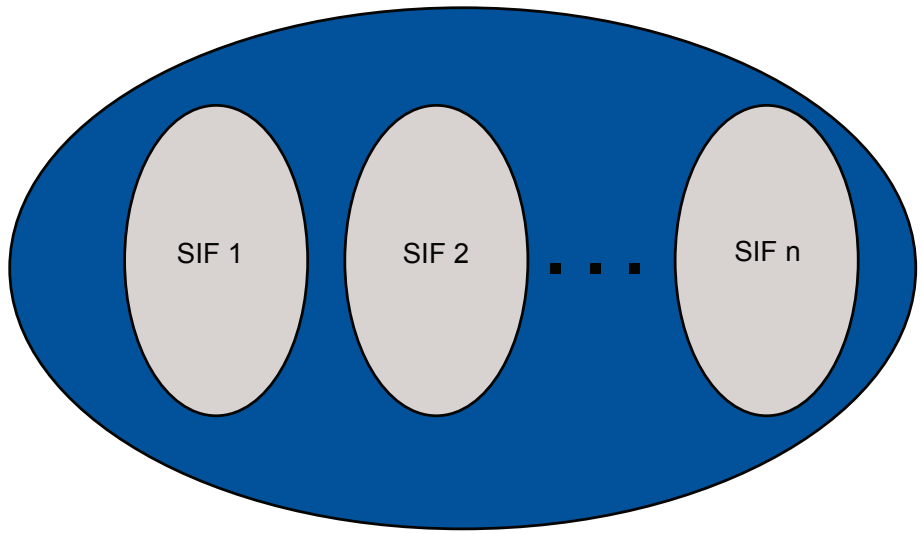
- The chance that the safety system will fail when called on to operate.

RRF – Risk Reduction Factor

- The reciprocal of the average PFD or PFD avg. To calculate the risk reduction needed to lower the risk in a SIF to an acceptable level (consistent with the defined SIL level), the following formula can be used; RRF=(Unmitigated Risk)/(Tolerable Risk).

For example, if there are 10,000 units in the field and there are fifty failures per year, the MTBF would be (8760 H/yr X 10,000)/50 = 1,752,000 hours or 200 years.

SIS system

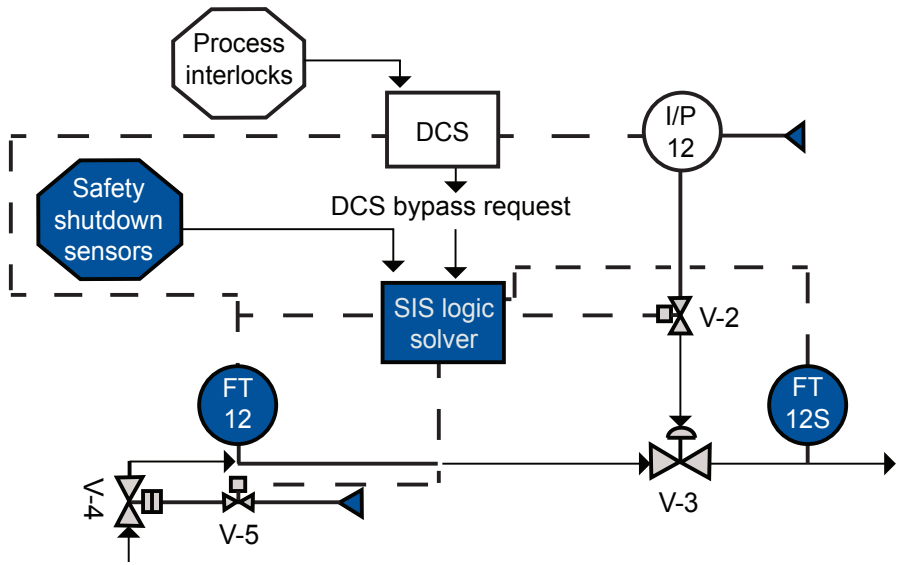


This diagram shows that a safety instrumented system is made up of at least one and probably more safety instrumented functions.

Main elements of an SIF system

1. Sensors to detect process anomalies
   - Flow meters
   - Level controls
   - Valve monitors
   - Pressure sensors etc.
2. Logic solvers to receive inputs, evaluate and drive appropriate outputs (typically separate from operating system)
3. Final control elements take action to drive process to safe state.
   - Safety shut-off valves
   - Control valves
   - Pumps/motors

Elements of SIS system



This shows that the SIS consists of the logic solver, safety shutdown sensors, inputs from flow transmitters 12 and 12S, and will manipulate valves V-3 and V-4 via solenoid valves V-2 and V-5 if a hazardous event is detected. This will happen independently of the DCS. Information from FT 12 is also used by the process control DCS.

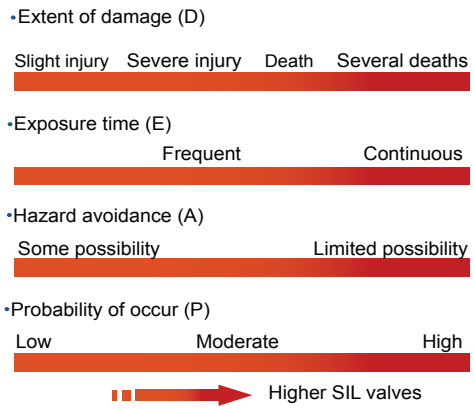
Determining risk

- PFD = Probability of Failure on Demand is the chance that the safety system will fail when called on to operate.
- More critical failure event - - lower acceptable system PFD
- PFD system = PFDsensors + PFDlogic solver + PFDfinal element
- Safety Integrity Level (SIL) defines the bounds of the PFD
- RRF = Risk Reduction Factor = 1/PFD
- End user determines SIL rating for plant

Determining risk		
SIL	PFD	RRF
4	.0001 to .00001	10,000 to 100,000
3	.001 to .0001	1,000 to 10,000
2	.01 to .001	100 to 1,000
1	.1 to .01	10 to 100

For example, if the end user determines that the risk of a process must be reduced by a factor of 5000 (RRF=5000) from the unmitigated risk of the process, he will then assign a SIL of 3 to the Safety Instrumented System (SIS). This means that the Probability of Failure on Demand (PFD) of each element in the SIS added together must be between .001 and .0001. This is the determination of each device's allocated MTBF because MTBF = 1/PFD.

SIL determination



Factors are fed into a table to determine potential damage consequences leading to a SIL level determination.

The SIL level takes these factors into account and is then determined by the end user or a third party hired by the end user.

PFD determination

Certified compliant by a third party

- Evaluated under fault conditions; errors safe or unsafe?
- Safety manual with device limitations

Proven in prior use (similar applications)

- Mean time between failures (MTBF)
- Values are well documented; 1/MTBF=PFD

PFD example

- 200 units are operating continuously and there are 15 failures over 2.5 years. What is MTBF?

Safety instrumented systems
PFD determination
200 units x 2.5 yrs/15 units = 33.3 years
33.3 years x 8760hrs/year = 292,000 hours
PFD = 1/MTBF = 1/292,000 hours
PFD = .0000034 = 3.4 x 10^{-6}

This PFD number is for one device. To get the PFD for the whole SIS, all device PFDs for that system must be added together. The most accepted way to get a PFD is by third party certification through analysis. Some third party approval agencies will not accept the proven in prior use concept.

Special note on MTBF

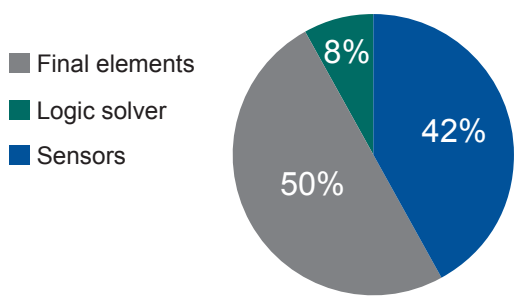
- MTBF is not life expectancy!!

MTBF represents the statistical approximation of how long a number of units should operate before a failure can be expected

- Lifetime is the period of time between starting to use the device and the beginning of wear out.

For example the MTBF in the previous example is 33.3 years. This does not mean that the device will be expected to operate without failure for 33.3 years. This number indicates that if there are 200 units in the field operating for 2.5 years, then about 15 failure can be expected.

Safety loop failure sources



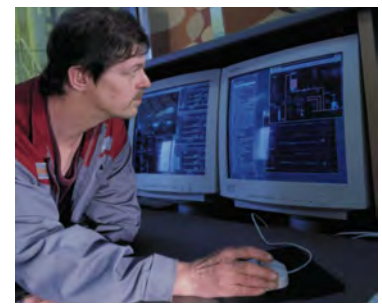
Final control element failures

- Valve/actuator sticks
- Incorrect selection or sizing
- Solenoid valve fails

Since the final control elements contribute the majority of the failures in a SIS, it makes sense to focus PFD reduction techniques on them.

PFD reduction

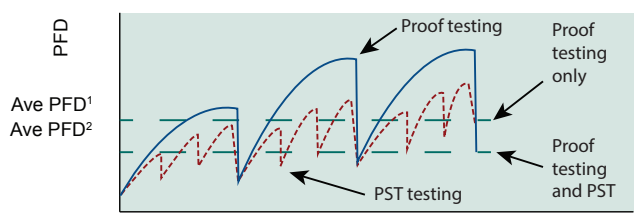
- Redundant safety sensors and final control elements
- Greater reliability components
- Proof testing the safety system (entire system is tested)
- Partial stroke testing the final control elements - -safety shut-off valves
- Diagnostic elements evaluating system components for potential problems



An effective and inexpensive way to reduce the PFD for the final control element is to perform partial stroke tests (PST) between proof tests. This reduces PFD without shutting down the process.

Partial Stroke Testing (PST) benefits

- Reduce “sticking” of valve and actuator
- Demonstrate performance
- Reduce PFDavg and improve reliability of safety system!
- As PFD increases over time, proof testing reduces PFD to near the original number
- PST is done more frequently, does not require the system to shut down, and reduces the average PFD
- Because a PST is not as comprehensive as a proof test, it does not reduce the PFD as a proof test would. The PFD still increases slightly over time.



In order to effectively perform a PST, a device specifically designed for this should be used. The Stonel Axiom Expeditor may be used to carry out this test.

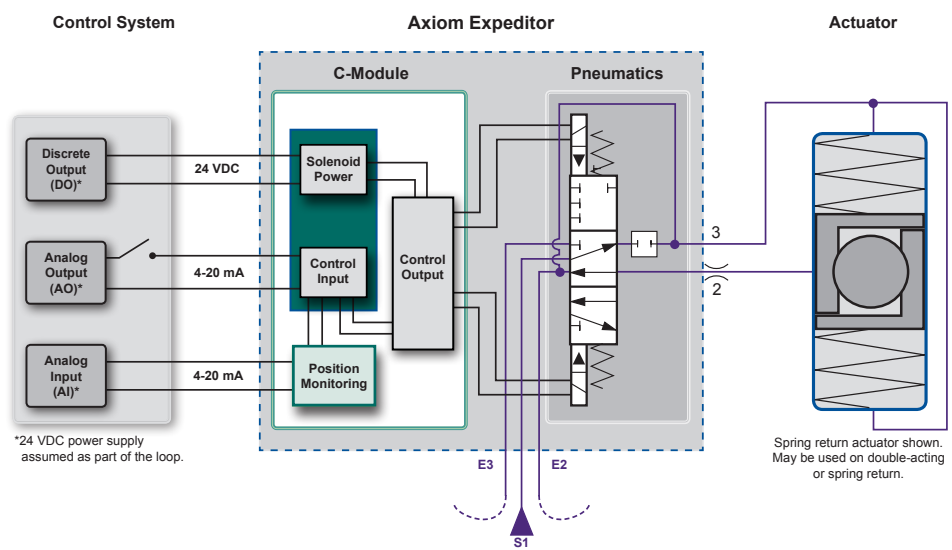
Emergency shut-down applications (ESD)

Axiom Expeditor overview

The Axiom Expeditor may be used to perform Partial Stroke Testing (PST) in a Safety Instrumented System (SIS) to increase reliability and decrease the Probability of Failure on Demand (PFD).

The Expeditor may be used to travel to a partial open or closed position to fulfill a partial stroke test.

Axiom Expeditor installation



Set-up is the same as any standard intermediate setting for partial opening or partial closing. Actual position at the intermediate stop will be plus or minus 3 degrees of rotation.

Notes

Wireless networking

Overview

Process applications for wireless

- Valve monitoring/automation
- I/O
- Transmitters
- Diagnostics
- Typical applications
  - Inside tanks or compartments
  - Remote areas
  - Mobile equipment
  - Redundancy
  - Low incidence monitoring (manual valves, safety showers etc.)

Typical applications:

Inside tanks or compartments

Remote areas

Mobile equipment

Redundancy

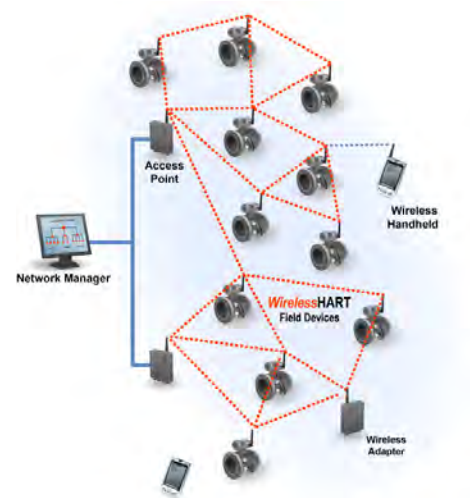
Low incidence monitoring (Manual valves, safety showers etc.)

Wireless applications for valve automation

- Important considerations:
  - Latency
  - Battery Life
  - Data requirements
  - Signal integrity
  - Hazardous area requirements

Market acceptance

- Wireless control: Still see reluctance from end users for wireless control
- Wireless monitoring is much more acceptable
- Wireless diagnostics retrieval is very desirable



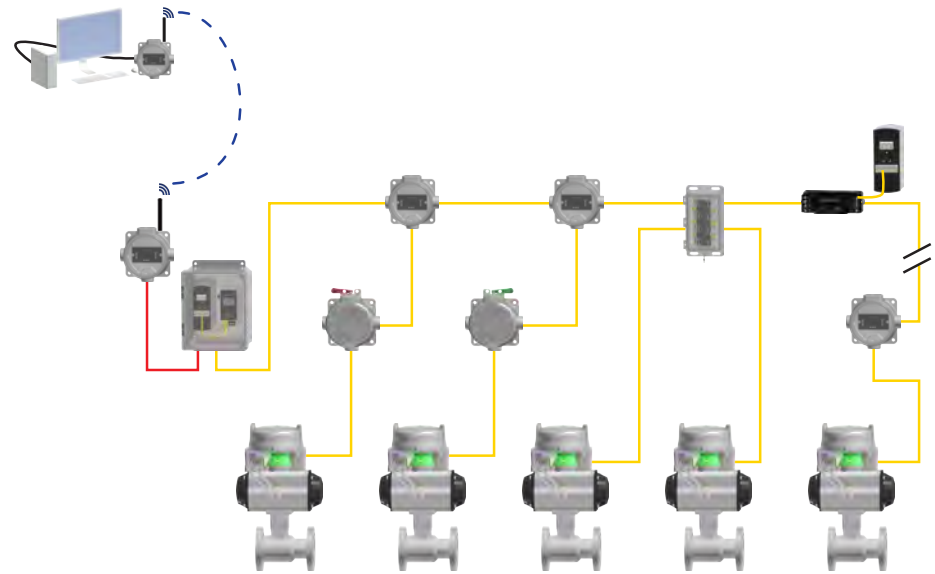
Source: HART Communication Foundation

Longer latency (less frequent updates) allows for longer battery life.

Special batteries would be needed to comply with hazardous location requirements.

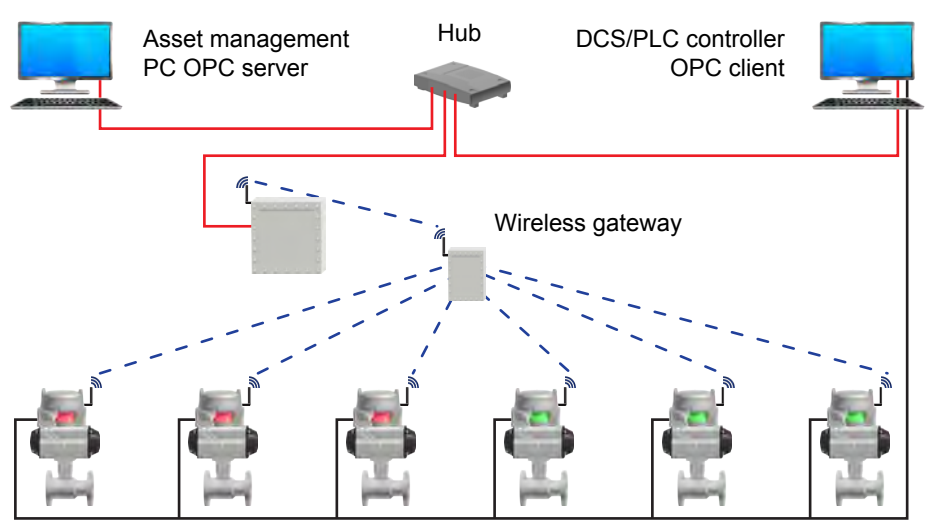
Our surveys show that end users are very interested in wireless, especially for retrofits and remote applications like tank farms, etc.

Wireless with a wired network



This diagram shows a wired AS-i network connected to a gateway that is connected to the control system via WLAN. This could be used in new remote installations or in retrofit cases.

Wireless network



Wireless communication could also be used to transfer diagnostic data from hard-wired devices.

Wireless trends

ISA SP100.11a standard

- Supports multiple protocols (HART, Profibus, Modbus, FF etc)
- Defines an entire wireless architecture (sensor level is 802.15.4)
- Supported by Honeywell

*Wireless*HART is gaining momentum

- Supports HART protocol (over 30 million installed)
- Uses 2.4 GHz; 802.15.4

  Emerson

  Endress + Hauser

  ABB

WirelessHART™

*Wireless*HART is gaining momentum and is very widely promoted by several of the largest process instrumentation and control system vendors.

HART wireless highlights

- Uses same software as HART 7 protocol; physical layer and data link layer are changed from hard-wired to wireless.
- Wireless transmission defined by 802.15.4 using 2.4 GHz Band
  - Up to 100 m line of sight transmission distances
  - Same physical medium as ZigBee (Assures high volume)
  - Utilizes mesh networking
  - Low power consumption and latency (powers up quickly to send message)
- Utilizes mesh networking to reinforce signal

Source: HART Communication Foundation

- Up to 100 m line of sight transmission distances
- Same physical medium as ZigBee (assures high volume)
- Low power consumption and latency (powers up quickly to send message)

Integrated automated valve diagrams

Stonel

NEC Hazardous area networking guide

Protocol	Topology	Max distance[1]	Max # devices	Cabling
AS-i	Not limited	100 m (328 ft) 300 m (984 ft) with 2 repeaters Additional distance with multiple parallel repeaters. Tuners and terminators available for special extensions.	31 per network (62 per network with 2.1 Rev and extended addressing)	Unshielded, untwisted 2-wire for data and power (16 AWG is preferred).
DeviceNet	Trunk/drop	500 m @ 125 Kbit/s[2] 250 m @ 250 Kbit/s[2] 100 m @ 500 Kbit/s[2]	62	(2) 2-wire with shield (5-wire bundle)
Fieldbus	Trunk with branching or chicken foot	1900 m (6200 ft) 120 m spur[3] Using FISCO 1000m	32 (16)[4]	Shielded twisted pair
HART	Hart handheld	n/a	1	Direct connection
	4-20 mA multiplexer	3,048 m (10,000 ft)	15	Twisted shielded cable

Legend

- Ethernet
- General usage
- AS-Interface
- DeviceNet
- Foundation Fieldbus
- Intrinsically safe
- HART
- PLTC/ITC in cable tray (any color)
- PLTC/ITC with strut support (any color)
- PLTC/ITC supported by messenger wire (any color)
- Extra hard usage cable (metal reinforced)
- Metal clad flexible conduit
- Liquidtight flexible conduit
- Rigid metal conduit
- Seal fitting
- Quick mini connector
- Quick mini connector with clasp
- Quick micro connector (general purpose cable)
- Compression fitting

NEC 500 wiring guidelines*

Tray cabling system
Class I & II, Division 2

Conduit/cabling
- Power Limited Tray Cable (PLTC) rated or Instrument Tray Cable (ITC) rated cable used in cable tray.
- PLTC or ITC used as open wiring up to 15 m (50 ft) protected by angles, struts or messenger wire and secured at intervals not exceeding 1.8 m (6 ft).
- PLTC or ITC used in liquidtight or MC flexible conduit.

Connections
- PLTC and ITC may be connected using compression fittings installed to avoid tensile stress at termination.
- Flexible cord and quick connectors suitable provided conditions are met as described for nonincendive equipment.

Field instruments
- Must be nonincendive equipment rated.

Special notes
- PLTC power supplies (Class 2 approved) limited to 100 watts with maximum of 60 VDC used to limit energy into the circuit.
- ITC power supplies limited to 5 amps and 150 volts rms.

Nonincendive equipment used in explosionproof and tray cabling systems
Class I & II, Division 2 only
- Seal-offs not required.
- Liquidtight conduit or flexible cord for extra hard usage may be used where flexibility is required.
- Field instruments must be nonincendive equipment rated.
- Quick connectors may be used with the following provisions:
  - Power removed before plugging and unplugging.
  - Current does not exceed 3 amps @ 120 VAC.
  - Cord is listed for hard usage with receptacle and plug of the locking ground type and does not exceed 900 mm (3 ft).
  - A label is attached to the receptable warning against unplugging while energized.

Special notes
- Nonincendive components have current interrupting contacts that are hermetically sealed or non-arcing (solid state).
- Enclosures may be opened while circuits are energized but wiring may not be manipulated until power is removed.

Explosionproof system
Class I & II, Division 1 & 2

Conduit/cabling
- Rigid metal conduit or steel intermediate conduit.
- MI (Mineral Insulated, Metal Sheathed) or MC (Metal Clad) where flexibility required.
- Seal-offs for all enclosures (except those with special rating).

Connections
- Fittings must be explosionproof approved.

Field instruments
- Complete apparatus must be explosionproof rated.

Special notes
- No seal-offs are required for Stonel JM, Quartz and Axiom (AX).
- Power must be removed before opening enclosures.

Intrinsically Safe (IS) systems
Class I & II, Division 1 & 2

Conduit/cabling
- General purpose cable.
- Cable capacitance and inductance must be considered.
- Barriers (associated apparatus) limit voltage and current.

Connections
- General purpose connectors.
- Quick connectors without limitation.

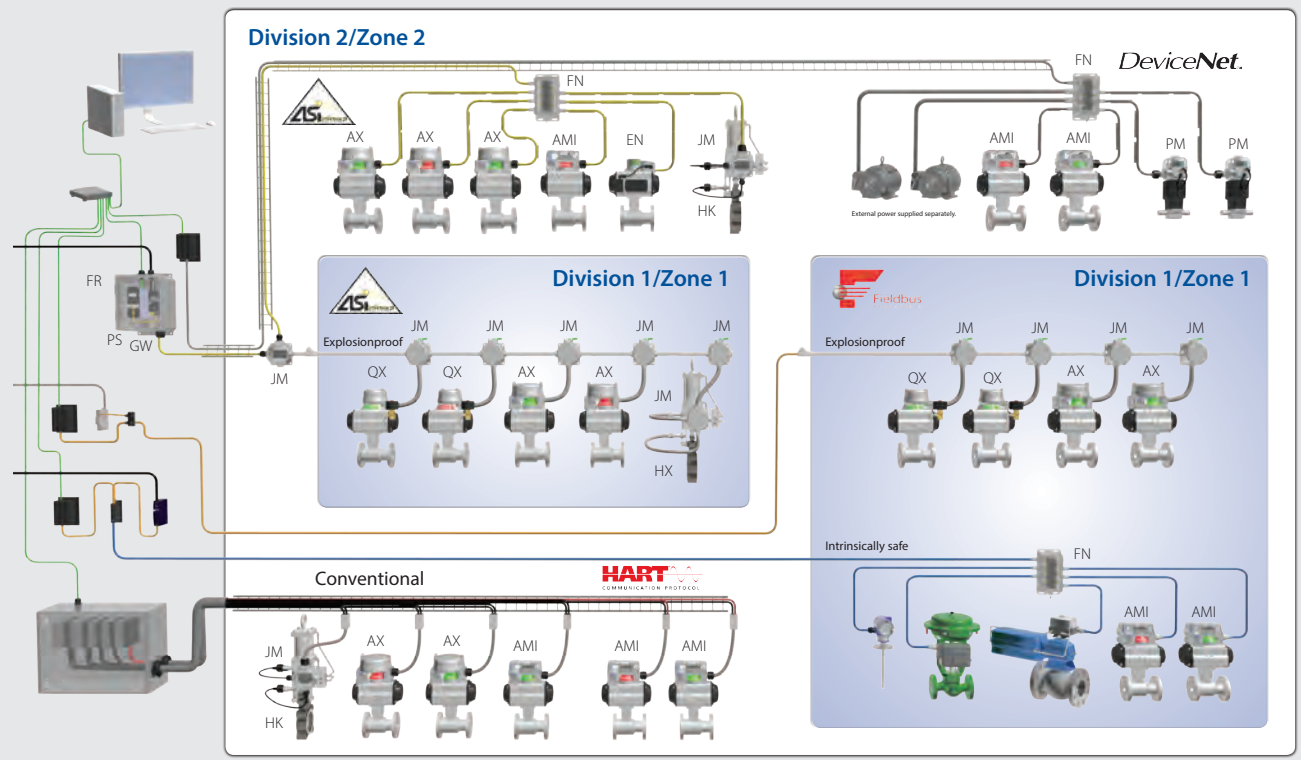
Field instrument components
- Field instruments must be classified as simple (non-energy storing) or IS (IS apparatus).
- IS devices must be approved per FISCO or entity concept.
- Parameter matching using entity concept:

IS apparatus		Associated apparatus
Lowest Vmax in segment	>	Voc
Lowest Imax in segment	>	Isc
Lowest Pmax in segment	>	Pt
Ctotal (field devices+cable)	<	Ca
Ltotal (field devices+cable)	<	La

- Parameter matching using FISCO is same as entity concept except cable and device Li & Ci may be ignored (must be within established FISCO values).

Special notes
- Instrument wiring may be manipulated while energized.
- Protected drop connectors are recommended since bus performance will be affected by short circuit on the spur.

* Reference NEC articles 501, 502 and 504.



Protection concepts shown are for illustration purposes. Final acceptance of installation including wiring practices is subject to the authority having jurisdiction.

Axiom AX

Axiom AMI

Eclipse EN

Quartz QX

Prism PM

Hawkeye HK/HX

FieldLink

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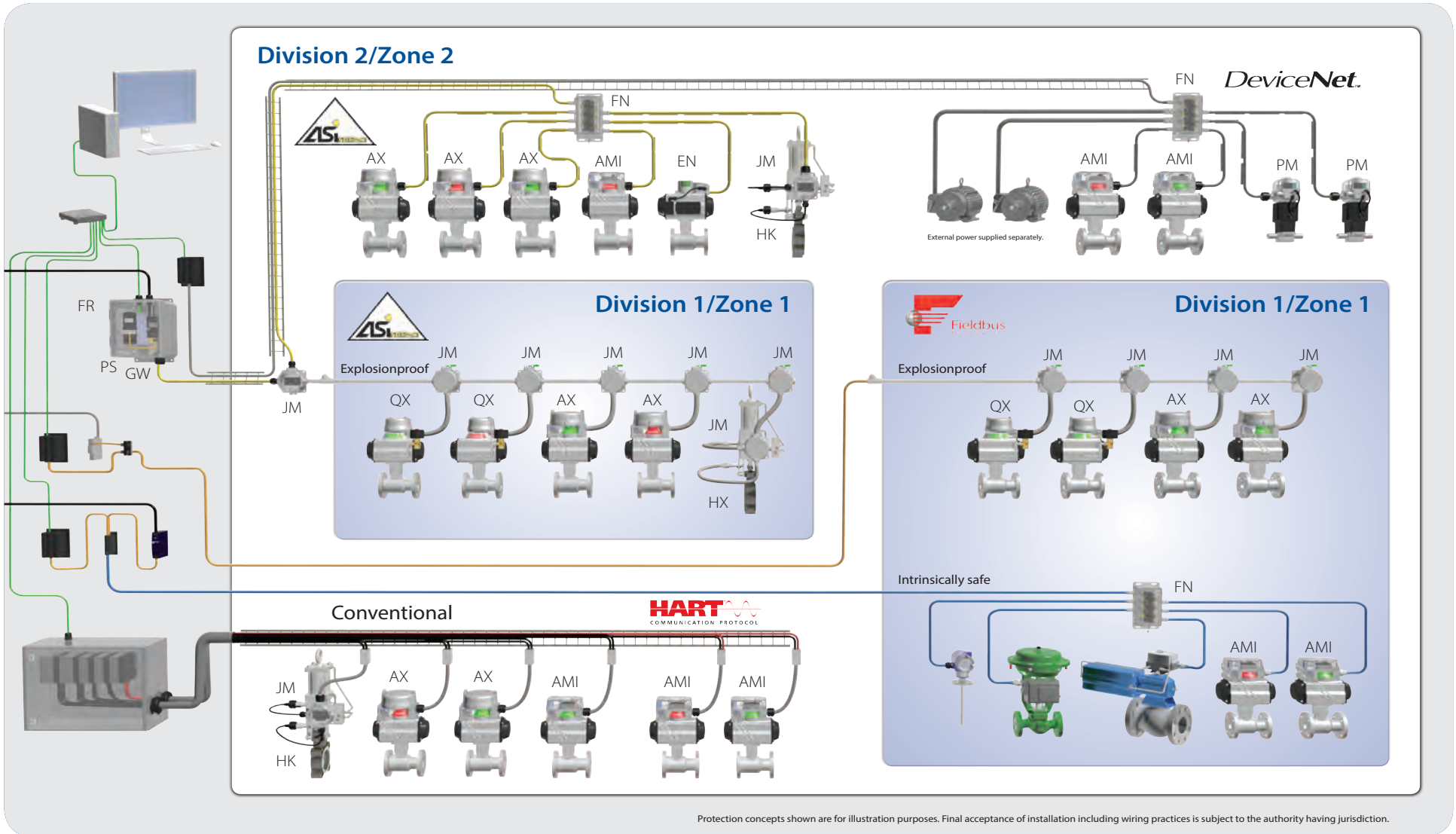


Protection concepts shown are for illustration purposes. Final acceptance of installation including wiring practices is subject to the authority having jurisdiction.

Protocol	Topology	Max distance[1]	Max # devices	Cabling
AS-Interface	Not limited	100 m (328 ft) 300 m (984 ft) with 2 repeaters Additional distance with multiple parallel repeaters. Tuners and terminators available for special extensions.	31 per network (62 per network with 2.1 Rev and extended addressing)	Unshielded untwisted 2-wire for data and power (16 AWG is preferred).
DeviceNet	Trunk/drop	500 m @ 125 Kbit/s[4] 250 m @ 250 Kbit/s[4] 100 m @ 500 Kbit/s[4]	62	(2) 2-wire with shield (5-wire bundle)
Fieldbus Foundation	Trunk with branching or chicken foot	1900 m (6200 ft) 120 m spur[5] Using FISCO 1000 m	32 (16)[6]	Shielded twisted pair
HART COMMUNICATION PROTOCOL	Hart hand-held	n/a	1	Direct connection
	4-20 mA multiplexer	3,048 m (10,000 ft)	15	Twisted shielded cable

Legend


Ethernet


General usage


AS-Interface


DeviceNet


Foundation Fieldbus


Intrinsically safe


HART

PLTC/ITC in cable tray (any color)

PLTC/ITC with strut support (any color)


PLTC/ITC supported by messenger wire (any color)

Extra hard usage cable (metal reinforced)


Metal clad flexible conduit


Liquidtight flexible conduit


Rigid metal conduit


Seal fitting


Quick mini connector


Quick mini connector with clasp

Quick micro connector (general purpose cable)


Compression fitting

NEC 500 wiring guidelines*

Tray cabling system

Class I & II, Division 2

Conduit/cabling

- Power Limited Tray Cable (PLTC) rated or Instrument Tray Cable (ITC) rated cable used in cable tray.
- PLTC or ITC used as open wiring up to 15 m (50 ft) protected by angles, struts or messenger wire and secured at intervals not exceeding 1.8 m (6 ft).
- PLTC or ITC used in liquidtight or MC flexible conduit.

Connections

- PLTC and ITC may be connected using compression fittings installed to avoid tensile stress at termination.
- Flexible cord and quick connectors suitable provided conditions are met as described for nonincendive equipment.

Field instruments

- Must be nonincendive equipment rated.

Special notes

- PLTC power supplies (Class 2 approved) limited to 100 watts with maximum of 60 VDC used to limit energy into the circuit.
- ITC power supplies limited to 5 amps and 150 volts rms.

Nonincendive equipment used in explosionproof and tray cabling systems

Class I & II, Division 2 only

- Seal offs not required.
- Liquidtight conduit or flexible cord for extra hard usage may be used where flexibility is required.
- Field instruments must be nonincendive equipment rated.
- Quick connectors may be used with the following provisions:
  - Power removed before plugging and unplugging.
  - Current does not exceed 3 amps @ 120 VAC.
  - Cord is listed for hard usage with receptacle and plug of the locking ground type and does not exceed 900 mm (3 ft).
  - A label is attached to the receptable warning against unplugging while energized.

Special notes

- Nonincendive components have current interrupting contacts that are hermetically sealed or non-arcing (solid state).
- Enclosures may be opened while circuits are energized but wiring may not be manipulated until power is removed.

* Reference NEC articles 501, 502 and 504

Explosionproof system

Class I & II, Division 1 & 2

Conduit/cabling

- Rigid metal conduit or steel intermediate conduit.
- Mineral Insulated/Metal Sheathed (MI) or Metal Clad (MC) where flexibility required.
- Seal offs for all enclosures (except those with special ratings).

Connections

- Fittings must be explosionproof approved.

Field instruments

- Complete apparatus must be explosionproof rated.

Special notes

- No seal offs are required for Stonel JM, Quartz and Axiom (AX).
- Power must be removed before opening enclosures.

Intrinsically Safe (IS) systems

Class I & II, Division 1 & 2

Conduit/cabling

- General purpose cable.
- Cable capacitance and inductance must be considered.
- Barriers (associated apparatus) limit voltage and current.

Connections

- General purpose connectors.
- Quick connectors without limitation.

Field instrument components

- Field instruments must be classified as simple (non-energy storing) or IS (IS apparatus).
- IS devices must be approved per FISCO or entity concept.
- Parameter matching using entity concept:

IS apparatus		Associated apparatus
Lowest Vmax in segment	>	Voc
Lowest Imax in segment	>	Isc
Lowest Pmax in segment	>	Pt
Ctotal (field devices+cable)	<	Ca
Ltotal (field devices+cable)	<	La

- Parameter matching using FISCO is same as entity concept except cable and device Li & Ci may be ignored (must be within established FISCO values).

Special notes

- Instrument wiring may be manipulated while energized.
- Protected drop connectors are recommended since bus performance will be affected by short circuit on the spur.

Stonel

IEC Hazardous area networking guide

Protocol	Topology	Max distance[1]	Max # devices	Cabling
AS-i	Not limited	100 m (328 ft) 300 m (984 ft) with 2 repeaters Additional distance with multiple parallel repeaters. Tuners and terminators available for special extensions.	31 per network (62 per network with 2.1 Rev and extended addressing)	Unshielded, untwisted 2-wire for data and power (16 AWG is preferred).
DeviceNet	Trunk/drop	500 m @ 125 Kbit/s[2] 250 m @ 250 Kbit/s[2] 100 m @ 500 Kbit/s[2]	62	(2) 2-wire with shield (5-wire bundle)
Fieldbus	Trunk with branching or chicken foot	1900 m (6200 ft) 120 m spur[3] Using FISCO 1000m	32 (16)[4]	Shielded twisted pair
HART	Hart handheld	n/a	1	Direct connection
	4-20 mA multiplexer	3,048 m (10,000 ft)	15	Twisted shielded cable

Legend

- AS-Interface
- DeviceNet
- Foundation Fieldbus
- HART
- Intrinsically safe cable *(used with HART, Foundation Fieldbus or Conventional)*
- Armoured cable
- Non armoured cable
- Armoured cable gland
- Non armoured cable gland
- Compression fitting

IEC wiring guidelines*

Intrinsically Safe (IS) systems
Ex ia Zone 0, 1 & 2

Conduit/cabling
- Use only insulated cable and conductors (test voltage > 500 VAC).
- Separate IS cables from non-IS with spacing (at least 50 mm) or other means (shielding, screens, metal housing).
- Identify with light blue color unless shielded or metal sheathed cable.
- Cable capacitance and inductance must be considered.
- Barriers (associated apparatus) limit voltage and current.

Connections
- Use glands or compression fittings suitable for particular cable and compatible with enclosure.
- Quick connectors may be acceptable.

Field instrument components
- Field instruments must be classified as simple (non-energy storing) or IS (IS apparatus).
- IS devices must be approved per FISCO or entity concept.
- Parameter matching using entity concept:

IS apparatus		Associated apparatus
Lowest Vmax in segment	>	Voc
Lowest Imax in segment	>	Isc
Lowest Pmax in segment	>	Pi
Ctotal (field devices+cable)	<	Ca
Ltotal (field devices+cable)	<	La

- Parameter matching using FISCO is same as entity concept except cable and device Li & Ci may be ignored (must be within established FISCO values).

Special notes
- Instrument wiring may be manipulated while energized.
- Protected drop connectors are recommended since bus performance will be affected by short circuit on the spur.

Flameproof system
Ex d Zones 1 & 2

Conduit/cabling
- Rigid metal conduit or steel intermediate conduit may be used. (Not illustrated)
  - Stopping boxes with special compound must be used not more than 50 mm from the flameproof enclosure wall.
  - Standard cables may be used but cross sectional area may not be greater than 40% of conduit.
- Armoured and non armoured cable with robust construction may be used, consisting of extruded inner bed to prevent gas propagation and tough rubber or synthetic sheath.
  - Cable glands rated Ex d and specifically designed for cable type (armoured or non armoured) must be used not more than 50 mm from the flameproof enclosure wall.

Connections
- Fittings must be flameproof approved.

Field instruments
- Complete apparatus must be flameproof approved.

Special notes
- Ex e cabling practices and fittings may be used if the terminal compartment is approved to that standard.
- Power must be removed before opening enclosures.

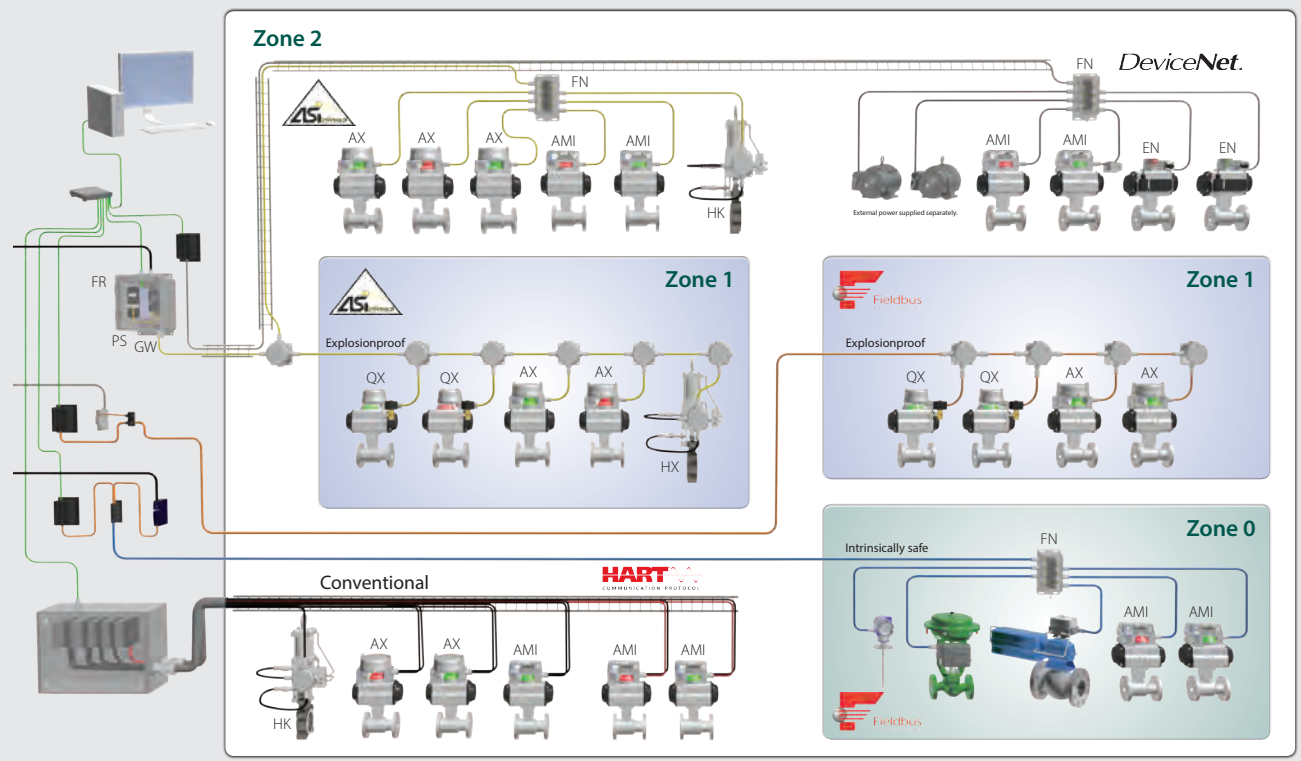
Nonincendive equipment used in flameproof system
Ex n Zone 2 only

Conduit/cabling
- Same as flameproof.

Connections
- Same as flameproof.

Field instruments
- Approved for use as nonincendive (nonsparking) devices by certified approval agencies.

* Reference IEC60079-14. Guidelines are general in nature and not meant to be comprehensive. Typically they are supplemented at the national level in order to describe detailed practices which are unique to each country.



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Axiom AX | **Axiom AMI** | **Eclipse EN** | **Quartz QX** | **Prism PM** | **Hawkeye HK/HX** | **FieldLink**

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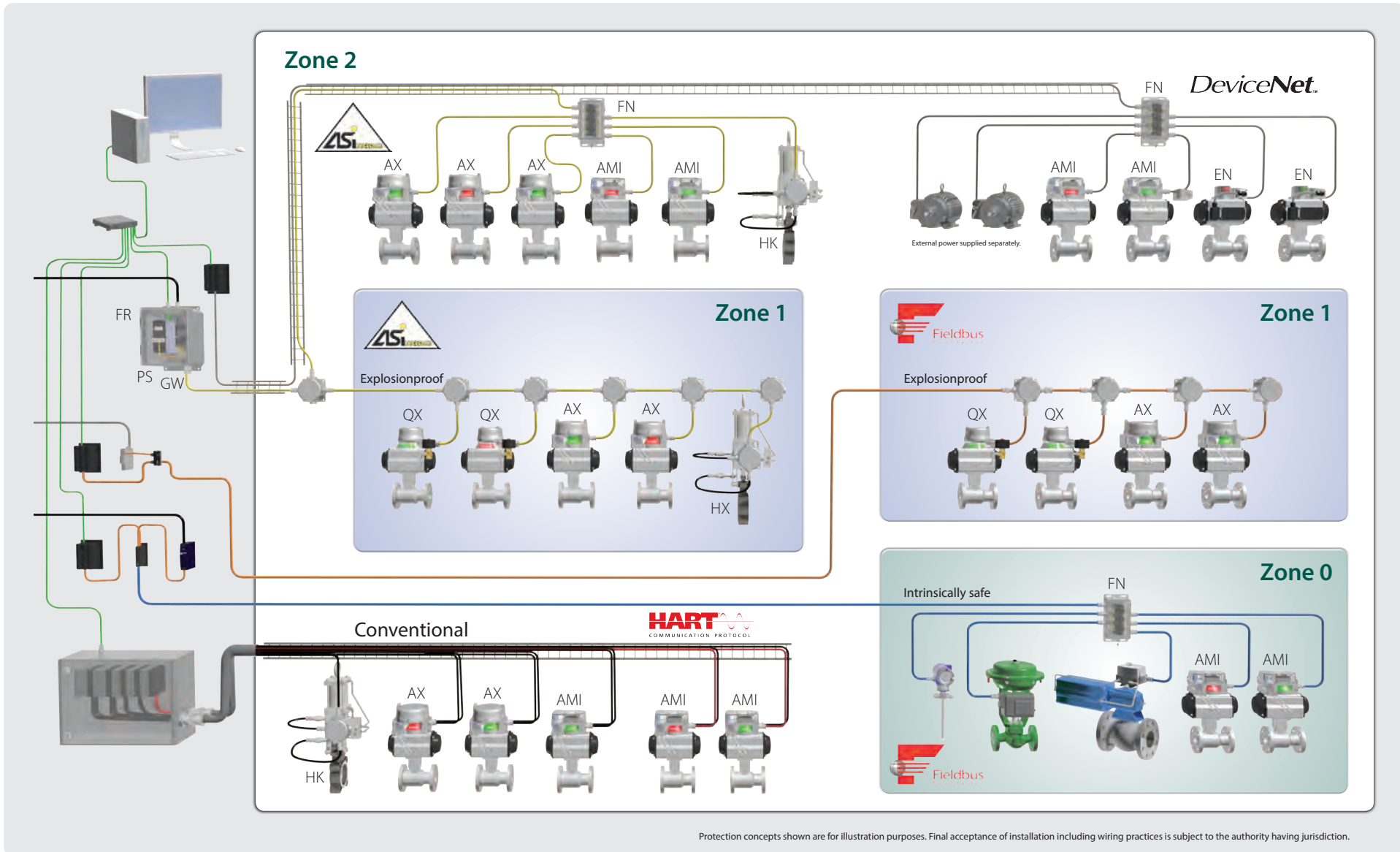

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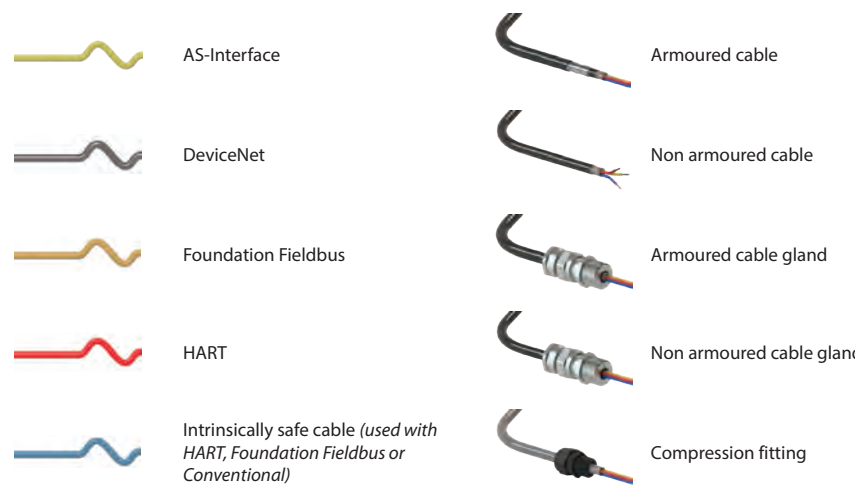
Fieldbus Foundation	Trunk with branching or chicken foot	1900 m (6200 ft) 120 m spur[5] Using FISCO 1000 m	32 (16)[6]	Shielded twisted pair
HART COMMUNICATION PROTOCOL	Hart hand-held	n/a	1	Direct connection
	4-20 mA multiplexer	3,048 m (10,000 ft)	15	Twisted shielded cable

Legend



IEC wiring guidelines*

Intrinsically Safe (IS) systems

Ex ia Zone 0, 1 & 2

Conduit/cabling

- Use only insulated cable and conductors (test voltage > 500 VAC).
- Separate IS cables from non-IS with spacing (at least 50 mm) or other means (shielding, screens, metal housing).
- Identify with light blue color unless shielded or metal sheathed cable.
- Cable capacitance and inductance must be considered.
- Barriers (associated apparatus) limit voltage and current.

Connections

- Use glands or compression fittings suitable for particular cable and compatible with enclosure.
- Quick connectors may be acceptable.

Field instrument components

- Field instruments must be classified as simple (non-energy storing) or IS (IS apparatus).
- IS devices must be approved per FISCO or entity concept.
- Parameter matching using entity concept:

IS apparatus		Associated apparatus
Lowest Vmax in segment	>	Voc
Lowest Imax in segment	>	Isc
Lowest Pmax in segment	>	Pt
Ctotal (field devices+cable)	<	Ca
Ltotal (field devices+cable)	<	La

- Parameter matching using FISCO is same as entity concept except cable and device Li & Ci may be ignored (must be within established FISCO values).

Special notes

- Instrument wiring may be manipulated while energized.
- Protected drop connectors are recommended since bus performance will be affected by short circuit on the spur.

Flameproof system

Ex d Zones 1 & 2

Conduit/cabling

- Rigid metal conduit or steel intermediate conduit may be used. (Not illustrated)
  - Stopping boxes with special compound must be used not more than 50 mm from the flameproof enclosure wall.
  - Standard cables may be used but cross sectional area may not be greater than 40% of conduit.
- Armoured and non armoured cable with robust construction may be used, consisting of extruded Inner bed to prevent gas propagation and tough rubber or synthetic sheath.
  - Cable glands rated Ex d and specifically designed for cable type (armoured or non armoured) must be used not more than 50 mm from the flameproof enclosure wall.

Connections

- Fittings must be flameproof approved.

Field instruments

- Complete apparatus must be flameproof approved.

Special notes

- Ex e cabling practices and fittings may be used if the terminal compartment is approved to that standard.
- Power must be removed before opening enclosures.

Nonincendive equipment used in flameproof system

Ex n Zone 2 only

Conduit/cabling

- Same as flameproof.

Connections

- Same as flameproof.

Field instruments

- Approved for use as nonincendive (nonsparking) devices by certified approval agencies.

* Reference IEC60079-14. Guidelines are general in nature and not meant to be comprehensive. Typically they are supplemented at the national level in order to describe detailed practices which are unique to each country.

Notes

Appendix

Glossary of bus networking terms

Term	Definition
10BaseT	One of several adaptations of the Ethernet (IEEE 802.3) standard for Local Area Networks (LANs). The 10 Base-T standard (also called Twisted Pair Ethernet) uses a twisted-pair cable with maximum lengths of 100 meters. It transfers data at 10 Mbps.
100BaseT	An Ethernet networking standard that supports data transfer rates up to 100 Mbps (100 megabits per second).
Access Methods	The method by which a device on a network gains control in order to transmit its information.
Access Point	A device that transports data between a wireless network and a wired network infrastructure. Also referred as base station.
Acyclic	A mode characterized by non-regular timing intervals.
Address	A uniquely defined location on a bus network.
Algorithm	A specific formula or method for solving a problem.
Analog	A transmission mode in which data is represented by a continuously varying signal e.g. 4 to 20 mA.
Antenna Gain	The ratio of the power produced by the antenna from a far-field source on the antenna's beam axis to the power produced by a hypothetical lossless isotropic antenna, which is equally sensitive to signals from all directions. Usually this ratio is expressed in decibels, and these units are referred to as "decibels-isotropic" (dBi).
AMS	(Asset Management System) A system used for calibrating, monitoring and predicting maintenance of field instruments.
ANSI	(American National Standards Institute) The principal standards development organization in the US. US's member body to the ISO.
AWG	(American Wire Gauge) A method of defining the cross sectional area of a wire.
Application Layer	The seventh layer of the OSI model which contains the operating system
ARCNET	(Attached Resource Computer NETwork) One of the oldest, simplest, and least expensive types of local-area networks, ARCnet was introduced by Datapoint Corporation in 1977. It uses a token-ring architecture, supports data rates of 2.5 Mbps, and connects up to 255 computers.
ASCII	(American Standard Code for Information Interchange) A code for representing English characters as numbers, with each letter assigned a number from 0 to 127.
ASIC	(Application Specific Integrated Circuit) An IC chip designed for a particular application.
Asynchronous	Occurring at irregular intervals.
Baud	The number of signaling elements that occur each second.
BAN	Body Area Network Interest Group.
Bandwidth	The carrying capacity of a communications channel describing the amount of information or data that can be sent over a network connection in a given period of time stated in bits per second (bps), kilobits per second (Kbps), or megabits per second (Mbps).

Term	Definition
Binary	A numbering system that has two unique digits, 0 and 1 which is the base 2 system. As placement expands the number is taken as a power of 2 e.g. 1001 is $1x2^3 + 0x2^2 + 0x2^1 + 1x2^0$
Bit	The smallest unit of measurement in a binary system.
Bit Rate	The number of bits that are transferred between devices in a specified amount of time, typically one second.
Block	A fixed-size grouping of bits or bytes that is transferred together.
Bluetooth	An industry specification for short range communication with data rates up to 3 Mbps. The physical and media access are specified in the IEEE 802.15.1 standard.
Bridge	A device that connects two local-area networks (LANs) that are running the same protocols and cabling. The bridge uses layers 1 and 2 of the OSI model.
Broadband	A type of data transmission in which a single medium may carry several channels at once e.g. cable TV
Bus	A single cable that connects all devices on a local-area network (LAN).
Byte	Eight (8) bits of data.
CAN	(Controller Area Network) A bus protocol developed by Bosch for automotive applications. Also used in the physical and data link layers of DeviceNet.
Class 2 Circuits	Electrical circuits with power limited to a maximum of 100 watts by means of a class 2 power source.
Coaxial Cable	A type of wire that consists of a center wire surrounded by insulation and then a grounded shield of braided wire. The shield minimizes electrical and radio frequency interference.
Collision	The simultaneous data transmission from two separate devices that results in the partial destruction of some or all of the transmitted data.
Connector, Micro	A waterproof, m12, quick-disconnect wiring device which may consist of several wiring points with in a single connector.
Connector, Mini	Same as a micro connector but larger in size.
CSMA/CD	(Carrier Sense Multiple Access / Collision Detection) A set of rules for determining how network devices respond when two devices attempt to use a data channel simultaneously (called a collision). Standard Ethernet networks use CSMA/CD. This standard enables devices to detect a collision. After detecting a collision, a device waits a random delay time and then attempts to re-transmit the message. If the device detects a collision again, it waits twice as long to re-transmit the message. This is known as exponential back off.
Client/Server Architecture	An arrangement where the client shares server resources and each performs portions of the whole task.
Cyclic	Communication which occurs at regular intervals.
Cyclic Redundancy Check	(CRC) A common technique for detecting data transmission errors. Data integrity of a received frame is checked via an algorithm based on the frame content and then matched to the result that is performed by the sender and included in a separate field appended to the frame.
Cyclic Polling	A repetitive sequential interaction with individual devices on the bus network
Data Highway	A medium transmitting large amounts of data between computer systems.

Term	Definition
Data Link Layer	Layer 2 of the OSI model, it determines data connections between devices on a network and controls access to the medium. Error checking is also performed at this level.
D/A	Digital to analog data conversion
DCS	(Distributed Control system) A networked system of client-server devices where the intelligence is distributed throughout the system to perform parts of the whole task.
DD	(Device Description) Used in the Foundation Fieldbus protocol to disclose special parameters and/or blocks used by a specific manufacturer to enable interoperability with other devices on the network.
DeviceNet	A "device level" bus protocol developed by Allen Bradley based on CAN technology to perform mission critical operations in process and factory automation. Up to 62 devices may be connected to a DeviceNet bus consisting of two power and two signal wires. Data rates may vary from 125 Kbs to 500 Kbs with cable length of 500 m and 100 m respectively.
Device tag	A specific physical description for identifying a particular device.
Device Configuration	Establishing the appropriate settings and loading information into a device in order to enable it to function properly on the network.
Deterministic	A network that has less than a one in 10 million chance of message loss typically due to noise, data collisions or network access. This is typically performed by a network with well defined data traffic schemes that prevent data collisions and device network access as well as physical topologies that prevent signal degradation.
Diagnostics	The ability to analyze data to detect problems.
Digital	The transfer of discrete messages typically in bits of data
DIN Standards	(Deutsches Insitut für Normung eV) An organization in Germany that sets standards covering quality assurance, environmental protection, and safety and communication in industry
Discrete Inputs/Outputs	Transmits information for on/off or open/closed applications.
DLL	(Dynamic Link Library) A library of executable functions or data.
Domain	A group of computers and devices on a network that are administered as a unit with common rules and procedures. Within the Internet, domains are defined by the IP address. All devices sharing a common part of the IP address are said to be in the same domain.
Drop	A spur or partial segment connected to the bus network. May also be referred to as a Drop Leg or Spur.
Drop Connector	Ties a drop or spur to the bus network. Connectors may be passive or protected (provides overcurrent and/or overvoltage protections to the drop or spur).
DTM	(Device Type Manager) A standardized method for providing the specific parameters and options of a field device using the Field Device Tools (FDT) concept for establishing system wide device configuration and diagnostics.
EBCDIC	(Extended Binary-Coded Decimal Interchange Code) An IBM code for representing characters as numbers.
Encryption	The translation of data into a secret code. Encryption is a method to achieve data security.
Error Detection	Refers to a class of techniques for detecting garbled messages.

Term	Definition
Ethernet	A local-area network (LAN) architecture developed by Xerox Corporation in cooperation with DEC and Intel in 1976. Ethernet uses a bus or star topology. The Ethernet specification served as the basis for the IEEE 802.3 standard, which specifies the physical and data link layers. It is one of the most widely implemented LAN standards.
Explosionproof Apparatus	Apparatus enclosed in a case that is capable of:
	• Withstanding an explosion of a specified gas or vapor that may occur within it.
	• Preventing ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes or explosion of the gas or vapor within. (Containing ignition pressure and cooling escaping gases)
	• Operating at such an external temperature that a surrounding flammable atmosphere will not be ignited.
	• Also cools the escaping gas to prevent the surrounding environment from exploding.
FAS	(Fieldbus Access Sublayer) A part of the application layer of Foundation Fieldbus in which virtual communication relationships are mapped to scheduled and unscheduled communication services in the data link layer.
Fault	The point of failure in a malfunctioning device or network.
Fiber Optics	A technology that uses glass (or plastic) threads (fibers) to transmit data. A fiber optic cable consists of a bundle of glass threads, each of which is capable of transmitting messages modulated onto light waves.
Field Device	An instrument that is located in the plant environment.
FDT	(Fieldbus Device Tool) Works on Microsoft COM/DCOM technology and provides a manufacturer independent basis to access all communication and application features of a device for system wide configuration and diagnostics.
FHHS	Frequency Hopping Spread Spectrum. A spread spectrum modulation that divides the 2.4 GHz band (83 MHz wide) into 79 hops, each 1 MHz wide. Every 0.4 seconds the transmitter hops to the next frequency determined by a pseudo-random sequence. Multiple channels, each creating a separate wireless LAN, are created with up to 15 different hopping sequences.
Fieldbus	A multi-drop digital bus network relegated to mission critical operation in a plant environment that will handle message strings sufficient for full process control functionality.
FIP	(Factory Instrumentation Protocol) Developed from a French standard, it is a master/slave protocol with a maximum bus length of 2km and a maximum of 256 stations. It has a data rate of 31.25kbit/sec and is primarily used in discrete manufacturing.
FISCO	(Fieldbus Intrinsically Safe Concept) Developed by PTB in Germany and internationally recognized as the basic model to follow to build an intrinsically safe bus network using the 61158-2 physical layer standard.
Frame	A packet of transmitted information.
Frame Relay	A packet-switching protocol for connecting devices on a Wide Area Network (WAN). Frame Relay networks in the U.S. support data transfer rates at T-1 (1.544 Mbps) and T-3 (45 Mbps) speeds. Frame Relay is a way of utilizing existing T-1 and T-3 lines owned by a service provider. Most telephone companies provide Frame Relay service for customers who want connections at 56 Kbps to T-1 speeds. (In Europe, Frame Relay speeds vary from 64 Kbps to 2 Mbps.)

Term	Definition
Foundation Fieldbus	A fieldbus developed for the replacement of the 4 to 20 mA standard in the process industry. It consists of two basic levels; H1 for connecting up to 32 field devices over a 1900 m bus network in hazardous plant environments and HSE (High Speed Ethernet) for control applications with Ethernet as the physical and data link layers using the same application and user layer features as H1.
Full Duplex	The ability to transmit and receive at the same time
Function Block	Used as part of the Foundation Fieldbus protocol to build process control strategies. Function blocks have an internal algorithm and several parameters that perform the basic monitoring and control functionality
Function Block, Flexible	Used in Foundation Fieldbus to incorporate other programming languages into the function block control strategy (e.g. ladder logic)
Gateway	A node on one network that serves as an interface to another network.
Graphical User Interface	(GUI) A program interface that takes advantage of the computer's graphics capabilities to make the program easier to use. Well-designed graphical user interfaces can free the user from learning complex command languages.
GSD	(Gerätestammdaten) Used in PROFIBUS to provide clear and comprehensive descriptions of the device type in a precisely defined format. Each PROFIBUS device has a GSD file provided by the manufacturer.
Half Duplex	The transmission of data in just one direction at a time. (Sending or Receiving)
HART	(Highway Addressable Remote Transducer) A point-to-point protocol that uses a communication signal overlaid on a 4 to 20 mA circuit to communicate data to smart instruments.
Hermetically Sealed	Equipment sealed against the entrance of an external atmosphere where the seal is made by fusion, for example, soldering, brazing, welding, or the fusion of glass to metal.
Homerun Cable	A multi-wire cable that runs from a field junction box to the I/O marshalling panel in conventional point to point wiring schemes.
Host	A computer that is connected to a TCP/IP network, including the Internet. Each host has a unique IP address.
HSE	(High Speed Ethernet) The enterprise level network used with the Foundation Fieldbus (FF) protocol. It consists of Ethernet physical and data link layers and utilizes the application and user layers of FF H1 made up of function blocks designed around process requirements.
Hub	A common connection point for devices in a network. Hubs are commonly used to connect segments of a LAN. A hub contains multiple ports. When a packet arrives at one port, it is copied to the other ports so that all segments of the LAN can see all packets. A passive hub serves as a conduit for the data, enabling it to go from one device (or segment) to another. Intelligent hubs include additional features that enable an administrator to monitor the traffic passing through the hub and to configure each port in the hub. Intelligent hubs are also called manageable hubs. A third type of hub, called a switching hub, actually reads the destination address of each packet and then forwards the packet to the correct port.
IEC	(International Electrotechnical Commission) An organization that cooperates with the International Standards Organization for technology standards.
IEEE	(Institute of Electrical and Electronics Engineers) An organization composed of engineers, scientists, and students. The IEEE is known for developing standards for the computer and electronics industry.

Term	Definition
IEEE 802 Standards	A set of network standards developed by the IEEE.
IEEE 802.15	The 15th working group of the IEEE 802 which specializes in Wireless PAN (Personal Area Network) standards.
Integration	The process of knitting together multiple devices and networks into a seamless control architecture.
Internet	A global network connecting millions of computers.
Interoperability	The ability of software and hardware on different devices from different vendors to seamlessly communicate.
Intrinsic Safety (IS)	A method for preventing ignition in a hazardous area caused by electrical energy. This is accomplished by limiting the power available to the electrical circuit and the energy storage capacity within the circuit under normal and fault conditions.
Intrinsic Safety Barrier	A device used to prevent excessive energy from flowing into an intrinsically safe circuit under fault conditions.
Intranet	A network based on TCP/IP protocols (an internet) belonging to an organization, usually a corporation, accessible only by the organization's members, employees, or others with authorization. An intranet's Web sites look and acts just like any other Web sites, but the firewall surrounding an intranet fends off unauthorized access.
IP	Internet Protocol specifies the format of packets, also called datagrams, and the addressing scheme. Most networks combine IP with a higher-level protocol called Transmission Control Protocol (TCP), which establishes a virtual connection between a destination and a source. TCP/IP establishes a connection between two hosts so that messages can be sent back and forth for a period of time.
ISA	(Instrumentation, Systems, and Automation Society) This organization helps members, other practitioners and organizations worldwide advance and apply science, technology and the allied arts of instrumentation, systems and automation in all industries and applications.
ISDN	(Integrated Services Digital Network) An international communications standard for sending voice, video, and data over digital telephone lines or normal telephone wires. ISDN supports data transfer rates of 64 Kbps.
ISO	(International Organization for Standardization) Derives from the Greek word iso, which means equal. Founded in 1946, ISO is an international organization composed of national standards bodies from over 75 countries. For example, ANSI (American National Standards Institute) is a member of ISO.
ITC	(Instrument Tray Cable) tray cabling for application to instrumentation and control circuits operating at 150 volts or less and 5 amps or less. In tray cables or with special support provisions as open wiring, ITC may be used in hazardous division 2 areas.
Jabber	(1) An error in which a faulty device continuously transmits corrupted or meaningless data onto a network. This may halt the entire network from transmitting data because other devices will perceive the network as busy. (2) A sent data packet greater than the maximum 1518 bytes specified in IEEE 802.3. To prevent this, jabber control should be added to the hardware to make the circuitry incapable of sending information for more than 150 milliseconds (approximately 1500 bytes).
Java	A high-level programming language developed by Sun Microsystems. Java was originally called OAK, and was designed for handheld devices and set-top boxes. Oak was unsuccessful so in 1995 Sun changed the name to Java and modified the language to take advantage of the burgeoning World Wide Web.
Jitter	Generally, any distortion of a signal or image caused by poor synchronization.

Term	Definition
LAN	(Local Area Network) A computer network that spans a relatively small area. Most LANs are confined to a single building or group of buildings.
Link	A communications circuit or transmission path connecting two points.
Link Active Scheduler	(LAS) Controls access of devices to the network and maintains time synchronization in the Foundation Fieldbus protocol.
Lithium-ion	A rechargeable battery technology, widely used in mobile phones, laptops and other mobile devices. It provides more energy capacity than Nickel Metal Hydride batteries of the same weight. Another advantage of the Lithium-ion batteries is that, unlike the Nickel-based, they do not require full discharge before being charged again.
Live List	A list of all devices that are granted permission by the LAS to use the network in Foundation Fieldbus.
Logic solver	A logic device, like a PLC, that accepts inputs and generates outputs but is designed and approved to IEC 61508. A Logic Solver is separate from the process PLC or DCS and contains the logic to perform the SIF.
Lonworks	A proprietary communication network that uses a special IC called the neuron chip. It has a data rate approaching 500 messages a second (1.25 Mbps). A complete network could have thousands of nodes. It uses a differential Manchester signaling system and a modified CSMA media access called predictive persistent which improves performance in heavily loaded buses. The protocol is used primarily in HVAC and discrete manufacturing applications.
MAC	(Media Access Control) The lower sub layer of the data link layer; controls device access to the network for transmitting data.
Manchester Encoding	Digital encoding technique in which each bit period is divided into two complementary halves. A negative to positive voltage transition in the middle of the bit period designates a binary 1 while a positive to negative transition represents a 0. This encoding technique also allows for self-clocking i.e the receiving device can recover the transmitted clock from the incoming data stream.
Master	In multipoint circuits, the unit which controls/polls the nodes. In point to point circuits the unit that controls the slave stations. In LAN technology, the unit on a token-passing ring that allows recovery from error conditions such as lost, busy or duplicate tokens.
MAU	(Media Access Unit) A transceiver connecting a device to the bus network.
Media	The medium over which information is transmitted between devices. The three types of media are copper, fiber and wireless.
Medium	Anything used for the propagation or transmission of signals.
Mesh Network	A network topology in which every device can communicate with any other device that's within range and may communicate using the same protocol.
Migration Path	A phased, organized transition to new technology.
Modbus	A protocol used extensively over the last 30 years to network remote I/O and PLCs into DCS control architecture. This is a master/slave protocol that uses a query-response access method wherein the slaves respond to the masters query. Modbus may use RS232 and RS422 for point to point transmission or RS485 for bus communication with up to 32 devices on a segment up to 4000 feet in length.
Modbus+	An updated version of Modbus with a 1Mbps data rate over an RS485 physical layer.

Term	Definition
Mode Shedding	A characteristic of a function block where, when the operating conditions make the set target mode impossible, the actual mode will change, i.e. automatic change of mode.
Modem	(Modulator-demodulator) A device that modulates an analog carrier signal to encode digital information, and also demodulates such a carrier signal to decode the transmitted information.
Modulation	To blend data into a carrier signal. At the receiving side, a device demodulates the signals by separating the constant carrier signals from the variable data signals.
MTBF	(Mean Time Between Failure) The statistical approximation of how long a number of units will operate before a failure can be expected.
Multiplexer	A communication device that combines several signals for transmission over a single medium.
Multidrop	The capability to have multiple devices connected to the same segment of a bus network.
Multi-Tasking	The ability to execute more than one task at the same time, a task being a program. The terms multi-tasking and multi-processing are often used interchangeably, although multiprocessing sometimes implies that more than one CPU is involved.
Namur	An association of users of process control technology. Two thirds of the members are located in Germany with the remainder located in Spain, Austria, Hungary, Switzerland, Belgium and the Netherlands.
NEC	(National Electrical Code) A collection of standards for electrical safety established by the National Fire Protection Association.
Network Layer	Layer 3 in the OSI model, the network layer is the logical netwok entity that services the transport layer. It is responsible for ensuring that data passed to it from the transport layer is routed and delivered through the network.
Nickel Metal Hydride	A type of battery that holds more power for their size than NiCd batteries.
Node	(1) In networks, a processing location. A node can be a computer or some other device. (2) In tree structures, a point where two or more lines meet.
Neuron Chip	The application specific integrated circuit made by Echelon Corp. that is used in the Lonworks protocol.
Nonincendive Circuit	A circuit, other than field wiring, in which any arc or thermal effect produced under intended operating conditions of the equipment is not capable, under specified test conditions, of igniting the flammable gas-air, vapor-air or dust-air mixture.
Nonincendive Component	A component having contacts for making or breaking an incendive circuit and the contacting mechanism is constructed so that the component is incapable of igniting the specified flammable gas-air or vapor-air mixture. The housing of a nonincendive component is not intended to exclude the flammable atmosphere or contain an explosion.
Nonincendive Equipment	Equipment having electrical/ electronic circuitry that is incapable, under normal operating conditions of causing ignition of a specified flammable gas-air, or dust-air mixture due to arcing or thermal means.
Nonincendive Field Wiring	Wiring that enters or leaves an equipment enclosure and, under normal operating conditions of the equipment is not capable, due to arcing or thermal effects, of igniting the flammable gas- air, vapor-air or dust-air mixture. Normal operation includes opening, shorting, or grounding the field wiring.
Nonincendive Field Wiring Apparatus	Apparatus intended to be connected to nonincendive field wiring. Entity parameters are similar to intrinsically safe apparatus.

Term	Definition
Object Code	The code produced by a compiler. To get from source code to machine language, programs must be transformed by a compiler. The compiler produces an intermediary form called object code.
OLE	Object Linking and Embedding is a compound document standard developed by Microsoft Corporation. It enables objects to be created with one application and then linked or embedded with a second application. Embedded objects retain their original format and links to the application that created them.
OPC	(OLE for Process Control) OPC client/server technology brings fieldbus data into the MS Windows environment.
OSI	(Open System Interconnection) An ISO standard for worldwide communications that defines a networking framework for implementing protocols in seven layers.
Packet	A piece of a message transmitted over a packet switching network. One of the key features of a packet is that it contains the destination address in addition to the data.
Parity	The quality of being either odd or even. The fact that all numbers have a parity is commonly used in data communications to ensure the validity of data.
Partial Stroke Test (PST)	A test in which a valve is moved off its Open seat (typically to 85% Open), checked for functionality, and opened up again. A PST is performed between Proof Tests to make sure the major elements of a SIF are still operational. This will decrease the average PFD without shutting down the process like a Proof Test will.
Peer-to-peer	A type of network in which each workstation has equivalent capabilities and responsibilities.
PFD	(Probability of Failure on Demand) The chance that the safety system will fail when called on to operate.
Physical Block	Responsible for overall management of a device such as running it or placing it out of service as well as forcing the output. It also contains general identification information and overall device diagnostics.
Physical Layer	Layer 1 of the OSI model which describes the actual means of connection to the media. This includes encoding and physically transferring messages between adjacent nodes.
PID Control	(Proportional Integral Derivative Control) A control algorithm used to provide accurate, responsive, smooth loop control functionality.
PLTC	(Power Limited Tray Cabling) tray cabling that is used in class 2 or power limited circuits of 100 watts or less and 60 volts or less. In tray cables or with special support provisions as open wiring, ITC may be used in hazardous division 2 areas.
Polling	In a master/slave scenario, the master queries each slave device in turn as to whether it has any data to transmit. If the slave answers yes then the device is permitted to transmit its data. If the slave answers no then the master moves on and polls the next slave device. The process is repeated continuously.
Preamble	Bits of information that are first transmitted at the beginning of a message to alert devices on the network and allow them to synchronize their receiver to the transmitting device.
Presentation Layer	Layer 6 of the OSI model which ensures that all the data typing and formatting will interface with the applications and session layers.

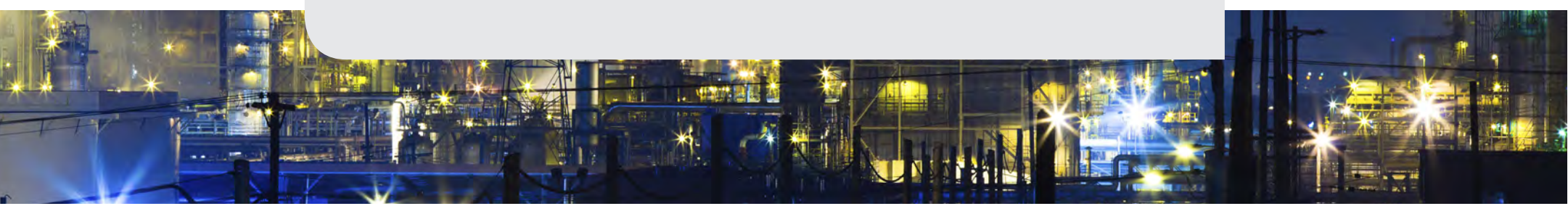
Term	Definition
PROFIBUS-DP	(PROFIBUS Distributed Peripherals) An open protocol which is optimized for speed and efficiency and is designed especially for communication between automation systems and distributed peripherals. It uses RS-485 as its physical layer and runs at data rates from 9.6 kbs to 12 Mbps (Trunk lengths vary from 1200 meters at the lower data rates down to 100 meters at the highest rate). Up to 32 field devices may be connected to the network (with repeaters up to 126).
PROFIBUS-FMS	(PROFIBUS Fieldbus Message Specification) Offers many sophisticated application functions for communication between intelligent devices. It is a "higher" level protocol (communication between PCs and PLCs) which is being relegated to a less dominant role because of the introduction of Profinet.
PROFIBUS-PA	(PROFIBUS Process Automation) Designed to be a bus replacement for the 4 to 20 mA standard in the process industry. It is either coupled or linked to the control architecture using PROFIBUS-DP and shares many of the DP protocol's attributes except for the physical layer. The physical layer is the IEC 61158-2 standard which enables the bus to be used in intrinsically safe applications in hazardous areas.
Profinet	A version of PROFIBUS using Ethernet and TCP/IP for the lower layers while maintaining the PROFIBUS user layer.
Proof test	A test to uncover undetected failures within the SIF that would prevent the safety function. An example would be to completely cycle an Emergency Shutdown Valve to make sure all elements are still operational.
Protocol	An agreed-upon set of procedures that are needed for seamless transmission of data between two devices.
PTB	(Physikalisch-Technische Bundesanstalt) The national institute of natural and engineering sciences; it is the highest technical authority for metrology and physical safety engineering in Germany.
Redundancy	(1) In data transmission, the portion of a message's gross information content that can be eliminated without losing essential information. (2) The technique for building in extra identical components to be used as back ups in case the primary components fail.
Remote Access	The ability to log onto a network from a distant location.
Repeater	A layer 1 device that regenerates (repeats) the input signal, restoring its amplitude and clock sequence.
Resource Block	Used in Foundation Fieldbus to describe the characteristics of the fieldbus device such as device name, manufacturer and serial number.
Ring Topology	Devices connected to one another in the shape of a closed loop, so that each device is connected directly to two other devices, one on either side of it.
RRF	(Risk Reduction Factor) The reciprocal of the average PFD or PFDavg. To calculate the risk reduction needed to lower the risk in a SIF to an acceptable level (consistent with the defined SIL level), the following formula can be used; RRF = (Unmitigated Risk)/(Tolerable Risk).
RS-232	(Recommended Standard-232C) A standard interface approved by the Electronic Industries Association (EIA) for connecting serial devices.
RS-422	(Recommended Standard-422C)Standard interfaces approved by the Electronic Industries Association (EIA) for connecting serial devices. The RS-422 standards are designed to replace the older RS-232 standard because is supports higher data rates and greater immunity to electrical interference. It is capable of supporting 4000 ft lengths with one transmitting device and 32 receiving devices.

Term	Definition
RS-485	(Recommended Standard-485)An Electronics Industry Association (EIA) standard for multipoint communications. It supports 4000 ft. bus lengths and 32 receiving and transmitting points.
SCADA	(Supervisory Control and Data Acquisition) A computer system for gathering and analyzing real time data. SCADA systems are used to monitor and control a plant or equipment.
Segment	A section of a network that is bounded by bridges, routers or switches.
Segment Coupler	A signal converter used to connect the IEC 61158-2 signal to RS-485. (Used with PROFIBUS-DP to PROFIBUS-PA to make one network transparent to the other.)
Serial Transmission	The transmission of a character or bit of data at a time.
Session Layer	Layer 5 of the OSI model, this layer is concerned with management and control of data flow from the application layer through the presentation layer. It also synchronizes and manages activities.
Shielding	A protective grounded metal covering around the wires or cable that protects the electrical signals from outside interference and lessens the chance that information moving along the cable will interfere with adjacent cables.
SIF	(Safety Instrumented Function) A safety function with a specified safety integrity level which is necessary to achieve functional safety (IEC 61511).
SIL	(Safety Integrity Level) A number from one to four that defines the required risk reduction an SIF needs to lower risk to an acceptable level. SIL 1 is the least stringent and SIL 4 is the most stringent. Typically SIL 4 is not used in process control.
SIS	(Safety Instrumented System) An automatic system to reduce the level of risk when a hazard condition occurs. An SIS can be made up of several SIFs.
Slave	Any device that is controlled by another device, called the master.
Spread Spectrum	Radio frequency modulation that spreads the radio energy across a wide frequency spectrum, reducing the power at any one frequency. This is used to reduce interference and make eavesdropping difficult. Spread spectrum is a required modulation in the 2.4 GHz band, by FCC rules.
Spur	A cable which connects the bus trunk to individual devices. Sometimes referred to as Drop or Drop Leg.
Star topology	All devices or spurs connected to a central hub or node.
Subnet	A portion of a network that shares a common address component. On TCP/IP networks, subnets are defined as all devices whose IP addresses have the same prefix. For example, all devices with IP addresses that start with 100.100.100. would be part of the same subnet.
Subscriber	A device, when a message is published or broadcast over the network, that will read the broadcast message.
Surge Protection	A device that protects a power supply and communications lines from electrical surges.
Synchronous	Tied to a common clock with the clock signal being transmitted along with the data.
T1	A dedicated phone connection supporting data rates of 1.544Mbits per second. A T-1 line consists of 24 individual channels, each of which supports 64Kbs.

Term	Definition
T3	A dedicated phone connection supporting data rates of about 43 Mbps. A T-3 line consists of 672 individual channels, each of which supports 64 Kbps.
Tag, device	see device tag
TCP	(Transmission Control Protocol) One of the main protocols in TCP/IP networks. Whereas the IP protocol deals only with packets, TCP enables two hosts to establish a connection and exchange streams of data. TCP guarantees delivery of data and also guarantees that packets will be delivered in the same order in which they were sent.
Terminator	A device attached to the end-points of a bus network. The purpose of the terminator is to absorb signals so that they do not reflect back down the network.
Token	A frame transmitted onto the network by the controlling device. Whichever device has the token is enabled to send a message across the network. There is only one token for each network, so that no two devices will attempt to transmit messages at the same time.
Token Ring	A network access mechanism and topology in which a supervisory frame or token is passed from station to station in sequential order. Stations wishing to gain access to the network must wait for the token to arrive before transmitting data. In a token ring, the next logical station receiving the token is also the next physical station on the ring.
Topology	The physical form of the connections, nodes and links of a network.
Totalizer	May be used as a function block which receives input from other functions and adds or subtracts input values in a preset manner.
Transport Layer	Layer 4 of the OSI model, it provides transparent reliable data transfer from end node to end node.
Transceiver	(Transmitter-Receiver) A device that both transmits and receives analog or digital signals.
Transducer	A device that is actuated by energy from one system and supplies energy usually in another form to a second system.
Transducer Block	A function block, used in Foundation Fieldbus, that decouples function blocks from the local input/output functions required to read sensors and command output hardware. It also contains information such as calibration date and sensor type. There is usually one transducer block for each input or output function block.
Tree Topology	A tree topology combines characteristics of linear bus and star topologies. It consists of groups of star-configured workstations connected to a linear bus backbone cable.
Trunk	The main network cable when using bus topology.
Twisted Pair	Two insulated conductors that are wound around each other mainly to cancel the effects of electrical noise.
UDP	(User Datagram Protocol) a connectionless protocol that, like TCP, runs on top of IP networks. Unlike TCP/IP, UDP/IP provides very few error recovery services, offering instead a direct way to send and receive datagrams over an IP network. It's used primarily for broadcasting messages over a network.
User Layer	A layer (not included in the OSI model) which resides above the application layer that defines the application program or objects that run on the application layer.
UTP	(Unshielded Twisted Pair) A popular type of cable that consists of two unshielded wires twisted around each other.
Vampire Taps	A drop connector which clamps onto the network cable and pierces the insulation with "fangs" that engage into the wire.

Term	Definition
VFD	(Virtual Field Device) Used in Foundation Fieldbus for network and system management. All of the configuration information needed by system management, such as function block scheduling, is described by object descriptions in the network and system management VFD in each device.
WAN	(Wide Area Network) A computer network that spans a relatively large geographical area. Typically, a WAN consists of two or more local-area networks (LANs).
Wireless	A method of propagating signals through the air.
Wi-Fi	Wireless Fidelity, the brand name for IEEE 802.11a, 802.11b and 802.11g products that have passed the Wi-Fi Alliance's certification procedure.
WNG	Wireless Next Generation Standing Committee
Zigbee	The name of a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs). The relationship between IEEE 802.15.4- 2003 and ZigBee is similar to that between IEEE 802.11 and the Wi-Fi Alliance. Target applications are control and monitoring systems that infrequently send small amounts of data.

Stonel brand product overviews



Stonel brand catalogs
Valve communication and control

FieldLink process networking

Valve communication and control

Platforms for quarter-turn valve and actuator applications

- Axiom AX: explosionproof monitoring with integral pneumatic control
- Axiom AMI: nonincendive monitoring with integral pneumatic control
- Quartz QX, QN and QG: versatile platform
- Eclipse EN and EG: compact and modular with integral proximity sensors

Axiom AX

Axiom AMI

Quartz (QX)

Eclipse (EN)

We offer a full range of monitoring, communication, and control platforms ideally suited for quarter-turn and linear discrete valve applications in extreme process environments.

Valve communication and control

Platforms for linear valve and actuator applications

- Prism PM: solid state sensors and pneumatic control for diaphragm and angle valve applications
- Hawkeye HK and HX: linear point sensors for globe, gate and specialty ¼ turn applications

Prism

Hawkeye

See Stonel ValvePoint: valve communication and control product catalog

Axiom AX

The AX series is suited for hazardous explosionproof applications with either a stainless steel or epoxy-coated anodized aluminum enclosure. This robust platform may be used in a broad array of extreme, corrosive process environments.

Overall capabilities

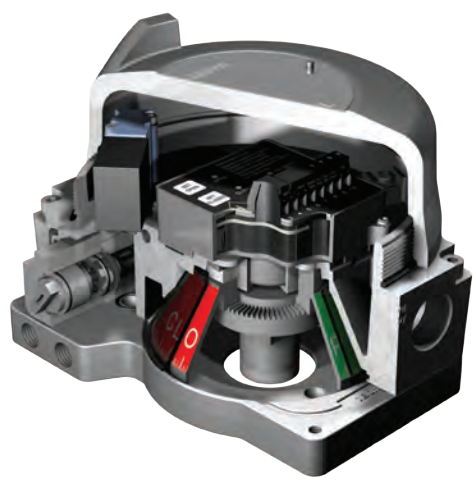
- Advanced non-contact position sensing system with push button settings
- High-flow integrated pneumatic valve with high tolerance to dirty air
- Rugged explosionproof enclosure available in epoxy-coated aluminum or 316 stainless steel
- Full range of feedback and control options for conventional and bus networking applications
- Space-efficient design consolidates all monitoring and control components minimizing automated valve space envelope

Stainless steel enclosure

Epoxy-coated aluminum enclosure

Overall construction

- Rugged enclosure with rapid access and vaportight screw on cover.
- Rugged epoxy-coated anodized aluminum or stainless steel enclosure and mounting/manifold
- High flow integral pneumatic valve
- Easy access pneumatic pilot
- High visibility, space saving visual mechanical indication
- Non-contact drive system with no shaft or bushings to bind or wear out
- All solid state “C-module” with push button settings and fully sealed construction for high tolerance to shock and vibration.
- Suitable for most challenging explosionproof requirements.
- Adaptability to most ¼ turn actuators



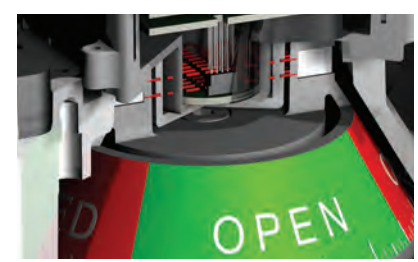
Integrated pneumatic control

- Exceptional tolerance to dirty air and high flow rate (Cv-0.7) make it ideal for most standard ¼ turn on/off valve actuators
- 5-way, 2-position configuration is capable of operating both double-acting and spring return actuators.
- Pre-filtered burn-out proof solenoid pilot features low power consumption
- Rebreather capability prevents contaminants from entering spring side of actuator
- Standard internal momentary override and optional external momentary or latching overrides available
- Single coil or dual coil shuttle piston configurations available
- Operational life over 1 million cycles; easily replace o-rings for additional life

Pneumatic control is available for most spring return and double acting actuators with the same AX model.

Sensing and communication C-Module

- Mag res sensor system detects exact valve position (Sensor accurately detects magnetic flux direction through aluminum or stainless steel housing)
- Push button settings lock in open and closed valve position with less than 1° of repeatability
- Actuator shaft wear resulting in shaft eccentricity will not affect drive system (No bushings or shaft to bind or wear)
- SST switching module enables universal 120 VAC and 24 VDC monitoring feedback and solenoid input.
- Wide variety of electronic monitoring and control options



The unique, compact and patent pending AX design offers unparalleled reliability due to its advanced capabilities.

Mounting/manifold system

- Adapts directly to VDI/VDE 3845 standard (NAMUR)
- All fasteners and coupler are 316 SS (Manifold is different than AMI)
- Set-up is the same as Axiom AMI
- Unit may be removed by turning off pneumatics and unbolting from actuator – No electrical disconnects or power down are needed

Stainless steel enclosure

- Enclosure is identical to AX aluminum but is made of 316L stainless steel
- All external components, fasteners and mounting manifold are also 316 stainless steel
- Visual indicator lens is fusion-coated Lexan®, and drum is polysulfone
- Pneumatic spool is nickel-plated, Teflon-coated 316 stainless steel
- Internal components are same as standard aluminum model

With the integrated pneumatic control and low profile design, the AX system minimizes the automated valve system dimensional envelope.

Axiom AX

Product approvals

- Explosionproof
  - NEC & CEC Class I, Groups B, C & D, Class II Groups E, F & G Divisions 1 & 2
  - IEC & ATEX Ex d IIC, T6 (II 2 G)
- Enclosure
  - NEMA 4, 4X & 6
  - IP 66 & IP 67 (less rigorous than NEMA)
- Also nonincendive and intrinsically safe are being added

The AX platform has been designed to withstand the most severe process environments.

See Stonel ValvePoint: valve communication and control product catalog

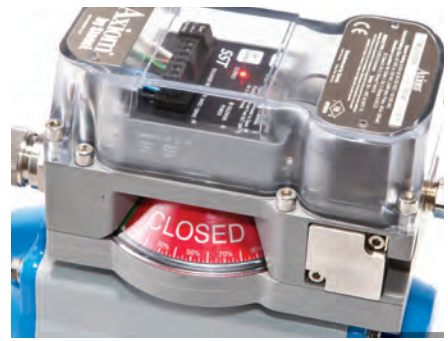
Axiom AMI

Monitoring

- (33) Dual SST switches (conventional applications)
- (44) Dual NAMUR sensors (intrinsically safe applications)
- (80) Expeditor 4-20 mA (intermediate control applications)

Valve Communication Terminals (VCTs)

- (71) 4-20 mA with HART diagnostics
- (92) DeviceNet
- (93) Foundation Fieldbus bus powered
- (94) Foundation Fieldbus externally powered
- (95) Modbus
- (96) AS-Interface (available with diagnostics option)
- (97) AS-Interface with extended addressing



Featuring the same electronic and pneumatic control capabilities as the explosionproof AX version, the AMI offers a compact design with high visibility position and control status. It is ideally suited for nonincedive, intrinsically safe and general purpose applications.

Overall construction

- High strength, corrosion proof epoxy-coated anodized aluminum and Lexan® enclosure
- High visibility mechanical indication
- Completely sealed electronic module tolerates moisture
- High accuracy solid state position sensing with no mechanical wear points
- Standard rebreather system to prevent actuator corrosion
- Direct VDI/VDE 3845 (NAMUR) attachment
- C-module and integrated pneumatic control same as Axiom AX

Pneumatic design is also similar to the AX, enabling one unit to operate both single-acting and double -acting actuators. In addition, the AC/DC universal input on the SST versions increases application adaptability.

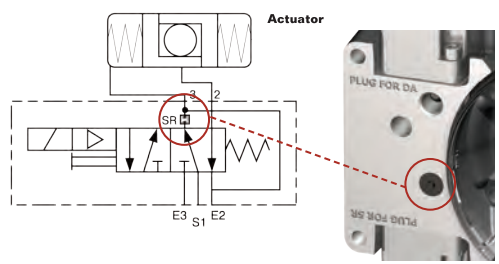
Mounting/manifold system

- Visual indicator indexing coupling (part of communication and control module)
- Shaft coupling and fastener; made of stainless steel and designed for specific actuator (mounting kit)
- Mounting plate, manifold, o-rings and fasteners; four different sizes epoxy-coated anodize aluminum (mounting kit)
- Pneumatic porting to actuator

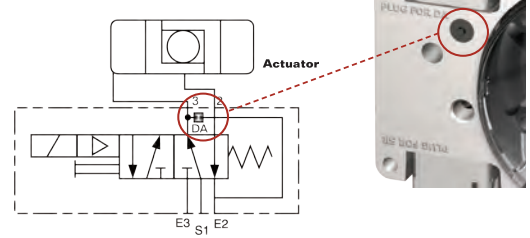
Mounting may be accomplished in minutes and the valve assembly envelope dimensions minimized.

Mounting/manifold system

Spring return actuator



Double-acting actuator



All Axiom versions feature a simple to set-up rebreather feature and the adaptation for single- or double-acting actuators. Field configuration may be made by removing and re-inserting the pneumatic plug into the designated port for the appropriate actuator type.

See Stonel ValvePoint: valve communication and control product catalog

Quartz

Capabilities

- Readily adaptable to most actuators
  - Same mounting kits
- Approved for most hazardous areas
  - Class I & II Div. 1 and 2 (includes group B always)
  - Ex d IIC Zone 1 and 2
  - Ex nA IIC Zone 2
- Wide variety of electrical options
  - 2, 4 or 6 switches
  - Mechanical, reed proximity or solid state
  - Position transmitter (4 to 20 mA with or without switches)
- Multiple conduit options (2 conduits standard)
- Rugged enclosure made of epoxy-coated anodized aluminum
- Operational life exceeds 1 million cycles with proximity switches

QX

QN

QG

The Quartz epoxy-coated anodized aluminum enclosure is ideally suited for virtually any valve monitoring application in explosionproof areas (QX models).

Features

- Aluminum cover for Zone 1 areas
- Quick access screw-on cover is vaportight
- Quick set cam system is secure and convenient
- Epoxy-coated anodized marine grade aluminum is corrosion proof
- Stainless steel grounding inserts
- O-ring sealed shaft at top and bottom
- Up to 3 conduit entries for solenoid termination
- Oil impregnated bronze bushing
- Space saving visual indicator
- Convenient wiring with pre-labeled terminal strip
- All internal fasteners, plates and mounting kits are stainless steel

The Quartz platform has been proven in service with an installed base spanning the globe. The latest version has been upgraded to further build on the Quartz's reputation for reliability.

Quartz

Position transmitters

- Used on modulating valves to tell control system exact position of valve
- Can be used for both quarter-turn and linear valves
- 4 to 20 mA output


Analog output capabilities and a variety of mounting kits enable the quartz to be used in a myriad of applications.

See Stonel ValvePoint: valve communication and control product catalog

Eclipse

Capabilities

- Compact design
- All solid state for ultra long life
- Approved for hazardous intrinsically safe (Zone 0 & 1) and nonincendive applications (Zone 2)
- Mounts directly to actuator with NAMUR (VDI/ VDE 3845) mounting patterns
- Unlimited operating life
- Lowest cost Stonel platform with solid state sensing and/or communication
- Select from conduit (EN) or micro connector (EG) versions

The Eclipse EN is designed for nonincendive applications and the EG is designed for general purpose micro-connector installations.

Features

- No moving mating parts assure long life and trouble-free operation.
- Red/green visual indicator boldly displays valve status, and coordinates with red/green LEDs. (yellow flow line indication also available)
- Direct attachment to ISO/NAMUR mounting pads with simple mounting kit (sold separately)
- High intensity red and green LEDs indicate electronic switch status to confirm electrical operation
- Sensor triggers are adjustable in 3.5 degree increments through 360 degrees for precision and flexibility
- Submersible and capable of high pressure washdown, Eclipse sensors and electronics are fully sealed to eliminate hazard threat and corrosion problems
- Extremely compact, rugged enclosure integrates position sensors, communication, electronics, and power outputs for solenoids
- All mechanical parts are made of Lexan® or stainless steel for corrosion resistance and durability

Unique features make the EN a very cost effective platform when modular, compact systems are desired.

Eclipse

Set-up is quick and flexible with the high visibility, corrosion-resistant visual indicator triggering system.

Lockout specifications

- Red/green visual indicator with adjustable trigger system
- Lexan® enclosure (fusion-coating available)
- Stainless steel targets
- Inductive solid state sensors
- Max leakage current of 0.25 mA
- 5 year warranty

Sensors and visual indication

Solid state switches

- 2 SST Sensors for 120 VAC or 24 VDC
- 2 NAMUR sensors for IS (EN 60947-5-6)

Bus network sensors

- AS-i, DeviceNet, Modbus

Visual indicator

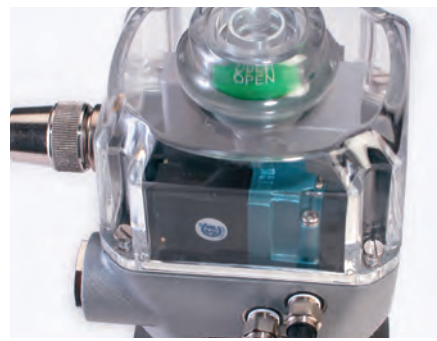
- Red/green visual indicator for Eclipse and stand alone versions (VIR or VIG)
  - Very compact design
  - ISO/NAMUR mounting (VDI/VDE 3845)
  - Low cost
  - Viewable from all angles at a distance up to 70 feet
- Yellow flow line indicator
  - Referenced to Eclipse function module
  - Viewable from all angles at a distance up to 30 feet

See Stonel ValvePoint: valve communication and control product catalog

Prism

Capabilities

- Sanitary diaphragm valve sizes 0.25” to 4”
- Angle valves (stroke lengths from 1/8” to 2 ¼”)
- Other linear valve systems with stable linear movement

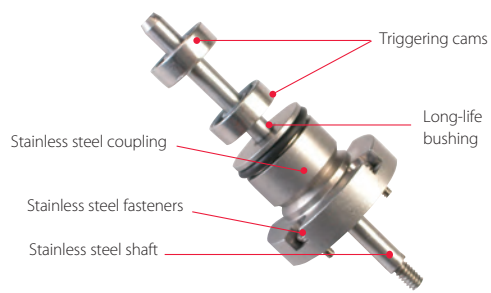


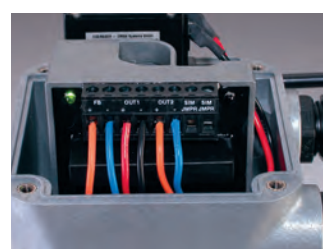
The Prism offers self-adjusting solid state position sensing and integral pneumatic control. This platform is ideal for monitoring and control of linear and diaphragm valves.

Prism

Features

- Integral pneumatic valve
- Secure, self-adjusting triggering system (no resetting needed as the diaphragm compresses over time)
- Solid state with inductive proximity sensors
- Fully sealed electronics
- Available options
  - (33) SST switching sensors
  - (44) NAMUR sensors (IS repeater barriers)
  - (96) AS-Interface (2 aux in)
  - (97) AS-Interface with extended addressing (2 aux in)
  - (92) DeviceNet (4 to 20 mA aux in)
  - (95) Modbus (4 to 20 mA aux in)
  - (93) Foundation Fieldbus bus powered
  - (94) Foundation Fieldbus externally powered

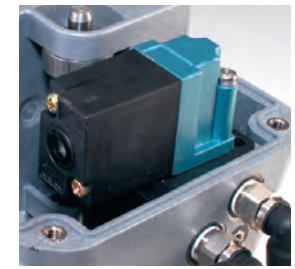




Prism

Integral pneumatic valve

- 3-way 2-position spring return (single-acting actuator)
- Stainless steel reinforced pneumatic ports
- Standard rebreather feature (no corrosives ingested into actuator)
- High cycle life
- Solenoid AC, DC or piezo options (Foundation Fieldbus bus powered)
- Filtration to
  - 40 micron, solenoid
  - 30 micron, piezo



The addition of a pneumatic valve does not increase the Prism dimensional envelope, making it compact as well as rugged and corrosion proof.

Prism

Pneumatic valve				
Valve code	Type	Description	Flow rate Cv	Kv
1A	Piezo	6.5 VDC (0.013 watt)	0.05	0.04
1B	Solenoid	24 VDC (1.8 watt)	0.06	0.05
1C	Solenoid	120 VAC (5.4 watt)	0.14	0.13
1D	Solenoid	24 VDC (0.5 watt)	0.05	0.04
1E	Solenoid	I.S. 12 VDC (0.5 watt)	0.04	0.03

See Stonel ValvePoint: valve communication and control product catalog

Hawkeye HK

Capabilities

- Ideal for all point sensing applications
  - Globe valves
  - Knife gate valves
  - Rotary valve couplings
  - Dampers and more
- Approved for nonincendive Zone 2 and corrosive environments; IS approved for Zone 0 & 1
- Senses off any metal target including stainless steel (4-6 mm; sensing distance will vary depending on target material)
- Open and closed sensors designed to work adjacent to one another (no interference)

Hawkeye applications include end-of-travel indication for knife gates and globe valves, valve-actuator coupling sensing, and more.

Features

- Lexan® sensing head triggers on any metal
- 316 stainless steel housing is rugged and corrosion proof
- Solid state electronics and sensing head are sealed in potting for long life and corrosion protection
- LED indication and coordinated tip visually identify switch status
- Approved for nonincendive (Zone 2) applications
- IS approved for Class I Division 1
- Select from conduit or quick connector options
- Use in both 120 VAC and DC circuits (operates same as SPST switch)
- Hawkeye available to interface with Stone'Ls bus network modules
  - AS-i, DeviceNet, Foundation Fieldbus and Modbus
- Inductive solid state sensors
  - 1 SST sensor for 120 VAC or 24 VDC (NO or NC)
  - Special sensors for bus powered Foundation Fieldbus
  - New NAMUR (40) sensor for IS applications

See Stonel ValvePoint: valve communication and control product catalog

Hawkeye HX

Capabilities

- Hermetically sealed SPDT Maxx-Guard proximity switch elements
- Urethane potting material
- Switches activated by external magnetic trigger embedded in a stainless steel fastener

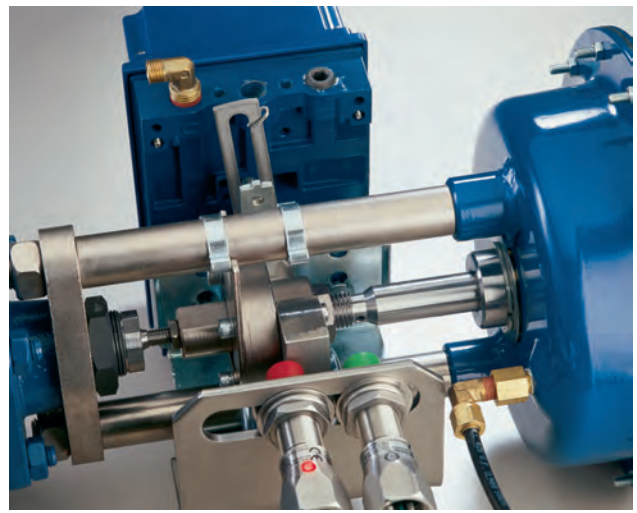
The explosionproof Hawkeye HX, with its stainless steel enclosure, is designed for service in harsh process environments.

Features

- 316 stainless steel body is extremely durable and corrosion resistant.
- Stainless steel washers and fasteners enable secure vibration resistant mounting.
- Maxx-Guard hermetically sealed switches are available for SPDT operational inputs into DCS/PLC and higher power applications.
- Switches are urethane sealed in a module which is sealed within the stainless steel body assuring high tolerance to shock and vibration.
- Stainless steel trigger system included with each HX enables switch triggering from distances up to 8 mm.
- Mounting kits available for convenient attachment to most of linear valve applications.
- 1/2” NPT or M20 conduit options are available with standard 6-foot cord lengths allowing flexible wiring options.
- No seal offs required with explosionproof conduit systems reducing installation costs.
- Suitable for Zone 1/Division 1 explosionproof, Zone 2/Division 2 nonincendive applications and may be used for passive switching with Zone 0/ Division 1 continuous gas exposure intrinsically safe applications.

Hawkeye HK

Globe valve application



HK sensors may be placed next to one another with no threat of interference due to close proximity. Open and closed sensors are tuned with different frequencies to enable this capability.

Hawkeye HX

Knife gate application

Magnetic target is attached directly to actuator/ valve stem. Sensing distance of up to 8 mm may be realized with the standard magnetic trigger.

See Stonel FieldLink process networking product catalog

FieldLink process networking products

Networking solutions

- Junction module (JM) explosionproof
- FieldBlock (FN) nonincendive and intrinsically safe connectivity
- FieldRack (FR) nonincendive
- Drop connectors
- I/O modules
- Repeater/power conditioners
- Masters/gateways
- Power supplies and other components

With Stonel FieldLink program, choose products and services to effectively integrate automated valves and other instrumentation into communication networks.

Components pre-installed in the JM or FN are also sold separately for DIN rail or conventional attachment in other field enclosures.

Masters/gateways

- Control the network segment and may interface from one protocol to another.
- Many options are available with emphasis on AS-Interface to higher level networks.

Power supplies

- Specially designed for process applications.
- Ideally suited for communication applications.
- Units available for hazardous nonincendive applications in the field and are short circuit protected.

Other components

- Field enclosures
- Terminators and tuners
- Network cable
- And more.

Select from an array of components to complete your network.

See Stonel FieldLink process networking product catalog

Junction module JM

Explosionproof

- Anodized aluminum is epoxy-coated for corrosion resistance
- Suitable for use in heavy washdown and submersible applications with NEMA 4, 4X and 6 ratings
- Housing rated for Class I & II Division 1 & 2 Groups B, C, D and approved (FM approved)
- Clear Lexan® (Div 2) cover available to view LED functions
- No seal fittings required in both Division 1 & 2 hazardous areas

Stonel explosionproof junction module is suitable for use in corrosive process environments with hard conduit or flexible wiring systems. It features external drop switching capability with explosionproof ratings for use in hazardous zone 1/Div 1 areas. In addition to drop connectors the JM also is available with I/O module, repeater, power conditioner, and many other functional capabilities.

Specialty applications

- Integrated pneumatics
- Special sensor connectivity
- Other configuration options

PROFIBUS MODBUS DeviceNet Fieldbus

See Stonel FieldLink process networking product catalog

FieldBlock FN

Nonincendive and intrinsically safe connectivity

Features

- Anodized aluminum enclosure is durable and corrosion proof
- Suitable for use in heavy washdown and submersible applications with NEMA 4, 4X and 6 ratings
- Multiple connector or cable gland options conveniently interface with flexible wiring systems
- Compact design minimizes space requirements

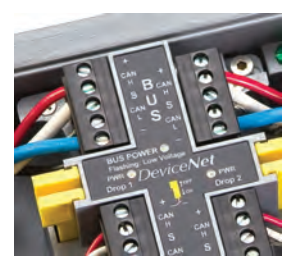
The FieldBlock platform is designed to interconnect field devices to the communication network in nonincendive, intrinsically safe, and general purpose applications. It may be used for flexible and hard conduit wiring systems. With its rugged corrosion proof enclosure, variety of drop connector, and I/O module configurations it will prove invaluable in field networking applications.

Individually switched drop connector features

- Reduced maintenance costs
- Improved safety
- Reduced set-up and commissioning costs
- Greater convenience for quick connectors in hazardous areas

Internal components available separately

Drop connectors and I/O modules are also available for DIN attachment or direct mounting.



Stonel valve communication solutions (discrete valves; on/off valves)				
	Quarter-turn		Linear	
	Automated	**Manual valve, gearboxes, globe valves, specials**	**Knifegate**	**Sanitary diaphragm, angle valves**
Axiom AX (integral solenoid) 	Yes			
Axiom AMI (integral solenoid) 	Yes			
Quartz (external solenoid) 	Yes	Yes		
Eclipse (external solenoid) 	Yes			
Prism 				Yes
Hawkeye HK/HX 			Yes	

Contact us/support

We provide

- ☑ Application/networking assistance
- ☑ On-site and off-site training
- ☑ Installation, trouble shooting, and commissioning support
- ☑ Local channel supply and assistance
- ☑ Extensive product reliability testing
- ☑ Field sales manager support

Tech hotline: 1-218-737-0701
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Valmet's professionals around the world work close to our customers and are committed to moving our customers' performance forward – every day.

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