

Intrinsic Safety

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Crouse-Hinds
by **E.T.N**



Responsibilities – plant operator

Plant and Installations are classified according to:

- The *nature* of the Hazardous Atmosphere
 - **Industry Group**
 - **Gas/Apparatus Grouping**
 - **Ignition Temperature**
- The *probability* that the Hazardous Atmosphere will be present
 - **Area Classification**



Area classification IEC/European member countries

Areas are classified with regard to the probability of a potentially explosive atmosphere being present and the length of time for which it is likely to exist:

Hazard	Zone	Definition
Gas	0	in which an explosive gas-air mixture is continuously present or present for long periods
	1	in which an explosive gas-air mixture is likely to occur in normal operation
	2	in which an explosive gas-air mixture is not likely occur in normal operation, and if it occurs it will exist only for a short time
Dust	20	in which a combustible dust atmosphere is continuously present or present for long periods
	21	in which a combustible dust atmosphere is likely to occur in normal operation
	22	in which a combustible dust atmosphere is not likely occur in normal operation, and if it occurs it will exist only for a short time

CROUSE-HINDS
SERIES

Group II Electrical Apparatus for gas atmospheres 'G' and combustible dusts 'D'

[illegible]

1. *Journal of the American Medical Association*, 1997; 278: 1039-1044.



ATEX EQUIPMENT GROUPS & CATEGORIES

Mining			Year 2017		Year 2018	
Investment Group	Development Category	Production Level	2017	2018	2017	2018
Mining	M1	High	100	100	100	100
	M2	Low	100	100	100	100
	M3	Low	100	100	100	100
Investment Group	M1	High	100	100	100	100
	M2	Low	100	100	100	100
	M3	Low	100	100	100	100

INGRESS PROTECTION (IP) CODES (NEMA 4X)

INGRESS PROTECTION (IP) CODES (NEMA AND IEC)			
FIRST NUMBER			
Protection against solids			
NO PROTECTION	0	1	2
OBJECTS GREATER THAN 1mm	3	4	5
OBJECTS GREATER THAN 0.5mm	6	7	8
OBJECTS GREATER THAN 0.1mm	9		
COMPLETE PROTECTION			
SECOND NUMBER			
Protection against liquid			
NO PROTECTION	0	1	2
VERTICAL DROPPING WATER	3	4	5
WATER SPRAY	6	7	8
WATER JET	9		
COMPLETE PROTECTION			
EXAMPLES			
Engine and drive shaft protected against water spray			

	08	07	06	05	04	03	02	01	00
08	07	06	05	04	03	02	01	00	09



IPS ENCLOSURE RATING

[illegible]

See also 180, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 9

Course/Module/Section - Course		REMARKS	
Engineering mathematics - part 1B	122-122-1001	revis-	basic concepts understanding for all essential operations
Engineering mathematics - part 1B	122-122-1001	revis-	basic concepts understanding for all essential

ENTRANCE EXAM

[illegible]

Conductable dust is defined as finely divided solid particles, filler or less in nominal size.
Conductive or non-conductive
(ICC 5009-4 Section 2.11.1)

Conductible filings are defined as solid particle
finer greater than filler in nominal size.
(ICC 5009-4 Section 2.11.2)

Functional Safety
ANALYSIS • Design • Verification • Validation

During the last several years, we have been using a variety of processes, products, and services to deliver a lot of value to our clients, and we are looking for ways to do this in a more efficient and effective way. We are looking for ways to do this in a more efficient and effective way. We are looking for ways to do this in a more efficient and effective way.



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2009	2010
2010	2011

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APR 2002	1
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2025 AUGUST 15/16
 2025 SEP 13/14
 2025 OCT 13/14
 2025 NOV 13/14
 2025 DEC 13/14

2014年12月12日



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reserved



The IEC methods of protection – current status

Method of Protection	Ex code	Permitted in:		
		Zone 0	Zone 1	Zone 2
Encapsulation	ma	✓	✓	✓
	mb		✓	✓
	mc			✓
Oil immersion	o		✓	✓
Powder filling	q		✓	✓
Pressurisation	px		✓	✓
	py		✓	✓
	pz			✓
Flameproof	da	✓	✓	✓
	db		✓	✓
	dc			✓
Intrinsic safety	ia	✓	✓	✓
	ib		✓	✓
	ic			✓
Increased safety	e		✓	✓
Type of protection “n”	nA			✓

Intrinsic Safety

- Fundamental of IS
 - origins, principles, apparatus, type of interfaces
- Customise Backplane Solution
- IS application
 - Selection of product (AI,AO,DI,DO,PULSE & TEMPERATURE)
- Design of IS system
 - Level of protection, Gas classification, Temperature classification
 - Compatibility of IS isolator and field device Determine the permitted cable parameter Solution for long cable application
- Installation
 - Cable installation
 - New requirement based on IEC60079-14: 2013
 - Terminal boxes with more than one IS circuit
 - Earthing
- Inspection and maintenance

Intrinsic Safety System

A system, comprising apparatus and interconnecting wiring, in which any spark or thermal effect in any part of the system intended for use in hazardous areas is incapable of causing ignition.

Three Principles of Ex i Design

1. Limit Current

2. Limit Voltage

3. Limit Stored Electrical Energy

Intrinsic safety levels of protection

Ex ia

**Intrinsically safe
with *two* faults**

Zones 0, 1 and 2

Ex ib

**Intrinsically safe
with *one* fault**

Zones 1 and 2

Ex ic

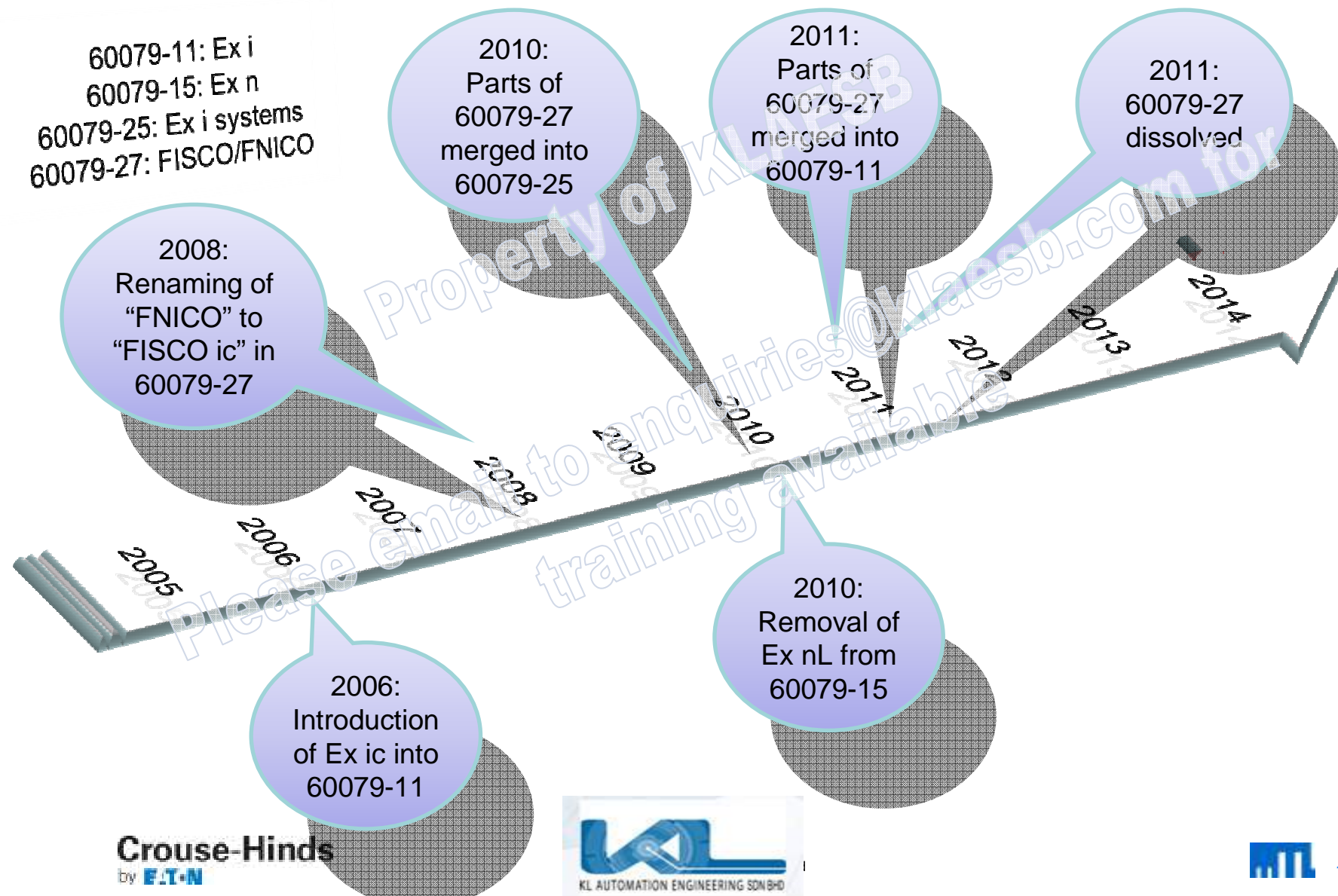
**Intrinsically safe
in *normal* operation**

Zone 2

"Faults" are those in components upon which safety of the installation depends.

Intrinsic safety is the only protection concept that considers failure of the field wiring.

Changes in Ex Standards on Ex ic



Ex nL versus Ex ic

Characteristic	Ex nL	Ex ic
Basic method of protection	Energy Limitation	
Acceptable Zone of use	Zone 2	
Applicable standard and protection method	IEC 60079-15: Ex n (safe in normal operation)	IEC 60079-11: Ex i (intrinsic safety)
Live-working permitted?	Yes	Yes
Cables may share same multi-core* as IS circuits?	No	Yes
Cables may share same multi-core as non-IS circuits?	Yes	No
Separation of terminals •from I.S. circuits •from non-I.S. circuits	•50 mm •Not required	•Not required •50 mm
Applicability	Obsolete, phasing out	Current, future-proof

* Multi-core cable for I.S. circuits has to meet certain criteria

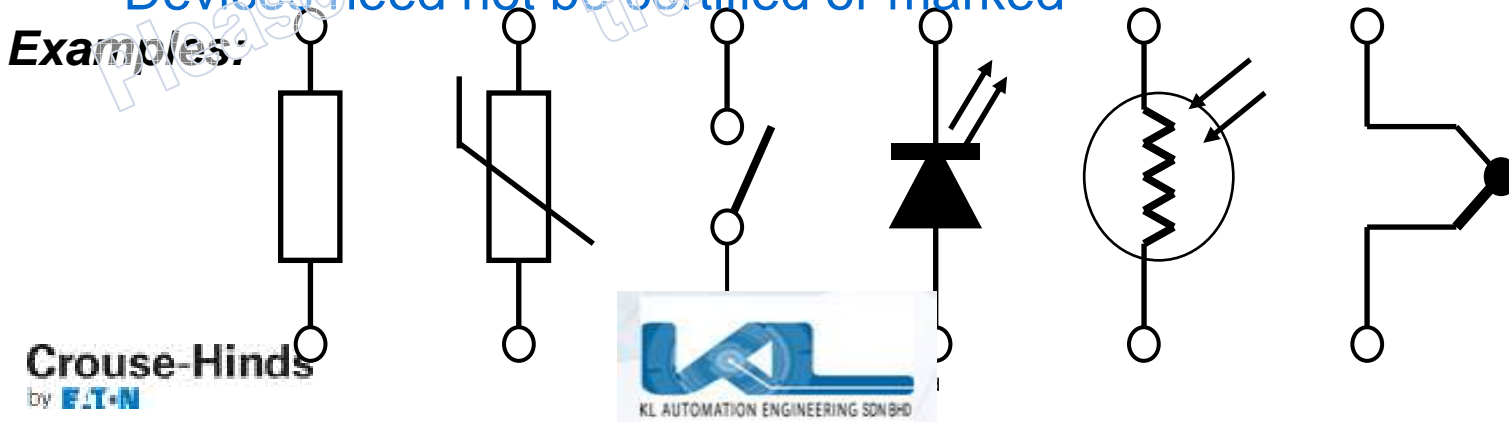
Uniqueness of IS system

- Suitable for zone 0
- Permits live maintenance, personnel safe
- Simple apparatus rules offer great flexibility

Simple Apparatus

- What is considered Simple Apparatus?
 - Passive components e.g. switches, junction boxes, potentiometers and simple semiconductor devices
 - Sources of stored energy within well defined parameters
 - Sources of generated energy which do not exceed 1.5V, 0.1A or 25mW
- IEC 60079-11: 2012, Clause 5.7 says:-
 - “Devices need not be certified or marked”

Examples:



Types of IS interface

There are 2 type of IS interface:

1. Zener Barrier

Also referred to as just 'barrier' , 'Shunt diode barrier', 'Zeners' or 'safety barrier'



2. Isolating Barrier

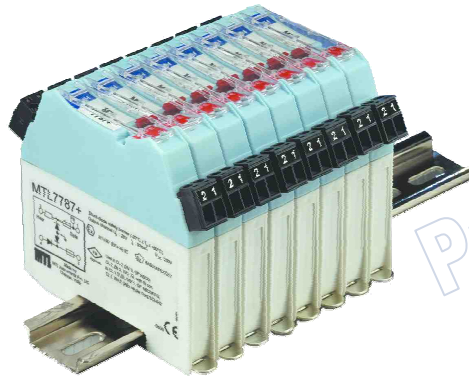
Also referred to as IS Isolator, Galvanic Isolator



These may also be located in, or part of, other equipment.

IS Interface Products

Shunt Diode Barriers



MTL7700 series

Isolating barriers / Isolator



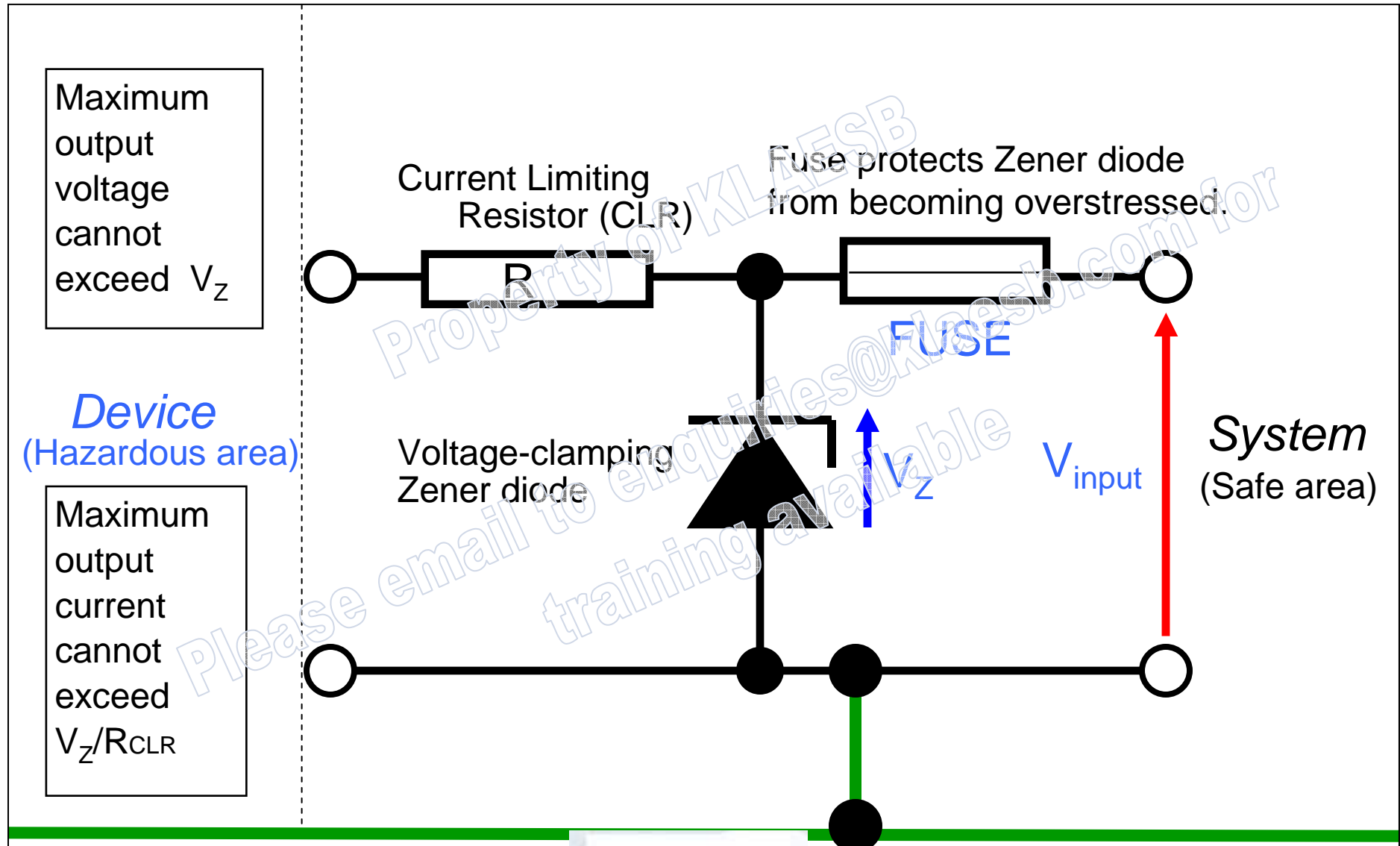
MTL 4500 series
Backplane mounted with
System connector for easy
And real system integrated



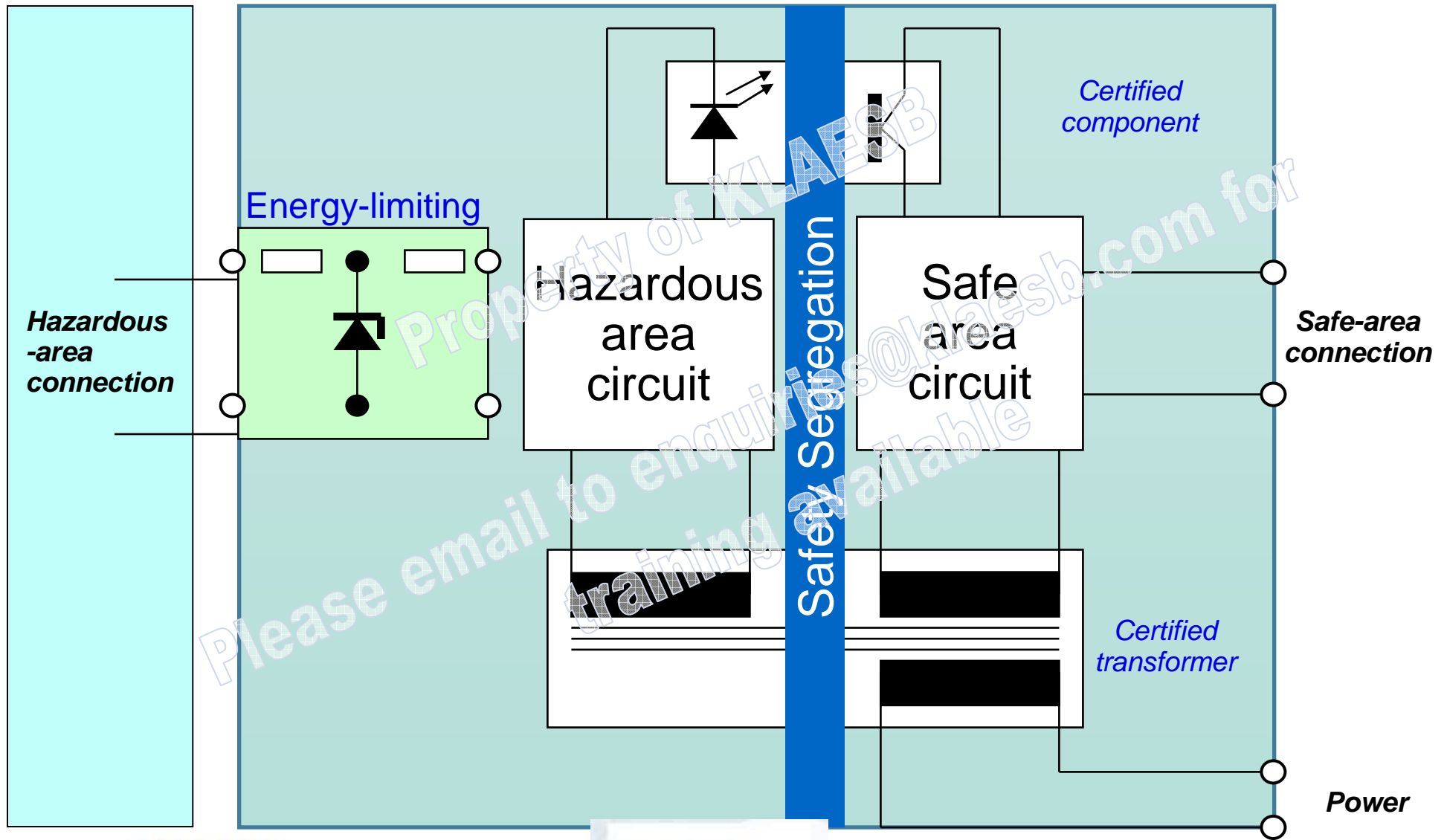
MTL5500 series
DIN-rail mounting
simple installation
with plug-in connectors

BASIC PRINCIPLES **of** **Barriers & Isolators**

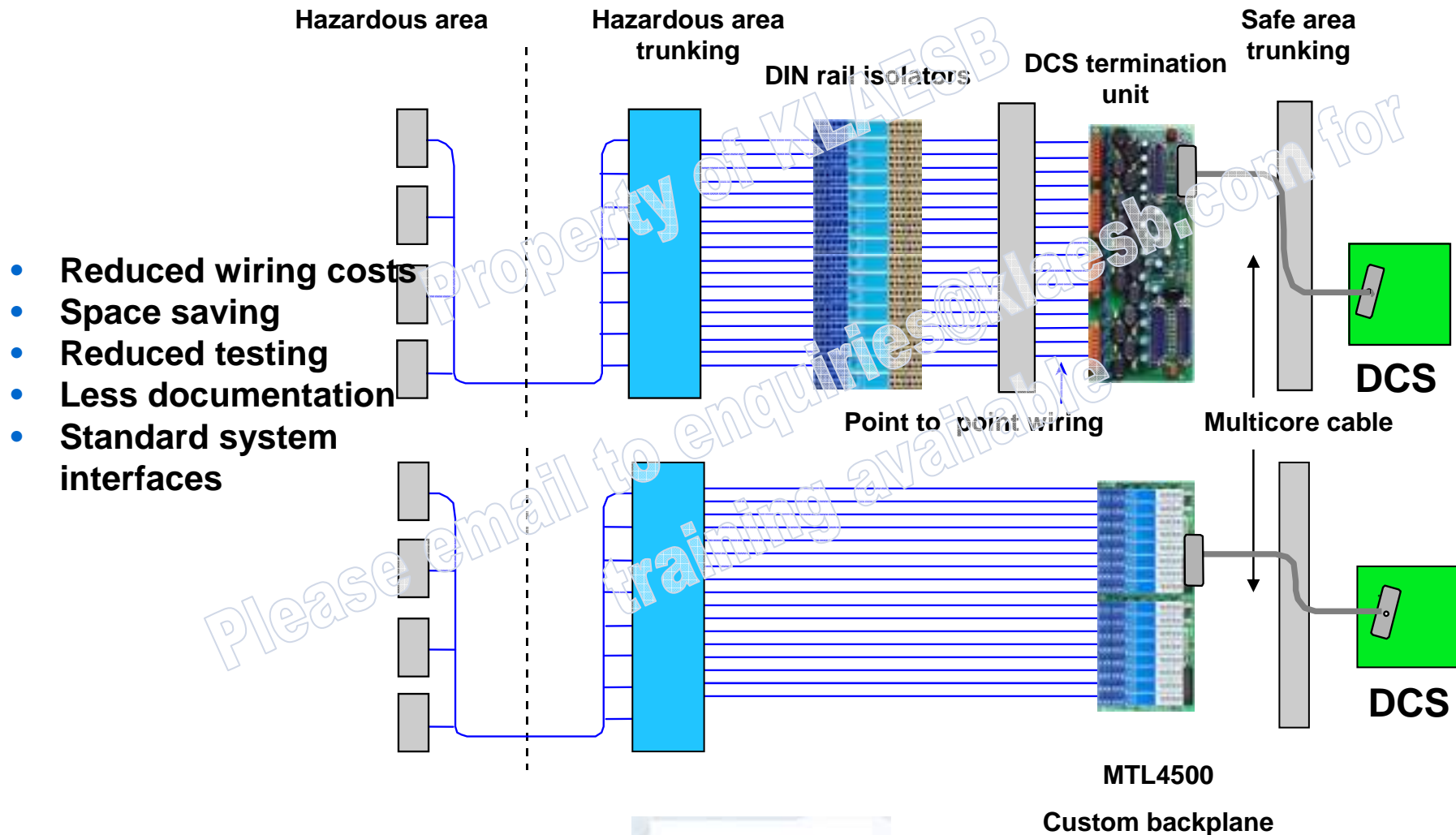
Barriers - How do they Work?



Isolators - How do they Work?



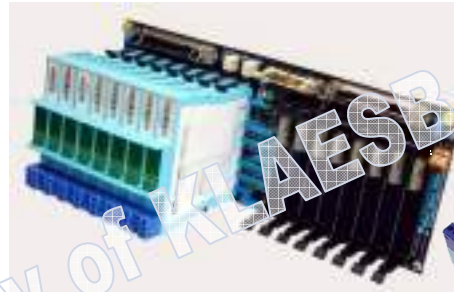
Cost and space saving - high reliability



Custom solution for **EASY** system Integration



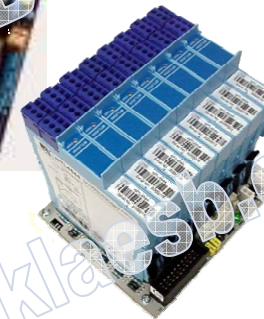
**Foxboro IA
FBM2XX**



Honeywell



**Triconex Tricon
Version 9/10**



**Honeywell
Safety Manager**

**Safety Manager
Universal Safe IO**

Triconex Trident

ICS Triplex



Yokogawa Centum VP R3

General Electric/Bently Nevada

Modicon

Yokogawa ProSafe RS

Siemens ET200M

Applications – Selection of IS interfaces

- The Application of Ex i Instrument Loops
 - Considering a System
- Use of Barriers and Isolators
 - Comparison of their use
- To demonstrate
 - Safety Compatibility
 - and
 - Operational Compatibility

Cable calculation tool

Intrinsically Safe Circuit Verification Calculation (Single Apparatus) - As Per BS EN 60079-14 (2008)														
Field							Panel							
<div style="display: flex; justify-content: space-between;"> <div> Manufacturer: Model: Tag Number: </div> <div> Cable 1 No: Pr / Cr : </div> <div> J/B Number: </div> <div> Cable 2 No: Pr / Cr : </div> </div> <div style="text-align: center; margin-top: 10px;"> </div>							Barrier No: Barrier Type: 							
This circuit requires investigation. Either Ci >= 1% of Co or Li >= 1% of Lo. See BS EN 60079-14														
Equipment Area / Zone: Instrument Classification: Instrument Certificate No.: 		J/B Area / Zone: J/B Classification: J/B Certificate No.: 		J/B Area / Zone: J/B Classification: J/B Certificate No.: 		Barrier Area / Zone: Barrier Classification: Barrier Certificate No.: 								
Allowed Voltage (Ui)	 V	Cable 1 length	 m	Cable 2 length	 m	Cable 3 length	 m	Output Voltage (Uo)	 V					
Allowed Current (Ii)	 mA	Capacitance per metre	 µF/m	Capacitance per metre	 µF/m	Capacitance per metre	 µF/m	Short Circuit Current (Io)	 mA					
Power (Pi)	 mW	Inductance per metre	 µH/m	Inductance per metre	 µH/m	Inductance per metre	 µH/m	Output Power (Po)	 mW (See Note 1)					
Capacitance (Ci)	 µF	Capacitance (Cc1)	 µF	Capacitance (Cc2)	 µF	Capacitance (Cc3)	 µF	Capacitance (Co)	 µF					
Inductance (Li)	 µH	Inductance (Lc1)	 µH	Inductance (Lc2)	 µH	Inductance (Lc3)	 µH	Inductance (Lo)	 µH					
<div style="display: flex; justify-content: space-between;"> <div style="width: 60%;"> <p>The following criteria must be met for an intrinsically safe circuit:</p> <table style="width: 100%;"> <tr> <td>The barrier output voltage (Uo)</td><td> V</td> <td>...must not exceed the equipment input voltage (Ui)</td><td> V</td> <td rowspan="5" style="text-align: center; vertical-align: middle;"> <div style="background-color: green; color: white; padding: 2px; margin-bottom: 2px;">Pass</div> <div style="background-color: green; color: white; padding: 2px; margin-bottom: 2px;">Pass</div> <div style="background-color: green; color: white; padding: 2px; margin-bottom: 2px;">Pass</div> <div style="background-color: green; color: white; padding: 2px; margin-bottom: 2px;">Pass</div> <div style="background-color: green; color: white; padding: 2px; margin-bottom: 2px;">Pass</div> </td></tr></table></div> </div>										The barrier output voltage (Uo)	 V	...must not exceed the equipment input voltage (Ui)	 V	<div style="background-color: green; color: white; padding: 2px; margin-bottom: 2px;">Pass</div> <div style="background-color: green; color: white; padding: 2px; margin-bottom: 2px;">Pass</div> <div style="background-color: green; color: white; padding: 2px; margin-bottom: 2px;">Pass</div> <div style="background-color: green; color: white; padding: 2px; margin-bottom: 2px;">Pass</div> <div style="background-color: green; color: white; padding: 2px; margin-bottom: 2px;">Pass</div>
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Notes:

1. With sources using resistive current limitation and a linear output characteristic, a maximum power value of Po = (Uo x Io)/4 can be assumed. Sources with electronic current limitation and non linear output characteristic can supply values up to Po = Uo x Io. (Refer to manufacturers information)

2. Category and group subdivisions are determined by the lowest common denominator. Hence if either piece of equipment is 'ib' then the system is 'ib'. The group subdivision is the least sensitive group: IIC, IIB, IIA in order of decreasing sensitivity.

Note: ()

Design of IS System

- Gas Classification
- Level of Protection
- Temperature Classification
- Safety Compatibility

IS system verification tool

Microsoft Excel - intrinsic_safety_IS_Single_Device_Template_-_Rev_1b.xls [Compatibility Mode]

Intrinsically Safe Circuit Verification Calculation (Single Apparatus) - As Per BS EN 60079-14 (2008)

Field

Manufacturer: PR
Model: 1151
Tag Number: PT001

Cable 1 No: C001
Per/Cu: []

Cable 2 No: C001
Per/Cu: []

370 Number: 101

370 Classification: H/A

370 Certificate No.: H/A

370 Group: H/A

370 Subgroup: H/A

370 Protection: H/A

370 Temperature: H/A

370 Humidity: H/A

370 Vibration: H/A

370 Shock: H/A

370 Corrosion: H/A

370 Other: H/A

Panel

Barrier No: 1001
Barrier Type: HTL2707

Barrier Classification: H/A

Barrier Certificate No.: H/A

Barrier Group: H/A

Barrier Subgroup: H/A

Barrier Protection: H/A

Barrier Temperature: H/A

Barrier Humidity: H/A

Barrier Vibration: H/A

Barrier Shock: H/A

Barrier Corrosion: H/A

Barrier Other: H/A

This circuit is intrinsically safe

Equipment Data/Zone 1		370 Data/Zone 1		370 Data/Zone 2		Barrier Data/Zone 2	
Insulation Classification: EEx (I)CT4-IB-CST4-IB-C		370 Classification: H/A		370 Classification: H/A		Barrier Classification: H/A	
Insulation Certificate No.: 0000000000000000		370 Certificate No.: H/A		370 Certificate No.: H/A		Barrier Certificate No.: H/A	
Rated Voltage [V]: 24	V	Cable Length: 20	m	Cable Length: 20	m	Cable Length: 20	m
Rated Current [A]: 0.25	A	Capacitance per meter: 0.000000	pF/m	Capacitance per meter: 0.000000	pF/m	Capacitance per meter: 0.000000	pF/m
Power [W]: 0.60	W	Inductance per meter: 0.0	pH/m	Inductance per meter: 0.0	pH/m	Inductance per meter: 0.0	pH/m
Capacitance [C]: 0.0000	pF	Capacitance [C]: 0.000000	pF	Capacitance [C]: 0.000000	pF	Capacitance [C]: 0.000000	pF
Inductance [L]: 0.0	pH	Inductance [L]: 0.0	pH	Inductance [L]: 0.0	pH	Inductance [L]: 0.0	pH

The following criteria must be met for an intrinsically safe circuit:

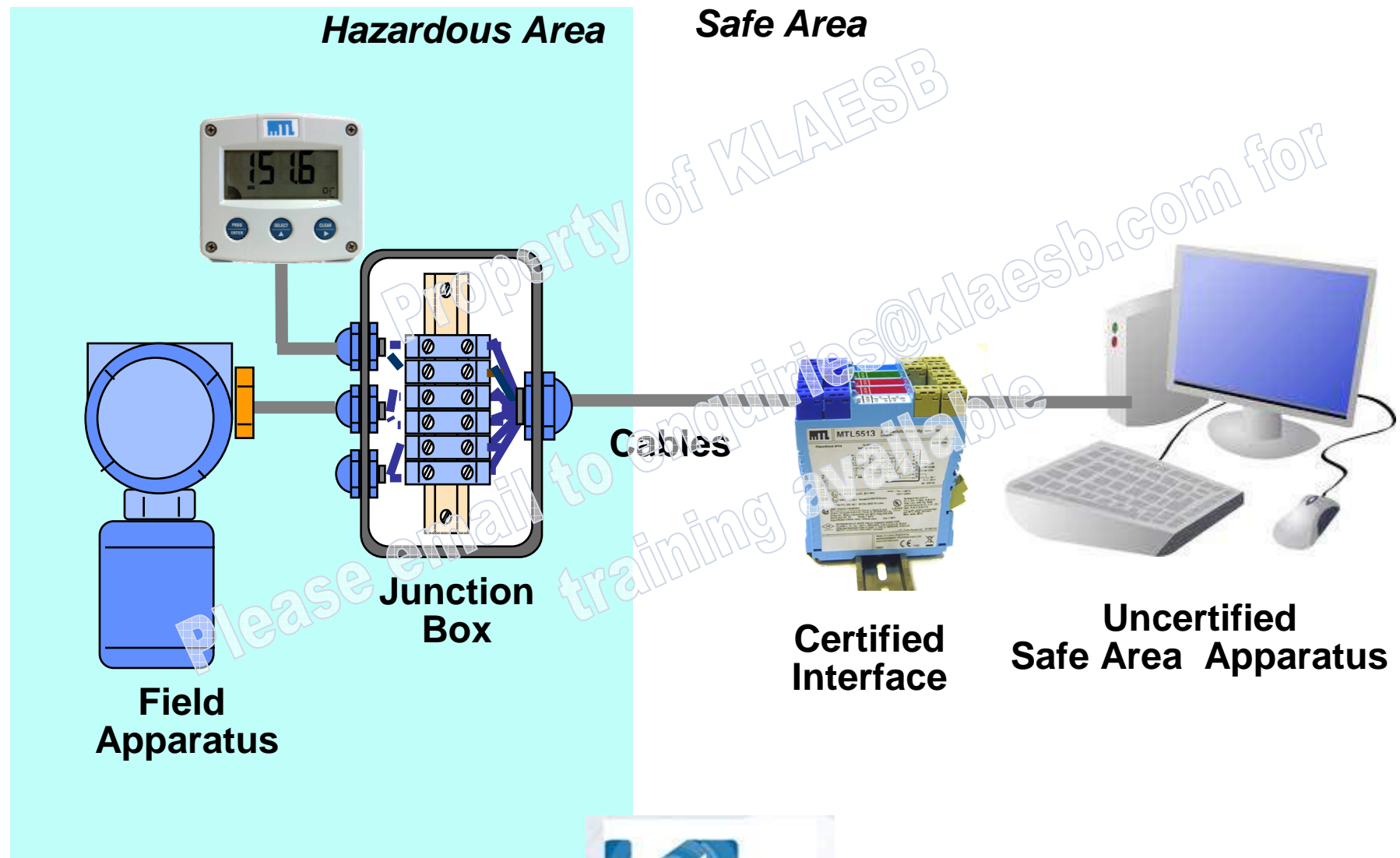
Criteria	Value	Unit	Criteria	Value	Unit
The barrier output voltage [V]	24	V	The barrier output current [A]	0.25	A
The barrier maximum current [A]	0.25	A	The barrier power [W]	0.60	W
The barrier power [W]	0.60	W	The capacitance of the cable [C]	0.0000	pF
The capacitance of the cable [C]	0.0000	pF	The inductance of the cable [L]	0.0	pH
The inductance of the cable [L]	0.0	pH			

Note: Only type in orange areas

Installation Overview

- Useful Information and Definitions – related to intrinsic safety
 - Ingress Protection to IEC60529
 - Creepage and Clearance
 - Segregation
 - Typical installation
- Status of Codes of Practice
 - General requirements of IEC60079:14
 - Specific requirements for Ex i circuits
- Installations summary sections
 - Safe area apparatus, Interfaces, Cables, Junction Boxes and Hazardous Area Apparatus

Typical System Block



Interface (IS isolator) Installation Requirements Summary

- Location of Interfaces should be permanently marked to show the correct type of replacement in each position
- Interface designs and mounting must meet minimum of IP20
- Isolators are normally mounted in the safe area at the nearest convenient point to the hazardous/safe area boundary.
- Enclosures required for protection from unauthorised interference
- Hazardous area mounting is permissible if the appropriate type of protection is provided for interfaces and cabling:
 - Zone 1 : Flameproof (Ex d) enclosure
 - Zone 2 : normally an Ex e certified enclosure (Interface has certified for zone 2 mounted)

Earthing of IS circuits

BS EN 60079-14:2014
60079-14 © IEC:2013

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16.2.3 Earthing of intrinsically safe circuits

Intrinsically safe circuits shall be either

- a) isolated from earth, or
- b) connected at one point to the equipotential bonding system if this exists over the whole area in which the intrinsically safe circuits are installed.

IS isolator meet this requirement
No need to earth

In intrinsically safe circuits, the earthing terminals of safety barriers without galvanic isolation (for example Zener barriers) shall be:

- 1) connected to the equipotential bonding system by the shortest practicable route, or
- 2) for TN-S systems only, connected to a high-integrity earth point in such a way as to ensure that the impedance from the point of connection to the main power system earth point is less than 1 Ω . This may be achieved by connection to a switch-room earth bar or by the use of separate earth rods.

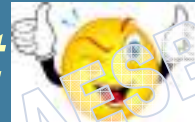
Fault Finding

You may



- Work live
- Short-circuit wiring on one loop at a time
- Open-circuit wiring on one loop
- Use screens as temporary returns
- Claim "Simple Apparatus" for:
 - wire links as switches
 - resistors as loads
- Perform measurements through interfaces

You must



- Use correct tools (eg *properly sized to avoid damage to enclosures*)
- Use Certified (if complex) test equipment
- Use barriers for measurements with uncertified equipment
- Abide by site working rules (eg *Permit to Work systems*)

You must not



- Compromise safety of the loop by:
 - bridging the interface
 - interconnecting separate loops
 - incorrect substitution of interfaces
 - invading IS circuits with unrestricted power
- Interfere with the process without authorisation

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