Intrinsically Safe Barriers — Zener vs Galvanic Isolators

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How intrinsic safety works under IEC 60079-11, the real difference between a Zener barrier and a galvanic isolator, the entity parameter arithmetic (Uo, Io, Po against Ui, Ii, Pi plus cable Co and Lo), the earthing rules that decide between them, loop examples for 4–20 mA transmitters and RTDs, and the MTL and Pepperl+Fuchs module families — with catalogue examples and replacement logic.

The short version

Intrinsic safety (Ex i) keeps the energy in the hazardous-area circuit below what can ignite the gas — under about 1.3 W and with voltage/current limits by gas group — so the instrument itself can live in Zone 0, 1 or 2 with no flameproof enclosure. The energy limiting happens in a barrier or isolator mounted in the safe area. The rules are IEC/EN 60079-11 (apparatus) and 60079-25 (system design).

A Zener barrier is passive: Zener diodes clamp the voltage, a resistor limits the current, a fuse protects the diodes. Cheap, accurate, no power supply — but it needs a dedicated low-impedance IS earth (the classic 1 ohm rule to the main earthing point) and it ties the loop to that earth.

A galvanic isolator does the same limiting behind a transformer or opto barrier: no IS earth needed, the loop floats, it can repeat/convert the signal (4–20 mA in, 4–20 mA out, HART through), and it tolerates plant earth problems. It costs more and needs a 24 V DC supply.

Selection is entity arithmetic, not brand preference. The barrier's output parameters (Uo, Io, Po, and its allowed Co, Lo) must cover the field device's input parameters (Ui ≥ Uo, Ii ≥ Io, Pi ≥ Po) with the cable's capacitance and inductance inside Co and Lo. If those five comparisons pass, the loop is certifiable; if not, no amount of brand loyalty fixes it.

Default choice in 2026: isolators for new work, Zeners for like-for-like replacement and for high-accuracy or fieldbus cases where their simplicity helps. Most new marine and process installations have given up maintaining a proving-tested IS earth network, which was the Zener's price of admission.

Blue is the IS colour: blue terminals, blue cable (see the marine cable guide), and segregation from non-IS wiring are part of the certification, not decoration.

1. How intrinsic safety works

Ex i limits the electrical energy available in the hazardous area so that neither a spark (opening/closing/shorting the circuit) nor a hot surface can ignite the surrounding atmosphere, with safety factors applied and faults assumed: Ex ia tolerates two countable faults (Zone 0-capable as part of a system per 60079-25 practice), Ex ib one fault (Zone 1), Ex ic the normal-operation level (Zone 2). The limits depend on the gas group — IIC (hydrogen, acetylene) is the strictest, IIB (ethylene) and IIA (propane) progressively easier — which is why the same barrier delivers less usable power when certified for IIC. The practical ceiling for a IIC loop is around 25–28 V, 93–300 mA resistor-limited, of the order of 1.2–1.3 W; enough for transmitters, RTDs, solenoid pilot valves of IS type, switches and LED beacons — never for motors or heaters.

2. Zener barrier vs galvanic isolator

Property | Zener barrier | Galvanic isolator |

Principle | Zener clamp + series resistor + fuse; passive | Same limiting + transformer/opto isolation; active |

IS earth | Required: dedicated, low impedance (≤ 1 Ω to the main earth), proven and maintained | Not required; loop floats |

Power supply | None | 24 V DC safe-area supply |

Signal | Pass-through; adds end-to-end resistance (voltage headroom must be checked) | Repeats/conditions; HART pass-through on standard models; can convert (RTD in, 4–20 mA out) |

Earth faults on the loop | Can blow the fuse / kill the loop | Tolerated; isolation breaks ground loops |

Cost per channel | Low | 2–4x Zener |

Typical 2026 use | Replacements in existing Zener installations; simple switch and LED circuits; metering loops where the passive path is preferred | New installations, marine and offshore, anywhere the IS earth is not worth owning |

Catalogue anchors for both camps: the MTL7089 shunt-diode Zener barrier, 28 V / 300 Ω is the classic transmitter-loop Zener; the MTL5541 isolated transmitter power supply is its galvanic successor for 4–20 mA loops (HART-transparent repeater power supply), and the MTL5575 temperature converter takes an IS RTD or thermocouple in and gives 4–20 mA out. Pepperl+Fuchs' K-system and Eaton's MTL4500/MTL5500 ranges mirror each other function for function; combined units exist too (the EXB-2000 Zener barrier/galvanic insulator for flow loops in our catalogue is one maker-specific example), and replacement modules for packaged systems appear as items like the OWS IS analogue repeater (replacement).

3. Entity parameters: the five comparisons

Every certified IS device publishes entity parameters. The barrier/isolator (associated apparatus) states what it can deliver: Uo (max output voltage), Io (max output current), Po (max output power), and the external reactances it may see: Co (max cable+device capacitance) and Lo (max inductance), sometimes as an Lo/Ro ratio. The field device states what it can accept: Ui, Ii, Pi, and what it adds: Ci, Li. The loop passes when:

| Check | Rule |

1 | Voltage | Ui (device) ≥ Uo (barrier) |

2 | Current | Ii ≥ Io |

3 | Power | Pi ≥ Po |

4 | Capacitance | Ci + C(cable) ≤ Co |

5 | Inductance | Li + L(cable) ≤ Lo (or Lo/Ro respected) |

Cable values come from the cable datasheet (typical instrument pair: 80–200 pF/m and about 0.7–1 μH/m — 500 m of pair at 120 pF/m is 60 nF against a typical Co of 80–160 nF for a 28 V IIC barrier). The system file (per IEC 60079-25) records the five comparisons per loop, with the certificates. This paperwork is what a surveyor or auditor actually reads, and assembling it is a supplier task we quote together with the hardware: certificates for every item, parameters tabulated per loop.

4. The earthing question, settled

A Zener barrier works by diverting fault energy to earth; its safety case collapses if that earth is poor. Hence the dedicated IS earth conductor from the barrier busbar to the plant's main earthing point, kept separate from power earths, with a proven total resistance commonly held below 1 Ω and inspected on a schedule. That infrastructure — not the barrier price — is the real cost of the Zener approach, and the reason floating galvanic isolators took over new work on ships, offshore units and most plants. If you inherit a Zener installation with a healthy IS earth, keeping it and replacing modules like-for-like is entirely sound engineering; if the earth's integrity is unknown, budget the survey before trusting it.

5. Standard loop recipes

Loop | Zener route | Isolator route |

4–20 mA transmitter (pressure, level) | 28 V / 300 Ω barrier (MTL7089 class); check voltage headroom: supply '' barrier drop ≥ transmitter minimum at 20 mA | Repeater power supply (MTL5541 class / P+F KCD2-STC); HART passes |

RTD / thermocouple | Dual-channel Zener; lead resistance matters | Temperature converter (MTL5575 class), 4–20 mA out, linearised |

Switch / NAMUR proximity sensor | Simple Zener + safe-area relay | Switch amplifier with line-fault detection (NAMUR EN 60947-5-6) — detects open and short circuit |

IS solenoid / beacon | Rarely done with Zener (power) | Solenoid driver module, matched to the valve's entity parameters |

The transmitter side of these loops is specified in our instrument specification guide; NAMUR sensor choices in the proximity sensor cross-reference.

6. Specifying and replacing

A complete barrier/isolator line on a requisition: function (repeater power supply, switch amplifier, temperature converter, solenoid driver), channels, Ex marking required ([Ex ia Ga] IIC for Zone 0 loops), entity parameters needed by the already-chosen field device, HART yes/no, line-fault detection yes/no, mounting (DIN rail, backplane), supply voltage, and — for replacements — the installed part number. Replacement logic: within MTL, 7000-series Zeners map to 7000-series successors, MTL4500 (backplane) and MTL5500 (DIN rail) carry the function in the last two digits (a 5541 is the DIN-rail twin of a 4541); across makers, match function and entity parameters, never just the channel count. Our team crosses MTL, Pepperl+Fuchs, Stahl and GM International module for module, with certificates attached — the marking logic itself is decoded in the ATEX/IECEx zoning and marking guide.

How buying works at cballast. We quote IS barriers and isolators by function and entity parameters with the certificates and per-loop parameter tables included, successors for obsolete modules declared next to like-for-like options. Accounts are vetted at onboarding; first order prepaid; established accounts on credit terms with repeat discounts; public bodies and utilities invoiced against purchase order from the first order. RFQs to sales@cballast.com.

Frequently asked questions

What is the difference between a Zener barrier and a galvanic isolator?Both limit the energy reaching a hazardous-area circuit per IEC 60079-11. A Zener barrier does it passively (diodes, resistor, fuse) and must sit on a dedicated low-impedance IS earth; a galvanic isolator does it behind transformer or opto isolation, needs a 24 V supply but no IS earth, and can repeat or convert the signal. New installations mostly use isolators; Zener installations are maintained like-for-like.
What are entity parameters?The certified electrical limits that make an IS loop checkable: the barrier's output values Uo, Io, Po and allowed external Co, Lo against the field device's input ratings Ui, Ii, Pi and its internal Ci, Li plus the cable's capacitance and inductance. Five comparisons — voltage, current, power, capacitance, inductance — all of which must pass.
Does a galvanic isolator need an intrinsically safe earth?No. The isolation barrier means no fault current needs a drain to earth, which is its main advantage: the loop floats, ground loops are broken, and the 1 Ω IS-earth infrastructure of Zener systems is not needed.
Can HART pass through a safety barrier?Through a Zener barrier, yes inherently (it is a passive series element). Through galvanic isolators, only models specified as HART-transparent — the standard repeater power supplies (MTL5541 class, P+F KCD2-STC class) are; always confirm it on the datasheet if configuration from the control room matters.
What does [Ex ia Ga] IIC on a barrier mean?It is associated apparatus (the brackets): it sits in the safe area but its output circuit is protected to level ia, suitable for supplying equipment in Zone 0 (EPL Ga) for gas group IIC. The barrier itself must never be mounted in the hazardous area unless it also carries its own protection marking.
What replaces an MTL5541?Functionally: a 1-channel HART-transparent repeater power supply with matching entity parameters — MTL's own current 5500-series successor, or equivalents in Pepperl+Fuchs' K-system and R. Stahl's ISpac range. We confirm the entity match and supply the certificate with the quote; send the loop details to sales@cballast.com.

References and related guides

Standards referenced: IEC/EN 60079-11 (intrinsic safety); IEC 60079-25 (IS systems); IEC 60079-14 (installation); EN 60947-5-6 (NAMUR); IEC 60079-0 (general requirements and marking); maker documentation for MTL 4500/5500/7000 and

Pepperl+Fuchs K-system.

ATEX and IECEx zoning and equipment marking

Specifying instruments — pressure, temperature, level, flow

Fixed gas detection — sensors, siting, calibration

Danfoss MBS pressure transmitters

Cable gland selection — metric, NPT, Ex, marine

Questions on a loop, a module or an entity check: write to sales@cballast.com. We answer whether or not you buy from us.

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