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Mechtric

Contactor and Starter Ratings

Contactors are electrically controlled switches, used for switching a power circuit at high current ratings. They are controlled by a circuit that has a much lower power level than the circuit being switched. They are not designed to interrupt short circuit currents but to open or close electrical loads, such as electric motors, lighting, heating, capacitor banks and so on.

North American and European ratings for contactors follow different philosophies. North American motor control devices are generally known for their heavy-duty construction and are physically large because of their rugged design.

On the other hand, European devices are rated for maximum operational current as specified by the International Electro technical Commission in publication IEC 60957-5-1. Choice of IEC contactors is based on running current, motor application and required contact life since European philosophy emphasises design for the intended life cycle of the application.

Magnetic starters are devices designed to provide power to electric motors with a contactor as an essential component, while also providing power-cut-off, under-voltage, and overload protection.

Contactors and motor starters (contactor +protection device) are devices designed to provide power to electric motor; the protection device provides for power cut-off, under voltage and overload safeguard. They are rated according to the size and type of load they are designed to handle.

A contactor is an essential component of the motor starter while ratings are given according to the load current per pole, maximum fault withstand current, coil voltage and classified by the utilisation categories, as follows:

In alternating current:

- AC1 - Non-inductive or slightly inductive loads
- AC2 - Starting of slip-ring motors
- AC3 - Starting of induction motors (squirrel-cage) and switching off only after the motor is up to speed. (Make Locked Rotor Amps (LRA), Break Full Load Amps (FLA))
- AC4 - Starting of induction motors (squirrel-cage) with inching duty and plugging duty. Rapid Start/Stop. (Make and Break LRA)
- AC5A - Switching of electric discharge lamp controls
- AC5b - Switching of incandescent lamps
- AC6A - Switching of transformers
- AC6B - Switching of capacitor banks

In direct current:

- DC1 - Non-inductive or slightly inductive loads, (resistive loads) such as resistance furnaces
- DC3 - Shunt-motor, starting, plugging, jogging, inching
- DC4 - Series motors, starting, plugging, and switching off motors while running.
- DC5 - Series motors, starting, plugging, jogging, inching.

Switch Disconnector Ratings

Switch disconnectors are used to make sure an electrical circuit is completely de-energised and isolated from the electrical system of the power source for service or maintenance. These switches are also found in electrical distribution systems and industrial applications where machinery requires switching for adjustment or repair, including fault isolation, transfer loads from one source to another, isolation of line segments for purpose of maintenance or new construction, and in some instances for shedding loads. Switch disconnectors are frequently used to switch low level line or cable charging currents and parallel load currents. They are manually operated switches, which are used for isolating high-voltage equipment, so that this equipment may be worked on safely.

LOVATO Electric switch disconnectors have been developed to satisfy requirements according to IEC, UL and CSA standards and have been tested and certified accordingly. Switch disconnectors meet requirements of IEC 60947-3 standards and have been designed primarily for use in inductive applications such as switching motors and as main control panel utilisation categories, listed as follows:

In alternating current:

- AC21A - Resistive loads including moderate overloads (frequent operation)
- AC22A - Switching of mixed resistive and inductive loads including moderate overloads (frequent operation)
- AC23A - Switching of motor loads or other highly inductive loads (frequent operations) (This category includes occasional switching of individual motors)
- AC23B - Switching of motor loads or other highly inductive loads (Infrequent operations) (This category includes occasional switching of individual motors).

In direct current:

- DC21 B - Switching of resistive loads including moderate overloads (Infrequent operations).

Useful Electrical Formulas

Common electrical units used in formulas and equations are:

- **Volt** - unit of electrical potential or motive force - potential is required to send one ampere of current through one ohm of resistance (V)
- **Ohm** - unit of resistance - one ohm is the resistance offered to the passage of one ampere when impelled by one volt (Ω)
- **Ampere** - units of current - one ampere is the current which one volt can send through a resistance of one ohm (A)
- **Watt** - unit of electrical energy or power - one watt is the product of one ampere and one volt - one ampere of current flowing under the force of one volt gives one watt of energy (W)
- **Volt Ampere** - product of volts and amperes as shown by a voltmeter and ammeter (VA)
  - In direct current systems the volt ampere is the same as watts or the energy delivered
  - In alternating current systems the volts and amperes may or may not be 100% synchronous
  - When synchronous the volt amperes is equal to the watts
  - When not synchronous volt amperes exceed watts, the difference is reactive power (VAr)
- **Kilovolt Ampere** - one kilovolt ampere - KVA - is equal to 1,000 volt amperes (kVA)
- **Power Factor** - ratio of watts to volt amperes (COS φ)

ELECTRIC FORMULAS

DC or AC with linear (restive) load AC1

$P = V I$

$P = I^2R$

$P = V^2 / R$

$V = R I$

$I = P / V$

$I = \sqrt{(P/R)}$

AC Single Phase

Total or apparent power VA = VI or I^2Z

Active power W = VI $COS\varphi$ or I^2R

Reactive power VAr = VI $SIN\varphi$ or I^2X

AC 3-Phase

Star connection
$V_p=V_1/\sqrt{3}$, $V_1=\sqrt{3}V_p$, $I_1=I_p$

Delta connection
$I_p=I_1//\sqrt{3}$, $I_1=/\sqrt{3}I_p$, $V_1=V_p$

Total or apparent power VA = $/\sqrt{3}V_1I_1$

Active power W $=\sqrt{3}V_1I_1\ COS\varphi$

Reactive power Q = $\sqrt{3}V_1I_1\ SIN\varphi$ or kVAr = $(kVA)^2 - (kW)^2$

LOADS

Inductive reactance $X_L = 2\pi fL$ (Ω)

Capacitive reactance $X_C = \frac{1}{2\pi fc}$ (Ω)

where
P = power (Watts)
V = voltage (Volts)
I = current (Amperes)
R = resistance (Ohms Ω)
V_1 = Line to line voltage
V_p = Phase voltage(line to neutral)
I_1 = Line current (star)
I_p = Line current (delta)
Z = impendance (Ohms Ω)
X = reactance (Ohms)
$P_{3\text{-phase}}$ = electrical power 3-phase (kW)
COSφ = power factor
f = frequency (hz)
L = inductance (henry)
C = capacitance (farads)
Q = reactive power (VAr)

The power factor of an AC electric power system is defined as the ratio of the active (true or real) power to the apparent power where-

- **Active (Real or True) Power** is measured in watts (W) and is the power drawn by the electrical resistance of a system doing useful work.
- **Apparent Power** is measured in volt-amperes (VA) and is the voltage on an AC system multiplied by all the current that flows in it. It is the vector sum of the active and the reactive power.
- **Reactive Power** is measured in volt-amperes reactive (VAR). Reactive Power is power stored in and discharged by inductive motors, transformers and solenoids. Reactive power is required for the magnetization of motors and transformers but doesn't perform any useful work. The reactive power required by inductive loads increases the amounts of apparent power - measured in kilovolt amps (kVA) - in the distribution system. Increasing of the reactive and apparent power will cause the power factor - PF - to decrease.

POWER FACTOR

It is common to define the Power Factor - PF - as the cosine of the phase angle between voltage and current - or the "cosφ".

PF = P / S (Watts/VA)

where

PF = power factor

P = active (true or real) power (Watts)

S = apparent power (VA, volts amps)

A low power factor is the result of inductive loads such as transformers and electric motors. Unlike resistive loads creating heat by consuming kilowatts, inductive loads require a current flow to create magnetic fields to produce the desired work.

An overall power factor less than 1 indicates that the electricity supplier needs to provide more generating capacity than actually required. A low power factor is expensive and inefficient and some utility companies may charge additional fees when the power factor is less than 0.95. A low power factor will reduce the electrical system's distribution capacity by increasing the current flow and potentially causing voltage drops. The use of power factor correction capacitors in system with low power factor will bring the power factor back up to near unity and provide a significant reduction in electricity consumption. In systems with a high level of waveform distortion (harmonics), harmonic filter reactors should also be used to prevent damage to the power factor correction capacitors.

The current waveform distortion that contributes to reduced power factor is caused by voltage waveform distortion and overheating in the neutral cables of three-phase systems.

International standards such as IEC 61000-3-2 have been established to control current waveform distortion by introducing limits for the amplitude of current harmonics. Variable speed drives are a common source of voltage harmonics and the use of line reactors on the supply side of the variable speed drive will reduce their effect on the system waveform.

Light Intensity

In photometry, **luminous flux** or luminous power is the measure of the perceived power of light. The other photometric dimensions such as illumination, radiance and intensity are obtained from the luminous flux.

Luminous efficacy is the ratio of luminous flux (in lumens) to power (usually measured in watts).

Luminous intensity is a measure of the wavelength-weighted power emitted by a light source in a particular direction per unit solid angle. The International System of luminous intensity is candela (cd).

Light intensity of the beacons in this catalogue are measured in Candela (Cd), where 1 Cd = 1 Lux @ 1m. Measurements are taken in photometric chamber using a luxometer and with the beacon fitted with a clear lens.

The following formula is applied:
Cd = LUX x distance^2

As a general rule, as the distance from the light source to the viewer is doubled the light intensity is reduced by ¼.

In the case of flashing lights, intensity is measured either as Peak Candela (Cd(p)) or as effective intensity Je (Cd) or candela seconds. Where the Peak Candela figure is quoted it needs to be noted that Peak intensity figures do not take into account flash duration which must be at least 5 microseconds for the human eye to react. Peak Candela is also measured in the direction of maximum light output. When comparing the light intensity of rotating, conventional lamp or LED beacons with xenon strobe beacons, the effective Je figure should be used.

The light intensity of a beacon will vary according to:

1) Power of the light source
2) Type of light source (xenon, halogen bulb, LED etc)
3) Distance from the light source and viewer
4) The lens type (brightness is increased with the use a fresnel lens)
5) Lens colour

It should also be noted that the method of measuring light intensity in countries such as the USA and Japan is different to that used in Europe. The resultant figures quoted by manufacturers in these countries are often many times greater than those that would have been obtained using the European method.

Where light intensity figures are unavailable the lamp power watts (W) or energy joules (J) data is quoted. Although these figure do give some indication of the beacon's light output, measurements of power and energy output can be misleading.

The light intensity for a given figure of watts or joules will depend on how efficiently the lamp or discharge tube converts the energy to light and also how effectively the light is then distributed by the lens optics.

For industrial applications the light intensity of warning beacons should be five times brighter than the ambient light. Emergency beacons should have a light intensity 10 times greater than the ambient level.

COMPARING LED WITH TRADITIONAL BULBS

The only values we can use today to justify or compare, in terms of brightness, a LED light source with respect to a traditional light source is the luminous efficacy:

Category	Type	Total luminous efficacy (lm/W)	Total luminous efficacy
Incandescent	100 W tungsten, incandescent (220 V)	13.8	2.0%
	100 W tungsten, halogen (220 V)	16.7	2.4%
	5 W tungsten, incandescent (120 V)	5	0.7%
	100 W tungsten, incandescent (120 V)	17.5	2.6%
	tungsten, halogen, quartz bulb (12-24 V)	24	3.5%
LED	white LED	10-189*	1.5-15%
Flash tube	xenon bulb	30-50	4.4-7.3%

*depends on the types

Colour

The intensity of light is reduced as it passes through of the lens of the beacon. The extent of this reduction is dependent to a large extent on the colour of the lens and the type of lamp used.

The table below gives an indication of the percentage of light that will pass through the beacon lens for different light sources and lens colours.

In the case of LED beacons where the colour of the LED light source is the same as the lens colour, there is almost no loss of light intensity through the lens regardless of the colour.

HUMAN VISIBLE SPECTRUM

The visible spectrum (or optical spectrum) is the portion of the electromagnetic spectrum that falls between red and violet including all colours that can be detected by the human eye. A typical human eye will respond to wavelengths from about 380 to 750 nm.

COLOUR	FILAMENT	HALOGEN	XENON
CLEAR	100%	100%	100%
AMBER	70%	70%	70%
RED	30%	27%	23%
GREEN	12%	15%	25%
BLUE	8%	10%	13%

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Rotating Reflector

The Rotating Beacon uses a rotating reflector, driven by a small electric motor, which revolves around a centrally located lamp. The effect is a beam of light which rotates through 360° usually at a speed of 180rpm for industrial beacons. The rotating beacon is available with either conventional filament lamps or halogen lamps.

In general rotating beacons should only be mounted in an upright position within 30° of vertical although some designs do allow for inverted or horizontal mounting.

Although the rotating beacon is quite an effective signaling device, it has the disadvantages of relatively high current draw and the electro-mechanical drive components have a relatively short life(< 5,000 hours).

They are not suitable for applications which may involve continuous operation for long periods. The lamps also suffer from early failure due to vibrations.

Conventional Flashing

Flashing lights use conventional filament lamps or halogen lamps which are switched on and off by an electronic circuit. The light is emitted through 360° and the flash duration is relatively long.

Many flashing lights can also be supplied as continuous lights without the flasher circuit, or with a selectable flashing/static operation.

They are not particularly suitable for applications involving prolonged continuous operation, current draw is high and vibration can result in lamp failure in the case of higher voltage bulbs.

Xenon Strobe

Strobe lights use a xenon discharge tube and an electronic circuit which discharges a capacitor through the xenon tube to produce a short, high intensity burst of light. Although the strobe light is emitted through 360°, it is often most intense in one direction.

Strobes have the advantage of low current consumption relative to light output. Xenon tube life is typically 5 to 8 million flashes after which the light output progressively reduces by approximately 70%. They are available in double flash versions and some types have the capability to be synchronised allowing a number of lights to flash simultaneously.

The strobe beacon is suitable for prolonged continuous operation (particularly low power models) and the xenon tube is resistant to moderate levels of vibration. Due to the high temperature generated by the flash tube, the life of xenon beacons will tend to be reduced in applications of high ambient temperature.

LED Beacons

Light Emitting Diodes or LED based beacons offer significant advantages over other lamp technologies. The LED light source is constructed with an array of high output wide angle LED’s either in the form of a bulb to fit a conventional lamp holder or integrated into the beacon flash and driver circuit. LED beacons will often include a multi-function feature allowing for different flash patterns or effects to be selected.

Although higher in cost when compared to traditional technologies, they offer the advantages of low power consumption, very long life (>100,000 hours) and high resistance to vibrations. The high initial cost is usually recovered many times over during the life of the beacon.

An additional advantage of the LED beacon is that the light intensity is not reduced by coloured lens as is the case with conventional lamps and xenon strobes. In many cases however the light output is not sufficient for use in direct sunlight.

Audible Range

The output of all audible signals is expressed in decibels or dB(A) which is a measure of sound pressure level. The dB figure is always quoted at a certain distance from the signal, usually 1m although 3m is sometimes used and on very large sirens it may be quoted at a distance of 30m.

When both the sound output of a signal and the distance at which it was measured is known it is possible to calculate the sound level at other distances. This can be done by using the “Inverse Square Law” which states that the sound level will reduce by 6dB from the measured value at a distance double that of the measured distance. The effective distance of a sounder using this simple method is when the calculated dB(A) reaches 5dB(A) above the known ambient background noise (As stated in BS5839 Part 1).

For example the effective distance of a 100dB(A) @1m sounder in an ambient of 65dB(A) is the distance at which the sounder output level reduces to 70 dB(A) i.e. 100dB – 30dB = 70dB. From the table opposite (and using the inverse square rule / rule of thumb) a reduction of 30 dB means the sounder has an effective 70dB distance of 32m.

The sound level figures quoted in this catalogue are based on measurements made in an anechoic chamber which is a room, free of any obstructions, with still air, and with sound absorbing walls to eliminate reflections. The “Inverse Square Law” will only apply under similar conditions.

Selecting a Siren

In practice the conditions are far from those found in an anechoic chamber. There are obstructions such as buildings, trees and hills, there is usually some wind and of course there is some background noise.

The following should be considered when selecting how loud and what type of siren or sounder should be used.

1) Area to be covered
2) Ambient noise level and frequency
3) Location indoors or outdoors
4) Single or multiple tones required

How loud a siren needs to be can be determined by the inverse square law as described above. The frequency of the siren is also important. With high frequencies sound tends to reflect off obstacles whereas, with low frequencies the sound will tend to pass through obstacles. The frequency of the ambient noise is also significant, and the signal should have a frequency that is above or below that of the ambient noise.

In general, signals with high frequencies and multi-tones are ideal for indoor use and for areas with a high ambient noise. Low frequency signals are better suited for outdoor large area applications. For large areas, consideration should be given to the wind conditions in both the selection of the signal and in its location. It should also be noted that for large areas it is often more effective to use several smaller signals rather than one large signal and if a large signal is chosen the effect on personnel in close proximity to the signal needs to be considered.

Types of Signals

Audible signals can be divided into four types-

- Bells
- Horns and buzzers
- Motorised Sirens
- Electronic Sounders.

These are detailed below:

BELLS

Bells consist of a metal dome or gong which is struck repetitively by a metal plunger or hammer. The plunger is driven by either a small motor or more commonly a solenoid. They have the advantage of a distinctive sound, low current consumption and low cost.

HORNS AND BUZZERS

Horns or buzzers generate sound by vibrating a metal diaphragm either electrically with a coil or with compressed air. The sound is then usually attenuated by using a trumpet. They are however limited to low frequencies usually below 500Hz. Current consumption is low and very high sound levels are possible with compressed air horns.

MOTORISED SIRENS

Sirens consist of a motor driven slotted cylinder or rotor, which spins inside a slotted case. Air is drawn through the centre of the rotor and is expelled through the slots in the case generating sound in the process. They are available from very small up to very large sizes with the sound frequency tending to decrease with increased size.

Motorised sirens have the advantage of a distinctive sound which can be varied by switching the motor on and off at short intervals to produce a wailing sound. However they also have high current consumption and are often short time rated.

Electronic Sounders

Electronic sounders consist of an electronic circuit which produces sound via a sound transducer or speaker. They can produce single or multi-tone sounds and will often give the user a choice of sounds and volume control. They have low current consumption and are continuously rated, however low sound frequencies at high outputs are difficult to obtain. Electronic sounders also offer the possibility of producing pre-recorded voice messages to reinforce the warning given by a tone output. They can also readily incorporate a light source to give a very effective visual and audible signal in one device. New generation high power wide area warning systems are a variation on the traditional electronic sounder. Utilising high power amplifiers and separate speaker arrays with customised tones and voice messages are stored in memory. They provide an effective alternative to the traditional motor driven siren.

AUDIBILITY TABLE

The following table gives the sound level that can be expected under ideal conditions at a range of distances from the signal source.

m	dB																				
1	75	80	85	90	95	100	102	104	106	108	110	112	114	116	118	120	125	130	135	140	145
2	69	74	79	84	89	94	96	98	100	102	104	106	108	110	112	114	119	124	129	134	139
3	65	70	75	80	85	90	92	94	96	98	100	102	104	106	108	110	115	120	125	130	135
5	61	66	71	76	81	86	88	90	92	94	96	98	100	102	104	106	111	116	121	126	131
10	55	60	65	70	75	80	82	84	86	88	90	92	94	96	98	100	105	110	115	120	125
20	49	54	59	64	69	74	76	78	80	82	84	86	88	90	92	94	99	104	109	114	119
30	45	50	55	60	65	70	72	74	76	78	80	82	84	86	88	90	95	100	105	110	115
50	41	46	51	56	61	66	68	70	72	74	76	78	80	82	84	86	91	96	101	106	111
100		40	45	50	55	60	62	64	66	68	70	72	74	76	78	80	85	90	95	100	105
200			39	44	49	54	56	58	60	62	64	66	68	70	72	74	79	84	89	94	99
300				40	45	50	52	54	56	58	60	62	64	66	68	70	75	80	85	90	95
500					41	46	48	50	52	54	56	58	60	62	64	66	71	76	81	86	91
1000						40	42	44	46	48	50	52	54	56	58	60	65	70	75	80	85
2000									40	42	44	46	48	50	52	54	59	64	69	74	79
3000												42	44	46	48	50	55	60	65	70	75
5000														42	44	46	51	56	61	66	71

Note: An increase of 3db is the equivalent to doubling the volume. For example a siren with an output of 110dB is approximately 8 times louder than one with an output of 100dB. The effective distance of a siren is when the calculated dB(A) is at least 5dB(A) above the known ambient background noise. For example the effective distance of a 100dB(A) @ 1m siren in an ambient noise of 65dB(A) is the distance at which the sounder output reaches 70dB(A) (ie 100dB-30dB=70dB). From the table above (or using the inverse square rule) a reduction of 30dB means the sounder has an effective distance of 32m.

A 120dB(A)@1m siren has a 70dB(A) distance of 300m ie. Ten times the effective distance and more importantly 100 times the coverage area of a 100dB(A) siren.

Two identical sirens placed together will produce a combined output of 3dB greater than their individual outputs. Four identical sirens will produce an increase of 6dB. ie 4x 100dB(A) @ 1m sirens will together produce 106dB@1m.

A further adjustment to the above table should be made to take into effect the tone frequency-

Sound Frequency	Adjustment
Up to 500Hz	0dB(A)
500Hz to 1000Hz	-3dB(A)
1000Hz to 2000Hz	-5dB(A)

Other points to consider-

a) In the open a siren will spread the sound in all directions, whereas in an enclosed space some of the sound will be reflected from hard surfaces and increase the sound level.

b) The closer a wall mounted siren is positioned near a ceiling the more sound will be reflected. The same is true of a ceiling mounted siren positioned near a wall.

c) A siren mounted on a wall will be more effective than one mounted on a pillar.

d) Sirens should be positioned to avoid immediate obstacles. Ideally at a height of 2 to 2.5m above the floor.

e) Large outdoor sirens should be mounted 10-12m above ground level or 2-3m above any nearby obstacles such as buildings or trees.

Hazardous Area

In industries such as oil and gas installations, petrochemical, chemical plants, grain storage, coal handling and refuelling areas there is often a hazard resulting from flammable gases, vapours, mists and dusts which can produce explosive mixtures with air.

The electrical equipment installed in these potentially hazardous areas must be designed to provide protection against the possibility of gas or dust ignition. In this section we offer two solutions to this problem, namely flameproof equipment certified Exd and intrinsically safe equipment certified Exi. An explanation of both is given later.

All equipment for use in a hazardous area is classified according to the following:

IEC 60079-10-1: Classification of areas – explosive gas atmospheres

IEC 60079-10-2: Classification of areas – combustible dust atmospheres

HAZARDOUS ZONES

The likelihood of an ignition of gas occurring depends on the probability of an explosive mixture of gas being present at the same time as the electrical apparatus produces an ignitable source (i.e. a spark or a hot surface).

Hazardous areas are therefore classified into zones according to the likelihood of a flammable gas or dust mixture being present:

Group II flammable gases, vapours and mists

Zone 0 - area in which explosive mixture exists more or less continuously.

Protection technique allowed- Ex ia intrinsically safe.

Zone 1 - area in which gas is not normally present but is likely to occur from time to time.

Protection technique allowed-
- Ex ib intrinsically safe
- Ex d flame proof
- Ex de
- Ex e increased safety
- Ex p pressured or purged
- Ex v ventilation
- Ex s special protection

Zone 2 - area in which an explosive mixture is likely only in abnormal conditions and for short periods.

Protection technique allowed - Ex n non sparking.

Group II flammable dusts and powders

Zone 20 - area where an explosive atmosphere exists in the form of combustible clouds of dust in the air, either permanently, for long periods or frequently.

Protection technique allowed - Ex ia

Zone 21 - area where an explosive atmosphere exists in the form of combustible clouds of dust in the air during normal operation occasionally.

Protection technique allowed-
- DIP IP6x
- Ex tD –A21-IP6x

Zone 22 - area where an explosive atmosphere in the form of combustible clouds of dust in the air is unlikely to occur during normal operation but, if it does occur, it is only for a short period.

Protection technique allowed-

Non-conductive dusts - Ex tD-A22 -IP5x

Conductive dust - Ex tD-A21 - IP6x

It is clear that equipment for use in a Zone 0 area should offer a greater degree of protection than equipment for use in Zone 2 area. This does not mean that the equipment in Zone 2 area is any less safe, since it is the combination of an explosive mixture and an ignition source which is to be avoided. Obviously Zone 0 equipment would also be suitable for use in Zone 1 and Zone 2 areas.

GAS GROUPING

There are so many gaseous mixtures that to ensure by testing that equipment is safe in all gases would be very time consuming. It can be shown by test that gases may be grouped such that if the equipment passes the prescribed tests relative to one gas (known as the test gas for that group) the equipment will be safe for use in all gases in that group (and, if applicable in any other less stringent group).

The four groups into which gases have been categorised are as follows:

Group 1
For mining applications specifically underground mining.

Test Gas – Methane

Group II
For general industry

IIA Test Gas – Propane

IIB Test Gas – Ethylene

IIC Test Gas – Hydrogen

Of these, group IIC gases are the most easily ignited, followed by IIB, IIA. Similarly group IIC gases have flame propagation properties necessitating the most stringent design requirements. If equipment has been shown to be safe in the group IIC gases, then it will also be safe for group IIB and IIA. Equipment suitable for group IIB gases will also be suitable for group IIA.

Hazardous Area

CLASSIFICATION OF THE MORE COMMON COMBUSTIBLE GASES AND VAPOURS ACCORDING TO TEMPERATURE CLASS AND GROUP

Group	Temperature classes					
	T1	T2	T3	T4	T5	T6
I	Methane (firedamp)					
IIA	Acetic acid Acetone Ammonia Benzoyl Benzene Butanone Carbon monoxide Ethane Ethyl acetate Ethyl Chloride Methane Methanol Methyl acetate Methyl alcohol Methyl Chloride Naphthalene Propane Toluene Xylene	Acetic anhydride I amyl acetate n butane n butyl alcohol Amylic alcohol Butyl acetate Cyclohexanon Ethyl alcohol Iso butylic alcohol Liquefied gas Natural gas Propyl acetate	Cyclohexane Cyclohexanol Decane Diesel fuels Gasoline Heating oil Heptane Hexane Jet fuels Pentane Petroleum*	Acetaldehyde Ether		
IIB	Coke-oven gas	1, 3 - butadiene Ethylene Ethyl benzene Ethylene oxide	Hydrogen sulphide Isoprene Petroleum*	Ethyl ether		
IIC	Water gas	Acetylene				Carbon disulphide Ethyl nitrate

* depending on composition

TEMPERATURE CLASSIFICATION

To further streamline safety assessment, equipment is given one of six temperature classifications, based on a reference ambient of 40°C as shown in the table below:

Temperature Class	Maximum temperature of surfaces freely accessible to surrounding atmosphere (°C)	Minimum ignition temperature (°C)	
		Gas	Dust
T1	<450	>450	>500
T2	<300	>300	>350
T3	<200	>200	>250
T4	<135	>135	>185
T5	<100	>100	>150
T6	<85	>85	>135

Devices with a temperature class T6 can be used with gases or dusts with a temperature class of T6 or lower, similarly devices with T5 temperature class can be used with gases or dusts with a lower temperature class

Hazardous Area

FLAMEPROOF EQUIPMENT

Flameproof equipment is designed to withstand an internal explosion and prevent the ignition of external gases. It is basically a mechanical form of protection which works on the basis that as a flame (explosion) attempts to spread from the inside to the outside of an enclosure it is cooled to such an extent that any gas surrounding the enclosure will not be ignited. All flame proof enclosures must comply with certain dimensional requirements applicable to the particular gas group to be covered. Flameproof equipment is generally accepted for use in Zone 1 areas.

INTRINSICALLY SAFE EQUIPMENT

Intrinsically safe equipment is essentially equipment which is designed and operated so that any electrical sparking which may occur during normal operation, or during a fault, is incapable of causing an ignition of the prescribed flammable gas. This form of protection is more suited to low voltage equipment as the ability of a spark to ignite the gases increases rapidly with rising supply voltage. Intrinsically safe equipment can be used in Zone 1 areas and are usually suitable for use in Zone 0 areas.

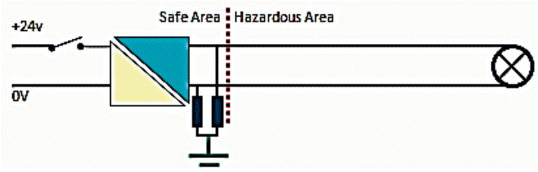
INTERFACE SELECTION: ZENER BARRIERS OR ISOLATION INTERFACES

The decision between these two types of interface will normally be down to site preferences and both have advantages and disadvantages.

Zener barriers are much simpler than isolation interfaces and tend to be more flexible in application. Generally zener barriers can be used in different circuits. Isolation interface's tend to be designed for a specific application and are limited in the way they are used.

Earthing with Zener barriers is perceived to be difficult as they have a strict Earthing requirement although in practice this is rarely a problem. Maintaining an intrinsic safety earth is not as difficult as some believe but, particularly when only a few zener barriers are used, it can introduce extra complication and cost.

Isolation interfaces (also known as Galvanic Isolators) do not require the same degree of integrity on the Earth as zener barrier interfaces. However to avoid the risk of cables charging to uncontrolled potentials and so acquiring stored capacitive energy which may be incendive, a discharge path to Earth should be provided. This would typically be between 200kΩ and 1MΩ and is not deemed to be earthing in terms of the instrumentation loop.



SELECTING AN INTRINSIC SAFETY INTERFACE

The associated apparatus (intrinsic safety interface) preserves the integrity of the field device such as E2S sounder or beacon. It can only do this if it limits the energy by way of voltage and current to a level below the maximum permitted by field device.

These values are the **entity parameters** (often referred to as safety parameters) and consist of voltage current power capacitance and inductance. All of these may not always be specified if they are irrelevant or can be derived directly from the other parameters.

The E2S sounders and beacons main terminals all have the same entity parameters (The suffix "i" denotes input characteristics)		
Ui = 28v	Ii = 93mA	Pi = 660mW

I.S. equipment must, be operated via a shunt zener diode safety barrier or galvanic isolator.

Protection Mode	Area Classification
Flameproof Ex d	Zone 1 & 2
Increased safety Ex e	Zone 1 & 2
Intrinsically safe Exia	Zone 0, 1 & 2
Intrinsically safe Exib	Zone 1 & 2
Special protection Ex s	Zone 0, 1 & 2
Oil immersion Ex o	Zone 1 & 2
Pressurised Ex p	Zone 1 & 2
Powder filling Ex q	Zone 1 & 2
Encapsulation Ex m	Zone 1 & 2
Non sparking Ex N	Zone 2
Ventilation Exv	Zone 1 & 2
Dust Ignition proof DIP	Zone 20, 21 & 22
Intrinsically safe Exi	Zone 20, 21 & 22
Pressurised Ex p	Zone 20, 21 & 22
Encapsulation Ex m	Zone 20, 21 & 22

Mechtric

Hazardous Area

INTERFACE SELECTION: ZENER BARRIERS OR ISOLATION INTERFACES (CONT.)

This means that the integrity of the apparatus is maintained, i.e. is it is safe, providing these figures are not exceeded. Therefore the associated apparatus (barrier) must have parameters of less than or equal to these figures.

Note that the power figure is not the direct calculation based on Voltage and Current; these are entity or safety parameters not actual working values.

The capacitance and inductance figures	
Ci = 0μF	Li = 0mH

Refer to the capacitance or inductance that the apparatus contributes to the circuit. In the case of E2S sounders and beacons this is zero which simplifies the safety assessment of the circuit.

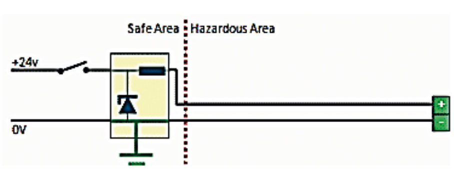
A suitable barrier would have entity parameters of		
Uo ≤ 28v	I o ≤ 93mA	P o ≤ 660mW

Please refer to the relevant certification prior to use. As all E2S sounder and beacons have the same entity parameters in most circuits different E2S intrinsically safe field apparatus may be used providing it has the relevant input feature.

The basic installation is straight forward on/off control using a zener barrier with entity parameters 28v 93mA (often referred to as 28v 300Ω) which is an industry standard barrier (Power driver).

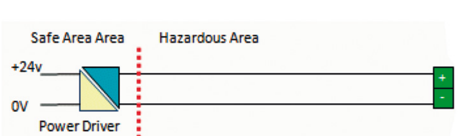
This is suitable for all E2S Intrinsically safe sounders and beacons.

ZENER BARRIERS



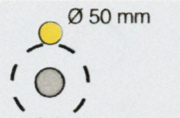
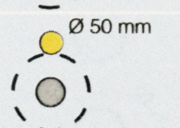
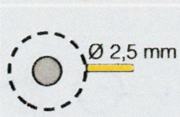
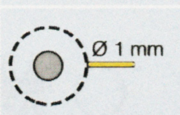
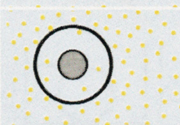
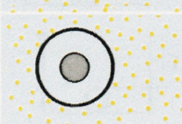
Any Interface with parameters		
Uo ≤ 28v	I o ≤ 93mA	P o ≤ 660mW
or for the Diode return channel		
Uo ≤ 28v	I o ≤ 0mA	

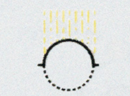
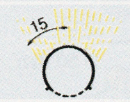
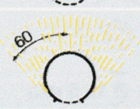
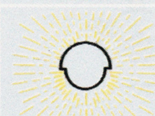
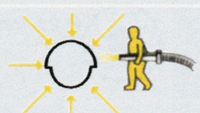
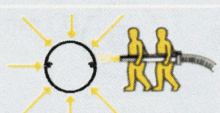
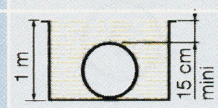
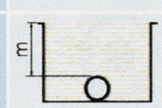
ISOLATION INTERFACE



A suitable barrier would have entity parameters of		
Uo ≤ 28v	I o ≤ 93mA	P o ≤ 660mW

IEC Ingress Protection (IP) Ratings

IP	First digit: protection against accidental contact and penetration by solid foreign bodies	
0		No particular protection
1		Protection against solid bodies over 50 mm and against contacts by large surfaces of the human body (e.g. the hands)
2		Protection against solid bodies over 12,5 mm and against finger contact
3		Protection against solid bodies over 2,5 mm (e.g. tools, wires)
4		Protection against penetration of solid bodies with a diameter or thickness over 1 mm (e.g. wires)
5		Dust penetration is not fully excluded, but the quantity that penetrates causes no damaging effects
6		No dust penetration is permitted

IP	Second digit: protection against penetration of liquids	
0		No particular protection
1		Protection against the vertical fall of drops of water (e.g. condensation)
2		Protection against the vertical fall of drops of water with a maximum incline of 15°
3		Protection against the vertical fall of drops of water with a maximum incline of 60°
4		Protection against splashes of water from all directions
5		Protection against jets of water from all directions
6		Protection against waves of water or powerful jets
7		Protection against the effects of immersion
8		Protection against the effects of prolonged immersion under pressure

Mechtric

Conversion Table

Length (m)	
Ci = 0µF	Li = 0mH
1 mil	25.40µm
1 inch	25.40mm
1 foot	0.3048m
1 yard	0.9144m
1 mile	1.6093km
1 nautical mile	1.852km
Area (m^2)	
1 circular mil	506.7μm^2
1 in^2	645.2mm^2
1 ft^2	0.0929m^2
1 yd^2	0.8361m^2
1 acre	4,047m^2
1 acre	0.4047ha
1 $mile^2$	2.590km^2
Volume (m^3)	
1 in^3	16.39cm^3
1 ft^3	0.0283m^3
1 yd^3	0.7646m^3
1 UKfloz	28.41mL
1 UKgal	4.546 litre
1 USgal	3.785 litre
1 UKgal	0.004546m^3
1 USgal	0.003785m^3
Mass (kg)	
1 oz	28.35g
1 lb	0.454kg
1 cwt	50.80kg
1 UKton	1016kg
1 USton	907kg
Energy (J), power (W)	
1 ft lbf	1.356J
1 m kg	9.807J
1 Btu	1055J
1 therm	105.5kJ
1 hp h	2.685MJ
1 kW h	3.60MJ
1 Btu/h	0.293W
1 ft lbf/s	1.356W
1 m kgf/s	9.807W
1 hp	745.9W

To convert °F to °C
Tc = (5/9)*(Tf-32)

To convert °C to °F
Tf = (9/5)*Tc+32

Velocity (m t/s, rad/s) Acceleration (m/s^2, rad/s^2)	
1 ft/min	5.080mm/s
1 in/s	25.40mm/s
1 ft/s	0.348m/s
1 mile/h	0.4470m/s
1 mile/h	1.609km/h
1 knot	0.5144m/s
1 deg/s	17.45mrad/s
1 rev/min	0.147rad/s
1 rev/s	6.283rad/s
1 ft/s^2	0.3048m/s^2
Flow rate (kg/s, m^3/s)	
1 lb/h	0.1260g/s
1 ton/h	0.2822kg/s
1 lb/s	0.4536kg/s
1 ft^3/h	7.866cm^3/s
1 UKgal/h	1.263cm^3/s
1 UKgal/min	75.77cm^3/s
1 UKgal/s	4.546L/s
1 UKga/min	0.273m^3/h
1 USga/min	0.227m^3/h
Density (kg/m, kg/m^3)	
1 lb/in	17.86kg/m
1 lb/ft	1.488kg/m
1 lb/yd	0.496kg/m
1 lb/in^3	27.68Mg/m^3
1 lb/ft^3	16.02kg/m^3
1 ton/yd^3	1329kg/m^3
Viscosity (pa s, m^2/s)	
1 poise	9.807Pa s
1 kgf s/m^2	9.807Pa s
1 lbf s/ft^2	47.88Pa s
1 lbf h/ft^2	172.4kPa s
1 stokes	1.0cm^2/s
1 in^2/s	6.452cm^2/s
1 ft^2/s	929.0cm^2/s
Illumination (cd, 1m)	
1 $1m/ft^2$	10.76lm/m^2
1 cd/ft^2	10.76cd/m^2
1 cd/in^2	1550cd/m^2

Inertia (kg m^2) Momentum (kg m/s, kg m^2/s)	
1 oz in^2	0.018g m^2
1 lb in^2	0.293g m^2
1 lb ft^2	0.0421kg m^2
1 ton ft^2	94.30kg m^2
1 lb ft/s	0.138kg m/s
1 lb ft^2/s	0.042kg m^2/s
Torque (n m)	
1 ozf in	7.062nN m
1 lbf in	0.113N m
1 lbf ft	1.356N m
1 tonf ft	3.307kN m
1 kgf m	9.806 N m
Force (n), pressure (pa)	
1 dyn	10.0µN
1 kgf	9.807N
1 ozf	0.278N
1 lbf	4.445N
1 tonf	9.964kN
1 dyn/cm^2	0.10Pa
1 lbf/ft^2	47.88Pa
1 lbf/in^2	6.895kPa
1 $tonf/ft^2$	107.2kPa
1 $tonf/in^2$	15.44MPa
1 kgf/m^2	9.807Pa
1 kgf/cm^2	98.07kPa
1 lbf/in^2	0.069 Bar
1 mmHg	133.3Pa
1 inHg	3.386kPa
1 inH_2O	149.1Pa
1 ftH_2O	2.989kPa
1 Bar	100kPa
Thermal quantities (W, J, kg, K)	
1 W/in^2	1.55kW/m^2
1 Btu/(ft^2 h)	3.155W/m^2
1 Btu/(ft^3 h)	10.35W/m^3
1 Btu/(ft h ˚F)	1.731w/(m K)
1 ft lbf/lb	2.989J/kg
1 Btu/lb	2326J/kg
1 Btu/ft^3	37.26Kj/m^3
1 ft lbf/(lb ˚F)	5.380J/(kg K)
1 Btu/(lb ˚F)	4.187kJ/(kg K)
1 Btu/(ft^3 ˚F)	67.07kJ/m^3

Notes: