# Making Safe Waves in Hazardous Areas

## A Wireless White Paper


Wireless Vision Engineering Tracking

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As wireless devices such as mobile phones and laptop computers become more reliable and cost effective, there is growing interest amongst the process industry about the benefits to be found from enabling such devices for hazardous areas. However this is not a simple task. Installing wireless networks in hazardous areas requires careful, expert planning and execution. John Hartley, Managing Director of Extronics, explains the hazards posed by radio frequency sources, the issues involved when installing wireless networks in hazardous areas, and how to minimise the potential risk.

We've been using radio waves in both the business and consumer worlds for a long time, but it is only in the last decade or so that radio devices have become more prevalent in the process industries. Portable radios and pager devices were the first devices to gain certification for use in hazardous areas after they had been tried and tested in the wider business world. Now there is considerable interest in, and commercial requirement for, improved communications throughout process areas including those areas with a known incendive risk.

The radio frequency spectrum covers a wide range from radio waves to gamma rays but the agreed area of RF under the explosion protection standards only considers the range from 9KHz to 60GHz. That is where this article will focus. It has always been understood that radio frequency (RF) can cause ignition in the right set of circumstances, but when the early radios and pagers were first introduced to the process plants there was little information or guidance in the Explosion Protected (Ex)- type approval standards to clarify what was a safe amount of RF power to be allowed in the different types of hazardous area. The earliest research into this matter came about approximately 40 years ago when the UK Government was proposing to build new petrochemical facilities near to existing TV and radio transmitter networks. Those in opposition to the schemes objected on the basis that these installations would be dangerous due to the risk of inadvertent ignition by the radio frequency transmissions. Because of the strategic nature of these facilities and their importance to the UK economy a large amount of research and testing was undertaken and the resultant findings proved what the acceptable safe limits of RF were. It is only in more recent times, as interest is gathering in RF devices and networks, that this information has been more widely circulated and published with acceptable explosion protection techniques agreed upon. There are now a number of approval standards that must be adhered to, including the CLC/TR50427 , EN60079 series, IEC60079 series and others such as FM3600. For the purposes of this article we will refer to the IEC specifications as almost all national standards around the world are derived from these documents.

The standard 'CLC/TR50427 ' explains the methods that can be used to assess if an RF installation is safe to operate in a hazardous area. It details methods and principles to assess installations that are above the safe RF power limits and if they present a hazard due them acting as an antenna and possible source of spark ignition. The IEC60079-0:2011 provides radio frequency power or energy threshold tables (table 4 and 5), which can be used to determine if equipment will be safe for use within hazardous areas. Many people don't even realise that RF is a hazard. Many users ask "why do we need a certified antenna when it is only fed with RF?" This common misconception is understandable, as there are still very few certified wireless devices on the market and they are only just starting to appear under relevant standards .

**Table 8 – Radio frequency power thresholds**

| Equipment for | Threshold power W | Thermal initiation time µs |
|---|---|---|
| Group IIA | 6 | 100 |
| Group IIB | 3,5 | 80 |
| Group IIC | 2 | 20 |
| Group III | 6 | 200 |

For pulsed radar and other transmissions where the pulses are short compared with the thermal initiation time, the threshold energy values $Z_{th}$ shall not exceed those given in Table 9.

**Table 9 – Radio-frequency energy thresholds**

| Equipment for | Threshold energy $Z_{th}$ µJ |
|---|---|
| Group IIA | 950 |
| Group IIB | 250 |
| Group IIC | 50 |
| Group III | 1 500 |

NOTE 2 In Tables 8 and 9, the same values are applied for "Ga", "Gb", "Gc", "Da", "Db", or "Dc" equipment due to the large safety factors involved.

NOTE 3 In Tables 8 and 9, the values apply in normal operation, provided that the user of the equipment does not have access to adjust the equipment to give higher values.

NOTE 4 These requirements are derived from IEC 60079-0.

There are a number of ways radio frequency can be a potential hazard in explosive atmospheres. We know that radio waves and microwaves induce currents in metallic structures such as cranes, pipes and other plant, which can cause sparking if there is a suitable gap in the structure. The power dissipated in the spark may be sufficient to ignite a flammable atmosphere if the radio wave is powerful enough. For some applications, such as pulsed radio transmissions in radar, the amount of power may be higher than these levels, but only for a relatively short amount of time. It is possible, in these circumstances, to use another limit based on threshold energy. Where the pulse time is less than half the thermal initiation time, and the interval between pulses is longer than the thermal initiation time, the above mentioned IEC60079-0 table can be referred to establish the safety of the device.

Fortunately, much of the latest wireless technology that is of great interest to users to deploy in their plants such as WiFi or RFID has RF power levels lower than the 2W limit. Providing antenna gain does not cause these levels to be exceeded, and they are installed with adequate protection e.g. Ex d enclosure, they can be used in a hazardous area without restrictions. However, when the amount of power is above the safe levels then CLC/TR50427 can be used to assess the installation for safe use in hazardous areas.

The most obvious, but not necessarily the most practical, solution for a safe installation is to ensure the antenna is placed a suitable distance outside of the hazardous area so that the level of RF power transmitted is below the acceptable limit before it enters the hazardous area. It is also possible to certify specific devices for use only within a safe distance from metallic structures and structures or equipment such as cranes, columns, pipes and tanker loading stations. These can act as antennas and thus pose as a sparking hazard. The issue with this approach though is ensuring that the conditions subsequently remain the same as at the time the assessment was carried out; as such is generally not considered as a suitable solution.

Gas detectors can be employed as a "Protective System" to monitor the unsafe perimeters around an antenna where the RF power is at an incendive level. If the system is certified for this purpose, it is possible to use very powerful RF transmitters or even devices that are not available in a hazardous area design. Should a gas at hazardous levels be detected, the power is isolated from the equipment thus rendering it safe. The obvious disadvantage of this solution is the loss of radio communication when gas is detected, often an unsatisfactory solution.

The main danger with wireless networking devices is associated with the electrical hazard from the transmitter and its power supply, as well as from the RF output stage. The hazard posed by electrical equipment has been catered for over many decades with the earliest standards and protection concepts now over 50 years old.
The two main dangers are the risk of a spark when a device short circuits due to inadequate creepage and clearances, or from a foreign body entering a piece of equipment. Ignition can also be caused by the heating effect of components, under fault conditions, conducting electrical current which are not adequately power rated. Also, a non-battery powered radio transceiver is ultimately connected to mains voltage and thus under fault conditions this voltage could be transferred through to an antenna. If that antenna does not have suitable creepage and clearance, or be of a suitably robust construction, it could cause an incendive spark or become dangerously hot. This means that either the RF stage has to have an intrinsically safe output or that antennas must meet a range of stringent mechanical, constructional and thermal requirements to ensure that the installation is safe should any of the above events occur.

For example, many of the earlier deployments of 802.11 WLAN access points used antennas pointing through 'Ex d enclosure windows' (flameproof, sealed enclosures with a toughened glass window for reading dials or, in this case, transmitting data). Some still do today. This is quite suitable for applications at lower frequencies but not ideal for higher frequencies such as 2.4 and 5GHz WLAN as the glass highly attenuates the signal and, with a typical output of only c.100mW from the device in the case of an 802.11b/g/n WLAN, this is a far from ideal solution.

*Figure 3 Antenna in Ex d enclosure with window*

A further issue with this method of protection is that the access point only directs RF power from the front of the enclosure (not in the case of glass dome Ex d enclosures), which will limit the flexibility of the device and also cause RF shadows in the close proximity of the unit. RF multi-path interference can also be created at higher frequencies which is an effect to be avoided in deployments. However, although this method has its failings, it is reasonably cost effective and the Ex certification is relatively simple, so it does have its place provided that the application suits the RF shortcomings.

A more preferable method of dealing with the antenna protection is to design and construct the antenna to comply with the IEC60079-0 general requirements and specific sub-categories. For example, Ex d flame proofing IEC60079-1, Ex e increased safety IEC60079-7 or Ex m device encapsulation IEC60079-18. Then the only other point requiring assessment by the installer is the maximum power output of the RF stage, which can be taken from the manufacturer's data sheet. This is because the antenna will have been designed and certified to be safe under fault conditions in a hazardous area. For instance, a 250VAC mains fault being transferred into the antenna via the RF stage of the transceiver. The main issues regarding these specially designed and Ex approved antennas is that currently there are only omni directional types available. Additionally they tend to be quite expensive compared with standard industrial antennas due to the fact they are made in low volumes and constructed from special materials. The best solution to minimise costs and widen the range of antenna's in hazardous areas is to use standard industrial antennas. This is possible if the output of the RF transceiver is intrinsically safe, Ex i in accordance with IEC60079-11.

*Figure 4 iANT100 Ex e Antenna*

If the radio transmitter electronic circuit is unknown (i.e. it is not the manufacturer of the transmitter designing the certified device) then one would immediately look to use off the shelf intrinsically safe barriers as these are designed to fit between the uncertified electronics and the electrical circuit fed to the hazardous area. The classic 'zener barrier' (a shunt safety barrier consisting of a current limiter circuit, a voltage limiter circuit and a fuse for power rating protection) is the simplest solution to making the transceiver RF stage intrinsically safe. This is because it will prevent any possible faults in the transceiver being propagated or transferred to the hazardous area. Any fault current up to a value of Um 250 VAC will be limited by the zener diodes and resistive current limitation and thereafter the fuse will blow, turning off the power to the hazardous area.

However nothing is ever that simple. Although the RF output stage may have been rendered intrinsically safe, the constraints of the zener barrier's capabilities means that this principle can only be used on lower frequency signals, typically less than 500KHz. This is because signal attenuation and distortion renders the RF signal useless from a functional point of view. The easiest way to block low frequency mains faults is to use galvanically isolated high pass, band pass or tuned filter circuits as these block all low frequency signals. However not all faults are blocked, some filter circuits can let through unsafe energy levels from transients. IEC60079-11:2012 stipulates the energy transmitted shall be in accordance with the permissible ignition energy of 10.7. All possible transients shall be taken into account, and the effect of the highest nominal operating frequency (as that supplied by the manufacturer) in that part of the circuit shall be considered.

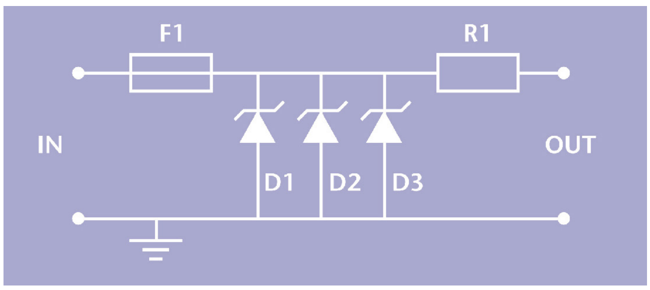



*Figure 5 Zener Barrier*

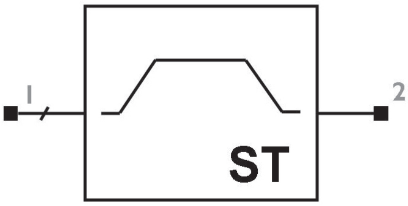



*Figure 6 - Band Pass Filter*

Whilst this type of circuit is a bona fide technique the filter circuit must be assessed along with the transceiver electronics to make sure other faults cannot pass through the circuit and pose an incendive risk. This means that when using this type of protection further certification by a Notified Body of the complete assembly is required. Any barrier device of this design can of course be certified in it's own right but it will only be classified as a "certified component". ATEX and IECEx schemes designate these as a certificate type "U" informing the user that further certification of the complete apparatus is required. It is worth noting that for zone 2 applications, the protection of the transceiver RF stage is much easier due to the fact that fault conditions are not considered.

A recent development by Extronics has completely altered the landscape of deploying wireless networks in hazardous areas by using the intrinsic safety protection concept and being able to deploy wireless hardware e.g. access points and standard antennas, without further Notified Body certification. The iSOLATE500 is an "associated apparatus" certified RF galvanic isolator and, just like a conventional zener barrier or galvanic isolator for analogue or discrete signals e.g. 4-20mA and volt free contacts, they can be deployed by the user without further certification by a Notified Body. The only requirement is that the conditions stipulated on the certificate are followed and the general rules of verifying intrinsically safe circuits are applied.

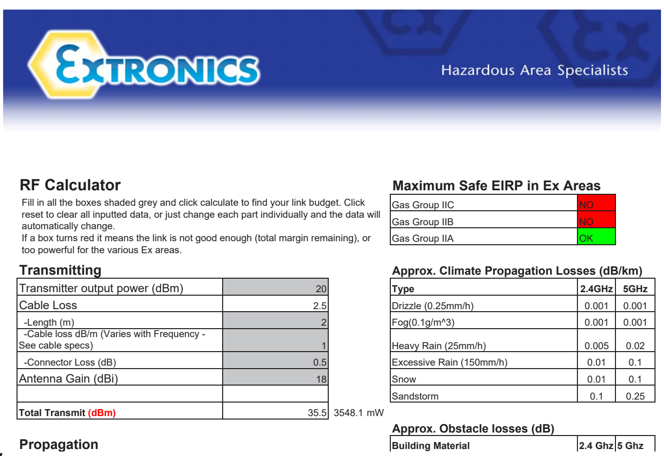

*Figure 7 - iSOLATE500 intrinsically safe galvanic RF isolator*

Another real advantage of intrinsically safe circuits is that they can be worked on "live" without them needing to be isolated as there is no concern of ignition. This means that standard RF connectors and cabling can be used which also simplifies deployment in the field. The apparatus certified iSOLATE-CT RF connector transit means that a conventional type N RF connector is present on the outside of the Exd enclosure for connection to the antenna. This completely eliminates the need use a cable gland to connect to the RF output of the transceiver inside the Exd enclosure and means that installation is a much quicker and simplified process.

*Figure 8 - iSOLATE CT connector transit on Ex d enclosure*

There is one final consideration to which the user must pay attention. This is the antenna gain when assessing if the RF transceiver, with its associated antenna, is suitable for use in a hazardous area. A calculation of the maximum EIRP (Effective Isotropic Radiated Power) must be made to ensure the power radiating from the antenna is below the limits for the relevant hazardous area. In this example of a long distance link (Figure 9) it is easy to see how the RF output stage is intrinsically safe and far below the 2W limit. But once a high gain antenna is connected, it is massively over the limit and would be considered an incendiary signal in any hazardous area.

It is not just a matter of making the network and devices safe and compliant with regulations. It also has to work! Any wireless point-to-point or MESH link of more than a few hundred metres should be calculated to see if it will function reliably, taking into account power from the transceiver, receive sensitivity, antenna gain and losses in cables, connectors and free space loss. This is often referred to as a link budget calculator. It is good practice to have at least 6dBm of fade margin between the link working and not to allow for changing RF conditions. Our calculator enables the user to determine if their planned installation is safe to use in a hazardous area with a simple 'green-go' and 'red-no-go' legend.



EXTRONICS
Hazardous Area Specialists

**RF Calculator**

Fill in all the boxes shaded grey and click calculate to find your link budget. Click reset to clear all inputted data, or just change each part individually and the data will automatically change.
If a box turns red it means the link is not good enough (total margin remaining), or too powerful for the various Ex areas.

**Maximum Safe EIRP in Ex Areas**

| | |
|---|---|
| Gas Group IIC | NO |
| Gas Group IIB | NO |
| Gas Group IIA | OK |

**Transmitting**

| | | |
|---|---|---|
| Transmitter output power (dBm) | 20 | |
| Cable Loss | 2.5 | |
| -Length (m) | 2 | |
| -Cable loss dB/m (Varies with Frequency - See cable specs) | 1 | |
| -Connector Loss (dB) | 0.5 | |
| Antenna Gain (dBi) | 18 | |
| | | |
| **Total Transmit (dBm)** | 35.5 | 3548.1 mW |

**Approx. Climate Propagation Losses (dB/km)**

| Type | 2.4GHz | 5GHz |
|---|---|---|
| Drizzle (0.25mm/h) | 0.001 | 0.001 |
| Fog(0.1g/m^3) | 0.001 | 0.001 |
| Heavy Rain (25mm/h) | 0.005 | 0.02 |
| Excessive Rain (150mm/h) | 0.01 | 0.1 |
| Snow | 0.01 | 0.1 |
| Sandstorm | 0.1 | 0.25 |

**Approx. Obstacle losses (dB)**

| Building Material | 2.4 Ghz | 5 Ghz |
|---|---|---|

**Propagation**

*Figure 9 - Extronics RF link budget calculator*

Every decade or so, there is a major new technology that offers huge gains in productivity in the work place. Roughly

20 years ago came the microprocessor, replacing analogue electronics. Then, 10 years ago, the PC and commercial grade operating systems were accepted as suitable for use for plant control and supervision as a DCS. We firmly believe that the next decade will see wireless networking technology make the next step change in working practices, safety and in productivity improvements in the process industry.

There is a huge amount of complex information for communications engineers to consider when planning a wireless network in any of the process industries, before they even start to consider what devices to support. Extronics is focused on the development of 802.11 products that are suitable for use in extreme environments, including WiFi and MESH Ethernet infrastructure, Real Time Location Systems for people safety and asset tracking, Telemetry devices and RFID. We are looking forward to creating the opportunities to lead the process industry into a new era based upon sound, researched and developed technology.