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Mobile devices in Hazardous Areas

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Introduction:

The intention of this paper is to outline the basic requirements to design & manufacture an IS mobile device. What are the risks & what do the standards say. This will hopefully explain why IS mobile devices are more expensive than standard rugged devices. This is not intended to be a design guide or a Promotional presentation. I have selected 5 areas, where the requirements of IS are important & substantial to avoid ignition. All references are to SANS 60079-11:2012 (based on IEC 60079-11:2011) unless otherwise stated. Note that IEC 60079-11:2023 has recently been released & SANS will follow in time.

Please note that excerpts of SANS60079-11:2012 are for illustration purposes only and have been included to provide context & evidence of comments. Only small relevant sections of the 149 page document are shown. The references illustrate the sections referred to and allow the reader to refer to relevant sections of the standard to be read in full, to obtain a complete understanding of the subject matter at hand. For your ease of reference, the standard can be purchased at https://store.sabs.co.za/sans-60079-11-2012-ed-4-00.html

1) The battery itself is the largest risk (see 7.4 for battery selection, suitability & specific requirements for IS). Battery design, short circuits, overheating, how the battery is charged are key. This includes battery charge connectivity (USB & magnetic charge terminals)

   Battery construction is defined in SANS/IEC60079-11 7.4.2 and extensive & destructive testing is defined in 10.5.3. Spark ignition tests are comprehensive defined in 10.1 & temperature tests defined in 10.2.

   SANS/IEC60079-11 6.2.5 defines the requirements for battery segregation & charging. Even if charging is carried out in the non-hazardous area, the charging/data connection must ensure the ratings of protective components are not exceeded. Therefore, the charging connections should either be rated to Um 250 V, or a special charger or cable must be provided.

6.2.5 Requirements for connections and accessories for IS apparatus when located in the non-hazardous area

Intrinsically safe apparatus may be provided with connection facilities that are restricted to use in a non-hazardous area e.g. data downloading and battery charging connections. Such facilities shall be provided with protection to ensure the ratings of the safety components within the intrinsically safe equipment comply with 7.1. The use of a fuse protected shunt Zener assembly complying with 7.3 and 7.5.2 shall be considered sufficient protection for voltage limitation.

Where these connections are provided for the connection of battery charger see also 7.4.9.

Protection circuitry and components may reside either in the intrinsically safe apparatus or the non-hazardous area equipment. If any part of the protection circuit is located in the non-hazardous area accessory, it shall be assessed in accordance with this standard and the non-hazardous area accessory shall be stated in the documentation.

10.5.3 Spark ignition and surface temperature of cells and batteries

If a battery comprises a number of discrete cells or smaller batteries combined in a well-defined construction conforming to the segregation and other requirements of this standard, then each discrete element shall be considered as an individual component for the purpose of testing. Except for specially constructed batteries where it can be shown that short-circuits between cells cannot occur, the failure of each element shall be considered as a single fault. In less well-defined circumstances, the battery shall be considered to have a short-circuit failure between its external terminals.

Note this is only first paragraph of 10.5.3 as the section defining testing is substantial.
Section 7.4.1 contains the following statement:

> Some types of cells and batteries, for example some lithium types, may explode if short-circuited or subjected to reverse charging. Where such an explosion could adversely affect intrinsic safety, the use of such cells and batteries shall be confirmed by their manufacturer as being safe for use in any particular intrinsically safe or associated apparatus. The documentation and, if practicable, the marking for the apparatus shall draw attention to the safety precautions to be observed.

Where the battery is user-replaceable, the IS mobile device should be marked in accordance with 12.3. External contacts for charging are defined in 7.4.9
Example from certificate showing that the battery has IS parameters.

Power Supply:
The smartphone may only be used with the approved, intrinsically safe battery pack

LiPo battery Uo = 3.8 V

6.2.2 defines the requirements on plugs & sockets to prevent accidental & unsafe connection errors.

6.2.2 Plugs and sockets

Plugs and sockets used for connection of external intrinsically safe circuits shall be separate from and non-interchangeable with those for non-intrinsically safe circuits.

Where intrinsically safe or associated apparatus is fitted with more than one plug and socket for external connections and interchange could adversely affect the type of protection, such plugs and sockets shall either be arranged, for example by keying, so that interchange is not possible, or mating plugs and sockets shall be identified, for example by marking or colour coding, to make interchanging obvious.

2) Electrostatic discharges are a source of ignition (Some plastics can be statically charged when wiped / cleaned with a cloth). Aluminium can rust becoming a spark risk. SANS/IEC60079-0 section 7 defines the requirements for non-metallic enclosures. Clause 7.4 concentrates on the requirements to prevent electrostatic charges. SANS/IEC60079-0 Section 8 defines requirements for metallic enclosures. 8.2, 8.3, 8.4 defines requirements for Group I, II, III respectively. E.g. Group I limit to 15% aluminium for use in fiery mines.

3) Other than purpose-built accessories (scanners, headsets etc. where the accessory Ui Ii Pi MUST be compatible with the mobile device Uo Io Po), cable connectivity to devices is limited to the Safe Area and these terminals need either electrical or mechanical protection whilst in use in the hazardous area to prevent short circuits / sparks. SANS/IEC60079-11 7.4.9 defines the protection of any connectivity points on the device. The magnetic coupling terminals require IP30 (Group II) (Protected from tools and wires greater than 2.5 millimetres.) or IS limiting circuitry to prevent sparks should they be accidently short circuited.

> **7.4.9 External contacts for charging batteries**
>
> Cell or battery assemblies with external charging contacts shall be provided with means to prevent short-circuiting or to prevent the cells and batteries from delivering ignition-capable energy to the contacts when any pair of the contacts is accidentally short-circuited. This shall be accomplished in one of the following ways:
>
> a) limiting the output in accordance with this standard, or;
>
> b) for Group II intrinsically safe apparatus, a degree of protection by enclosure of at least IP30 shall be provided for the suitably protected charging circuit and shall be marked with a warning label as specified in item c) of 12.3 (or item b) of the text of warning markings table of IEC 60079-0). The separation distances between the charging contacts shall comply with 6.3 considering the open-circuit voltage of the battery.

4) Induced currents from RF. RF power needs to be limited depending on the hazardous area environment. See table 5 (SANS/IEC60079-0) & Table 8 (SANS/IEC60079-14). Whilst Wifi & Bluetooth do not get near the 2W limit, devices can exceed this with GSM & LTE/4G/5G.

Table 5 – Threshold power

Equipment for	Maximum threshold power W	Maximum thermal initiation time µs
Group I	6	200
Group IIA	6	100
Group IIB	3,5	80
Group IIC	2	20
Group III	6	200

Table 6 – Threshold energy

Equipment for	Maximum threshold energy Z_{th} µJ
Group I	1 500
Group IIA	950
Group IIB	250
Group IIC	50
Group III	1 500

Please note that for Group I in South Africa, DMR directives (ME-2-2003 & MS-2-2010) stipulate 500mW maximum power transmission overriding IEC/SANS60079-0 standard of 6W. This is however academic as with no GSM/LTE/4G etc. in an underground mine, mobile devices will only transmit at approximately 100mW (Wifi & Bluetooth).

SANS/IEC60079-0 6.6.2 states that RF power should not be user/software configurable.

> **6.6.2 Radio frequency sources**
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> The threshold power of radio frequency (9 kHz to 60 GHz) for continuous transmissions and for pulsed transmissions whose pulse durations exceed the thermal initiation time shall not exceed the values shown in Table 5. Programmable or software control intended for setting by the user shall not be permitted.

5) Product design needs to meet safety component power derating, segregation distances, capacitance & inductance & design to prevent hotspots.
Safety components (resistors, Zener diodes etc.) require 2/3 power derating (SANS/IEC60079-11 7.1). 10.4.2 refers to safety factors (1.5 for Exia & Exib) required.
Requirements for creepage & clearance (including use of encapsulation) for PCB layout (components & tracks) are defined in 5.6.4

7 Components on which intrinsic safety depends

7.1 Rating of components

For Level of Protection "ia" and "ib" in both normal operation and after application of the fault conditions given in Clause 5, any remaining components on which the type of protection depends, shall not operate at more than two-thirds of their maximum current, voltage and power related to the rating of the device, the mounting conditions and the temperature range specified. For Level of Protection "ic", in normal operation, components on which the type of protection depends shall not operate at more than their maximum current and voltage and no more than two-thirds of their power. These maximum rated values shall be the normal commercial ratings specified by the manufacturer of the component.

7.2 Connectors for internal connections, plug-in cards and components

7.2 provides details for connectors. Requirements to prevent incorrect connection or interchangeability.

7.3 states uses must be rated for the Um voltage and encapsulated (7.3)

7.3 Fuses

Where fuses are used to protect other components, 1,7 I_n shall be assumed to flow continuously. The cold resistance of the fuse at the minimum specified ambient temperature may be taken as an infallible resistance complying with 8.5 for current limiting purposes. (In the absence of available information, this may be taken as the minimum resistance at the minimum specified ambient temperature when measured on 10 samples as required in 10.4.) The fuse time-current characteristics shall ensure that the transient ratings of protected components are not exceeded. Where the fuse time-current characteristic is not available from the manufacturer's data, a type test shall be carried out in accordance with 10.4 on at least 10 samples. This test shows the capability of the sample to withstand 1,5 times any transient which can occur when U_m is applied through a fuse.

Fuses for Levels of Protection "ia" and "ib", which may carry current when located in explosive atmospheres, shall be encapsulated in accordance with 6.6.

10.1.4.2 Safety factors

NOTE The purpose of the application of a safety factor is to ensure either that a type test or assessment is carried out with a circuit which is demonstrably more likely to cause ignition than the original, or that the original circuit is tested in a more readily ignited gas mixture. In general, it is not possible to obtain exact equivalence between different methods of achieving a specified factor of safety, but the following methods provide acceptable alternatives.

Where a safety factor of 1,5 is required it shall be obtained by one of the following methods:

a) increase the mains (electrical supply system) voltage to 110 % of the nominal value to allow for mains variations, or set other voltages, for example batteries, power supplies and voltage limiting devices at the maximum value in accordance with Clause 7, then:
   1) for inductive and resistive circuits, increase the current to 1,5 times the fault current by decreasing the values of limiting resistance, if the 1,5 factor cannot be obtained, further increase the voltage;
   2) for capacitive circuits, increase the voltage to obtain 1,5 times the fault voltage. Alternatively when an infallible current-limiting resistor is used with a capacitor, consider the capacitor as a battery and the circuit as resistive.

CONCLUSION

As can be seen, the requirements to make a device IS are onerous, time consuming & costly requiring specific battery design & PCB component level changes to meet power deratings & creepage & clearance. This makes it very difficult & complicated to convert a standard device to Ex ia/ib. Even Ex ic is challenging.

Further related comments: There are a few practical things to consider when selecting devices:

There have been reports in Europe of fake ATEX certificates & unsafe devices with 'legitimate' ATEX certificates in recent months (https://ec.europa.eu/safety-gate-alerts/). The mechanism to remove non-compliant ATEX devices/certificates devices is fractured as it is down to the market surveillance authority in each country. (There is however a formal mechanism for those authorities to collaborate and share information).

1) IECEx has mechanism for devices & certificates to be reported & removed. IECEx also has an online database of certificates, so it is easy to confirm certification & validity.
2) Batteries typically have a limited life (& typically only a 6 month warranty). Devices with replaceable batteries will extend the usable life considerably.
3) MDM compatibility & Android Enterprise compliance provide some guarantee of security & quality.
4) Consider the impact of security with respect to support & bug fixes.

Disclaimer:

The content or information provided in this article is strictly intended for educational purposes and does not constitute a design guide or a Promotional presentation. It is solely meant to provide general information regarding the current standards and an explanation of the reasons behind the high cost of Intrinsically Safe (IS) mobile devices. This article should not be considered a substitute for professional advice, guidance, or instruction. The information presented herein is based on established IS mobile device requirements and standard principles, which may not be universally applicable to all circumstances.

While we strive to provide accurate and up-to-date information, this article is provided for general informational purposes only, to educate the reader and reflects the most current Ex ia/ib and Ex ic standards set out in SANS 60079-11:2012 at the date and time of this article. While we endeavour to ensure its accuracy, we make no representations or warranties of any kind, express or implied, regarding the completeness, accuracy, reliability, suitability, or availability of the information or related excerpts contained in the article, should not be relied upon as the sole basis for making decisions.

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