The Problems with Batteries in TPMS

. . . . Safety and Environmental Concerns

Introduction

When the loss of pressure in a motor vehicle's tyre goes undetected during use, the tyre can become overheated and disintegrate, causing loss of control of the vehicle, leading to potential death and injury.

A monitoring system to detect a vehicle's abnormal tyre pressures and temperatures and give the driver advanced warning is clearly a desirable safety feature. This has been recognised by the Senate and House of Representatives of the United States of America in Congress with the introduction of the HR5164 TREAD Act in 2001. This legislation requires mandatory tyre pressure monitoring systems (TPMS) as a safety feature on all new vehicles at the time of their manufacture.

Several manufacturers of direct measurement TPMS use batteries to power wireless radio frequency (RF) transmitter modules located inside a wheel's air cavity.

The problems with powering TPMS safety systems with batteries may be understood as follows:

Primary Safety

Designers of battery powered RF TPMS transmitter modules are faced with challenging requirements:

- Long battery life: 7 to 10 years;
- Demanding automotive temperature range: -40 ^{o}C to +125 ^{o}C;
- Low weight so as not to adversely affect a wheel's balance;
- Small volume so as not to interfere with tyre industry equipment.

The practical volume and weight of a battery used in TPMS will be limited and thus the battery's power density, or energy that can be produced per unit mass, will also be limited. The available energy is finite and its rate of consumption defines the battery's life-time for any given load.

A battery's actual energy density is directly related to its chemistry, and its operating load and temperature profile. The load on a battery will be minimal when disconnected (in this case the load is the leakage current through battery's terminal to terminal resistance and contributes to the battery's 'shelf life') and will vary according to the in-circuit power requirements of the TPMS implementation over time.

Manufacturers of batteries used in TPMS provide performance data on their products which demonstrate that battery life varies considerably over the automotive temperature range.

In order to accommodate the required 7 to 10 year battery life time, designers of battery powered RF TPMS transmitter modules aim to conserve the 'power budget' by employing techniques to power down unused electronics, or to only operate whilst the vehicle is in motion, or to transmit data at an increased rate during abnormal conditions. It is conceivable that during the vehicle's lifetime

there could be many extended episodes of abnormal tyre pressures where RF transmitters in the TPMS wheel modules would be required to be active and be presenting significant loads to the battery. Calculations based on battery manufacturer's data and typical TPMS RF transmitter power requirements demonstrate that TPMS supplier's claims of 7 to 10 years battery life are optimistic at best for no fault conditions, let alone for several flat tyre episodes.

In any case, at some point in time, and within the vehicle's lifetime, every battery will ultimately become exhausted and there will be an 'unsafe' window where the system is unavailable.

To classify tyre pressure warning systems as 'safety' systems they must have maximum reliability and availability throughout a vehicle's operating life-time. Logic says that the use of batteries in such a critical system appears to defeat the system's basic requirement of being a critical life saving product.

Secondary Safety & Environmental Impact

When designing a battery into any application, the chemical stability and toxicity of the battery system are primary concerns. All batteries have a life cycle and at some point in time, every battery will need to be disposed of.

There are three stages in every battery's life cycle: manufacture/shelf life; active use/abuse; and final disposal. Safety concerns and Environmental issues exist in all three stages.

In the US there are approximately 16 million new passenger vehicles manufactured annually which must ultimately comply with the legislative requirements of the TREAD Act and be fitted with TPMS. If each vehicle has four (five, if the spare is equipped) wheels fitted with battery-powered RF TPMS rim modules there will be approximately 80 million batteries introduced annually into the environment. Assuming that battery manufacturers observe pollution control during their manufacturing processes, there will still be abuse and disposal phases of the batteries life cycle impacting on individual's safety and the environment. Hence, concerns about safety and handling in such a widespread consumer applications should be carefully considered.

In order to achieve long service life between replacement intervals, manufacturers of battery powered RF-based TPMS wheel modules are specifying high energy density batteries. These batteries are predominantly based on **Lithium thionyl chloride** chemistry. An example is the SL-740 battery manufactured by Sonnenchein Lithium.

Material Safety Data Sheets (MSDS) on such batteries list hazardous decomposition products, when exposed to water, which include Sulphur Dioxide gas, Hydrogen Chloride gas and strongly acidic wastewater. Furthermore, MSDS toxicological information for thionyl chloride lists acute toxicity which is corrosive on contact with eyes and skin. Another component of lithium battery's chemistry is Aluminium Chloride which the MSDS fetotoxicity lists as having "adverse effects on growth and behaviour" (Reference: MSDS Spectrum Batteries Inc - http://www.etv.com.au/Thionyl180msds.pdf).

In general the hazards associated with lithium thionyl chloride batteries may be divided into two categories:

- Toxicity: external physical abuse such as cell incineration and puncture will cause corrosive contents to leak and be hazardous.

Inhalation of contents may result in pulmonary oedema; Skin, eye and fetotoxicity hazards.

- Fire and Explosion: battery may vent or be explosive at higher temperatures above 150 ^{o}C; Explosions due to abnormal electrical operation ie., short-circuit of these high energy density batteries may result in explosion and fire.

Because of its high energy density capability, the lithium cell must be constructed with an internally fused design. If the battery is inadvertently charged or shorted, and the fuse mechanism fails, the cell may rupture and explode.

Battery products utilize chemical reactions and are thus classified as chemical products. As such, batteries are being subjected to a growing number of agency and legislative guidelines for environmental and safety, during both the active life cycle in a product and at the time of disposal. Environmentally, because of the highly toxic and corrosive thionyl chloride in the cell, this chemistry of lithium cell is not recognized as normal waste and requires special handling and disposal.

In general the hazards associated with disposal of lithium-thionyl chloride batteries may are related to aquatic toxicity if battery contents are released into waterways, groundwater, wastewater or marine environments.

Cost

Batteries used in the RF based TPMS application have special chemistry requirements. These are high energy density (high power, low weight & small volume), long life, wide temperature range. These batteries are presently very expensive.

Furthermore, there is an ongoing maintenance cost of replacing each wheel's entire wheel module when batteries become depleted. The reason for this follows:

In order to have reliable battery contacts in the high vibration situation of RF based TPMS, batteries are usually welded to contact posts or directly soldered to their load circuit. Because of the relatively high volatility of lithium chemistry, Underwriter Laboratories requires that only a trained technician replace the batteries. This means that field battery replacement is not possible and the whole electronics wheel module must be replaced at considerable cost (labour plus parts).

Underwriter Laboratory guidelines state that a battery which meets the component-class recognition guideline (meaning the battery is designed to be a life-of-the-device part in a product), is preferable to a product that would require a trained technician to replace the battery.

Other Useful Safety Related References:

EPA Information on Disposal of Batteries - http://www.epa.gov

OSHA Occupational Safety Health Administration standards & Documents - http://www.osha.gov

USDOT Office of Hazardous Materials - http://hazmat.dot.gov

49 CFR Transportation Regulations- http://www.myregs.com/dotrspa