Weekly Whitepaper
Week #32

The 6 Hazards of Product Safety – Risk of Fire

The "Designing for Compliance" Series
Hazard #3 – Preventing a Product Fire from Burning Down the House

"Designing for Compliance" is critical to getting your product certified on the first try. Designing for Compliance requires owning, knowing, and applying the standard(s) while designing your product. However, in order to successfully read and understand the standard, you have to know the intent of the requirements. Our "Designing for Compliance" series of whitepapers will educate you on "The 6 Hazards of Product Safety". The intent of the requirements in all UL/CSA/EN/IEC safety standards is to protect the user from the "6 Hazards of Product Safety". This whitepaper covers Hazard #3 – Risk of Energy.

Risk of Fire Definition: All electrical circuits, other than those at Class II voltage/power levels, are considered to involve a "Risk of Fire". Due to the potential for catastrophe as a result of a fire, the standards take the safest approach and assume that all products can catch fire at some point over their useful life. The requirements in the product safety standards are therefore focused on requiring design principles that limit the chances for a fire to start, spread, and escape from the product.

Risk of Fire – Only A Hazard If It Leaves the Enclosure: The potential for an electrically induced fire always exists within an electrical product. The sole concern with fire in the product safety standards is whether it can spread from the product to the building contents and structure, at which point it would be a threat to the building occupants. The product safety standards generally do not care if a product burns and turns to ash inside the enclosure, as long as fire does not get out of the product's enclosure. (There is generally no concern with smoke in the product safety standards other than smoke that is hot enough to spread fire.)

Risk of Fire: A 3-Step Approach: To help insure that any product fire is contained within the product's enclosure, the safety standards require a 3-step approach:

1) Limit the likelihood that combustible materials will catch fire in the first place by maintaining operating temperatures that are below the material's temperature rating. And,
2) Limit the likelihood that any fire will spread internally and grow by limiting the flammability of combustible materials – by requiring UL flame ratings for printed circuit boards, wiring, insulating materials, and internal plastics. And,
3) Limit the likelihood that fire can get out of the enclosure by controlling vent size and location near combustible materials so that any fire does not spread through the openings – the primary concern is a fault condition causing a fire that drips flaming particles onto the supporting surface. In addition, higher flame ratings are required for all plastic enclosures to insure fire containment.

We then perform fault testing to verify that there is no "Risk of Fire". One of the pass/fail criteria when performing fault testing is whether there was a "Risk of Fire" as a result of the fault condition = did fire escape the enclosure during testing? To make this determination, the standard specifies conducting fault tests with the product sitting on tissue paper and covered with cheese cloth. The tissue paper and cheese cloth are used as the "fire indicators" – should either of these materials discolor or char, the results are considered a "Risk of Fire" which is a test failure.

Fire Hazard Protection: Let's now dig deeper into the Fire Hazard Protection design principles that accomplish the 3 elements of Risk of Fire protection. Based on the definition of a Risk of Fire, the ultimate goal is to design the product for fire containment – during fault testing, the product can burn internally as long as the fire does not escape the enclosure.

We can take the 3 elements of Risk of Fire protection, and translate each into the design principles that achieve the intended level of protection.

1) We can limit the likelihood that the product will catch fire by:
    a) Keeping temperatures on combustible materials below their temperature rating. Components used within their ratings are unlikely to catch fire during normal operation.
    b) Providing adequate electrical circuit spacings to limit the chance of a fault and subsequent fire. Fires on circuit boards can occur when arcing between traces causes carbon to build up over time. This carbon conducts current causing heating that can lead to a fire.
2) We limit fuel to a fire so that any fire is unlikely to grow by:
    a) Limiting the flammability of combustible materials thru the selection of plastics, wiring, and insulating materials with suitable UL flame ratings.
    b) Using certified wiring with a VW-1 rating (Vertical Wire Flame Test). This helps to insure that the wire insulation doesn't drip flaming particles or spread fire throughout the product.
    c) Using printed circuit boards with a minimum V-0 flame rating. The most flammable part of electrical products are their integrated circuits. If you light a circuit board on fire, it looks like flaming popping corn. It's important these components are on a flame rated board so the board doesn't ignite during a component fire. The intent is for the fire to self-extinguish on the board with fire contained at all times.
    d) Using plastics with the appropriate flame rating for the application. The 5V rating being the highest rating and least flammable, typically required for enclosures of stationary and fixed equipment (where it can be critical that the fire remains contained or it will spread to the building structure). Lesser ratings are often permitted for portable appliances, this includes in descending order V-0, V-1, and V-2 ratings (V-0 being just below 5V). At the lower end of the plastics ratings is HB, which is typically permitted for decorative plastics (external) and enclosures of products that do not involve a risk of fire (i.e. computer mouse). For other internal plastics, a V-2 rating is usually acceptable.
3) Design the enclosure so that any internal fire will not escape the enclosure:
    a) The primary concern is a fault condition causing a fire that drips flaming particles onto the supporting surface. The standards generally assume that fire can drip vertically and at up to a 5° angle from vertical. This puts the focus on side and bottom openings. Therefore, you should avoid positioning flammable materials above vent openings or within a 5° drip angle.
    b) By controlling vent size and vent location near combustible materials, you will limit the likelihood that fire escapes through the openings. This is especially important with bottom openings. When you cannot avoid putting flammable materials above or within the 5° drip angle, the vents need to be very small in size and/or louvered to prevent flaming particles from escaping the enclosure.
    c) For plastic enclosures, using the highest flame rated material to insure that any internal fire does not spread along the enclosure surface or burn through the enclosure material. Make sure the enclosure plastic also has any additional ratings necessary for the application (Glow Wire, Needle Flame, Hot Wire Ignition, High Current Arc Ignition, High Voltage Tracking Resistance, Flame Spread, & UV Resistance).
    d) Finally, confirm the suitability of the design by conducting single fault tests to verify that fire does not escape the enclosure.

Risk of Fire – Summary: In summary, Risk of Fire can certainly be viewed as one of the most important of the 6 Hazards of Product Safety. The potential for a single product to risk many lives by causing a structural fire must be considered in the Risk Analysis of electronic products. Compounded by the fact that product fires are dramatic and, in today's social media era, the results of a single event can be shared with millions of potential customers. Yet there are no 100% fault free components meaning there are no 100% fault free products. As such, it is important that you fully understand and apply all the principles of fire containment as a means to help mitigate the inevitable potential for a fire in your product.