Transformer Fire Walls versus No Fire Walls

Physical Problem = EXTREME Fire Hazard = HIGH Risk

Substation Conditions (A HOT recipe):

- Fuel Type:
  - Highly combustible liquid hydrocarbon
  - Mineral oil has a higher energy content than gasoline

- Very LARGE Volume of fuel
  - Typical power transformers contain about 10,000 to 45, 000 gallons **per phase**
  - The codes classify a flammable liquid as **a hazard if the volume exceeds 5 gallons !**

- Very high temperature spark provided by an electrical arc
  - The arc's temperature exceeds that of the surface of the sun
  - Arcs, partial arcing or full-fledged arcs, inside a transformer are not unlikely events

- The oil is contained in a pressurized tank
  - Heat generated under fault conditions generates pressures high enough to rupture welded seams or shear off one-inch diameter bolts
  - The codes classify a flammable liquid as **a hazard if the pressure exceeds 15 pounds !**

Characteristics of a Transformer Oil Fire

- **Violent** explosions usually result as oxygen enters the tank, accompanied by a blast of intense radiation, flying shrapnel, and flaming oil
- The radiation's effect is instantaneous. This type of heat flux ignited a second transformer 70 feet away from the fire origin.
- The flame core temperature of an oil fire is in the range of 960°C to 1,200°C
- A typical power transformer fire has a duration of 4 to 28 hours, which is in most cases the time it takes the fire to burn itself out.
- The larger power substations are often located in outlying rural areas, hence the fire department's response time is usually too long.
- Fire departments, with few exceptions, are not trained nor equipped to suppress these type of oil fires (The standard fire truck carries only 5 gallons of chemicals to produce foam, which is by far a more effective suppression medium than water.)
- Water in excessive amounts is generally used to "fight" transformer fires, which produces large amounts of steam increasing the danger to personnel and creates an environmental clean-up problem of large proportions

- When utilities do install a fire suppression system on their transformers, water sprinklers are used

- Fire walls are only a third of the total solution to effectively protect a substation against fire. The other two components are an early detection and alert system and the correct fire suppression system. Hence, the installation of the appropriate fire walls is the bare minimum to protect a transformer bank and its neighboring equipment or structures.

- The seriousness of the fire hazard inherent to an electrical power substation was recognized circa 1910, as evidenced by transformer fire walls separating all transformer units in an early hydro generating plant, in addition to a special trap door at the bottom of the transformer tanks to dump the oil into the river as soon as the fire was detected.

- A California utility experienced three 500 kV transformer bank fires within a period of five years. The transformers that originated the fires varied from newly installed to middle-age. **The trend is for a higher frequency of catastrophic type of failures as transformer age and the system is cycled in ways it was not designed to operate.**

Potential Costs Resulting from Uncontained Transformer Fires

- Replacement cost of transformer = $1.5 Million to $2.5 Million per phase
- Replacement energy cost, during peak hours = $100,000 to $200,000 per hour (Long term contracted economy energy would most likely not be accessible after the fire and purchases from the spot market must then be made at premium prices.)
- There are no domestic manufacturers of large power transformers. The delivery time on a rush basis for these transformers is about 18 months.
- Possible increase of insurance rates (conversely, insurance companies have given rate reductions when fire walls are installed)
- Unfavorable public relations

What Do the Standards Say?

- IEEE 979 specifies fire wall dimensions and their placement relative to the transformers being protected. This standard references ASTM E-119 on the testing methods to be used for fire walls, which is in accordance with the ICC's codes (IBC, UBC, CBC, and local building codes). However, IEEE 979 does not require fire walls if there is a minimum separation between power transformers of only 30 feet, which is well known to be unrealistic and exceedingly risky.
- ASTM E-119's test procedure is adequate if the four-hour rating is applied. But this standard specifies a maximum allowable temperature rise, which applies for fires in buildings and is irrelevant for a transformer fire. On the other hand, this standard provides two loop holes that can result in an ineffective transformer fire wall:

a) The hose stream test, which is supposed to be performed immediately after the four-hour fire exposure, appears to be optional (in the real world fire walls are blasted with cold water at 45 psi or more when the wall's surface temperature is close to 2,000ºF, and the wall must survive to continue to contain the fire) ;
b) The use of a fresh sample is allowed to perform the hose stream test, thus bypassing the thermal shock, erosion, and pressure withstand tests necessary to verify the fire wall's survivability and integrity.

- NFPA standards reference ICC and ASTM fire wall standards. Standard NFPA 860 on fire protection at nuclear plant substations is scheduled for adoption in 2010. It might better reflect the actual conditions of an oil fire outdoors. The Nuclear Regulatory Agency has recently been more active enforcing fire protection in substations.
- ASTM 1529 on testing methods for fire rating of structures used in the oil industry's installations was written to replicate more faithfully an oil fire.
- The US Navy has the most stringent and most realistic standards to protect against oil fires on board their ships, which ironically are surrounded by a sea of water. (Foam suppression was invented by the Navy.)

- In general the standards and codes do not realistically address the conditions of large hydrocarbon pool fires in open air (very high temperatures, extra long duration, extreme radiation and heat flux as compared to solid fuel fires with limited oxygen supply). Performance-based criteria need to be applied to assure effective fire protection in substations.

What Does the Law Say?

- What is the law?
  a) Adopted standards and codes are the law.
  b) Best practice in the industry.
  c) The general consensus by experienced litigation attorneys specializing in cases of fire origin is that if the owner of an installation is aware of an alternative method or technology to better protect against fire, and that alternative is economically competitive, a judgment will usually go against the owner if the owner chose not to apply the better technology.