Power Transformer Tank Rupture

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Tank Ruptures are primarily caused by electric arcs within the tank of oil insulated transformers
The arc current decomposes the transformer oil into combustible gasses, mainly Acetylene and Hydrogen.
The volume of the gasses produced is much greater than the volume of the oil decomposed.
Transformer oil is incompressibility. As a result, the pressure in the transformer tank increases.
The tank expands slightly to accommodate the increased gas volume until the pressure exceeds the rupture strength of the tank.
**Example**

A 230 Kv transformer has an electric arc from the line lead to ground in the transformer tank.  
-the arc current is 40,000 amperes.  
-the arc length is 20 cm.  
-the duration of the fault is 0.1 seconds
This arcing fault produces 3600 litres (130 cubic feet) of combustible gas in 0.1 sec.
The flexibility of the tank at the 200 kP or 29 psi elastic limit is typically 700 litres
The tank pressure rises to 524 kP or 76 psi with these fault gasses (excluding dynamic pressure rises). The static rupture strength of the tank in the plastic region is typically 140-210 kP or 20-30 psi
Therefore, with this fault, the tank will first deform and then rupture.
HQ Failure statistics 735 kV (25 years)

- 175 failures that resulted in 111 high energy arcs causing 44 tank ruptures and finally 18 fires

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Consequences of tank rupture

- 1000’s of gallons of oil will spill into the environment
- 1500° C combustible gasses and oil blown 100 feet into surrounding area
- Explosion and fire
- Transformer has to be replaced
- Loss of power for 12 months
Transformers with operating voltages below 115 kv rarely rupture the tank.

Transformers between 115 – 301 kv sometimes do

Transformer 345 kv and above often do
Tank rupture mitigation

Transformers normally have one of the following pressure relief devices:

- A pipe on the cover of the tank with a membrane that ruptures at pressures between 5-10 psi static pressure

- A spring pressurized disc that releases at pressures between 5-10 psi static pressure
Both of these types of pressure relief devices respond only to slow rising pressure in the tank
Arcing Faults Tank rupture mitigation

- Increase tank rupture strength

- Dry type transformers

- Gas insulated transformers

- Rupture Discs to prevent Excessive tank pressure
Increase tank rupture strength

- The corners of the tank are rounded to give them more strength.

- The cover weld is reinforced by adding C clamps that are mounted all around the cover.

- Double welds to provide stronger weld joint between tank wall and bottom section.
Dry type transformers

For low voltage and MVA ratings, air is used as the insulating and cooling media.

Used in substations located inside buildings.
Gas Insulated Power Transformers

- Use SF6 Gas as the insulating and cooling medium instead of insulating oil.
- Several thousand units now in service.
- Primarily used in substations located in urban areas (including inside buildings, underground)
- Much more expensive
Rupture Discs

-Rupture discs operate instantly to release the tank pressure at 15-20 psi before the tank ruptures

-Released combustible gasses and oil captured in collector tanks
All sealed electrical equipment with oil insulation potentially has the same hazard including metering transformers and bushings.

Porcelain housing has the additional risk of breaking into small pieces
In order to avoid these hazards on metering units, synthetic rubber housing and gas insulation can be used.

Bushings can be purchased with epoxy casting instead of oil insulation.
And also, help me to be careful of the toes I step on today as they may be connected to the ass that I may have to kiss tomorrow.

The End