Transformer Rupture Statistics

EPRI Report 3212-1

March 21, 2006

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Documents Used
EPRI Report 3212-1

- The objective of this project has been to assess the risk of power transformer tank rupture for units currently in service and to identify appropriate mitigation measures.
- Prepared for EPRI by ABB and the University of Pittsburgh.

Definitions

- A tank rupture is defined here as any event initiated by a fault internal to the transformer which results in external leakage of transformer oil. This excludes oil spills due to through faults which do not produce internal arcing.

- Only the events following initiation of the arc are considered. Arcs of interest in this study occur outside of the winding structure. Arcs internal to the winding have lower voltage (shorter length) and have lower current due to impedance of part of the winding. Arc duration is typically 4 to 6 cycles.

Literature Search Performed
Categories

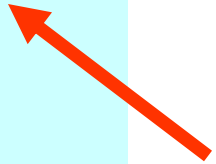
1. Experimental or analytical works directly associated with arcs in partially or totally oil-filled power transformers.

2. Experimental or analytical works directly associated with arcs in distribution transformers having a cover gas.

3. Studies of gas evolution and dielectric strength in oil-filled transformers.

4. Pressure caused by arcing in metal clad switchgear and substations.

5. Papers of general interest and applicability to the problem.



extensively reviewed.

Field Data and Case Histories

CASE HISTORY DEVELOPMENT The development of case histories was a crucial step in that it provided a data base for the entire project.

A major objective of this task was to obtain field data which could be translated into arc energy input during the internal fault.

UTILITY SURVEY: A number of EPRI members supplied information thru a survey and interviews.

Survey Results

Tank Damage Ruptured (R) - 30 cases
Deformed (no rupture) (D) - 11 cases
Incomplete information - 1

Case Rupture damage is observed as splitting of seams and welds.

Deformation is usually observed as bulging or doming of the tank top section and/or covers.

SYSTEM VOLTAGES:

115 kV	2 cases	2R
125 kV	1 case	1R
138 kV	4 cases	4R
161 kV	2 cases	2R
230 kV	1 case	1R
345 kV	12 cases	6R, 6D
500 kV	15 cases	10R, 4D
765 kV	5 cases	4R, 1D

Distribution by System Voltages

SYSTEM VOLTAGES:

115 kV -	2 cases	2R
125 kV -	1 case	1R
138 kV -	4 cases	4R
161 kV -	2 cases	2R
230 kV -	1 case	1R
345 kV -	12 cases	6R, 6D
500 kV -	15 cases	10R, 4D
765 kV -	5 cases	4R, 1D

The majority of the cases occurred at the 345 and 500 kV ratings. Both ruptures and deformations were identified at the extra high voltage levels.

Applications

Generator Step Up (GSU)	-	12 cases 10R, 2D
Autotransformer (AUTO)	-	21 cases 13R, 8D
Step	-	5 cases 5R
Phase Shift	-	1 case 1R

Autotransformer data is the most prevalent, outnumbering the GSU's almost two to one. However, the damage indicates that a failure in a GSU unit is more likely to result in tank rupture compared to an autotransformer failure.

Shell/Core Form

Shell Form	25 cases	17r, 8d
Core Form	15 cases	11r, 3d

Access to core form manufacturer's data was more restricted, hence the higher number of shell form incidents is not considered significant.

Fault Current Magnitudes

0 - 10 kA	1 case	0R, 1D
11 - 20 kA	10 cases	7R, 3D
21 - 30 kA	5 cases	5R, 0D
61 - 70 kA	1 case	1R, 0D
71 - 80 kA	2 cases	2R, 0D

As expected, the deformations occur at the lower magnitudes of fault current, ruptures at the higher magnitudes.

Fault Current Arcing Times

2.5 cycles -	1 case	1R, 0D
3.0 cycles -	2 cases	1R, 1D
3.5 cycles -	5 cases	3R, 2D
4.0 cycles -	6 cases	5R, 1D
4.5 cycles -	2 cases	2R, 0D
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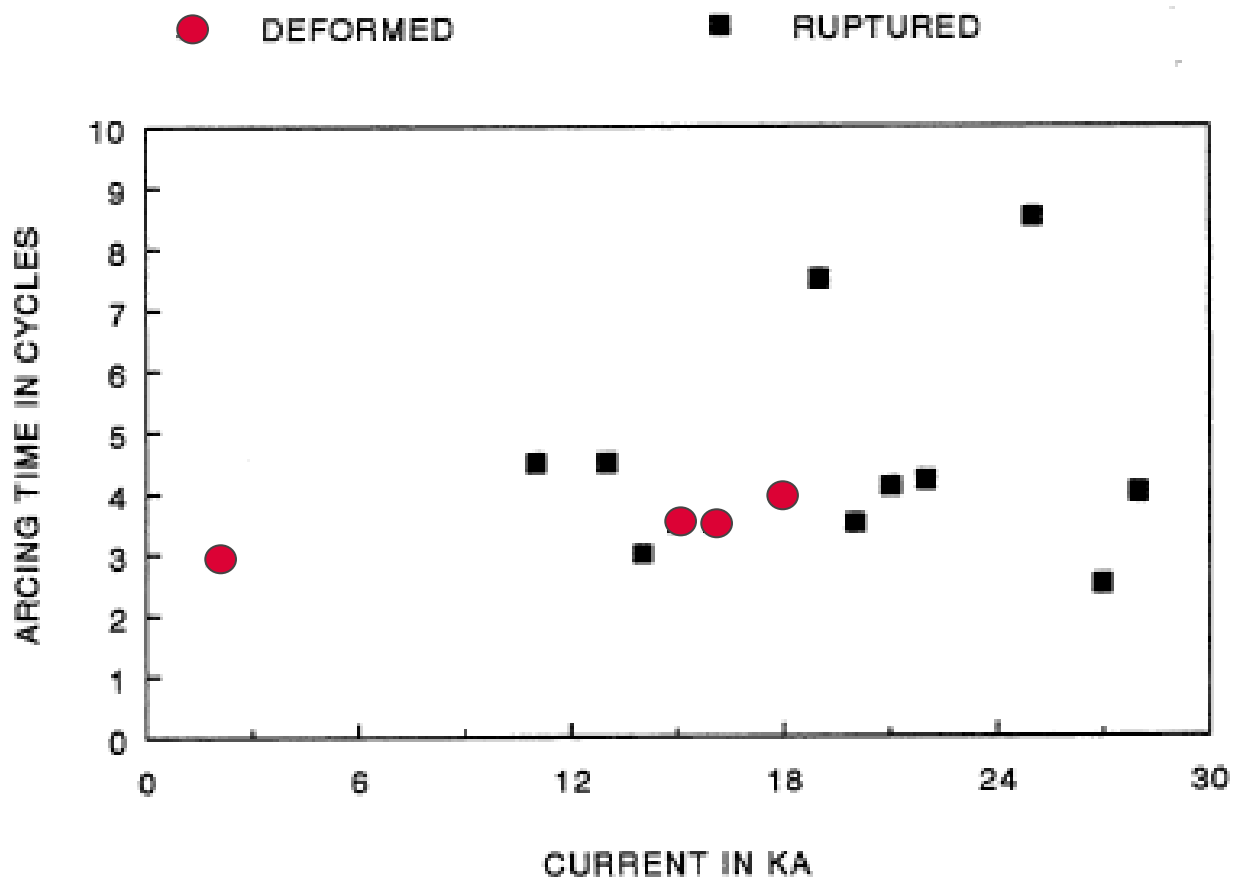
7.5 cycles -	1 case	1R, 0D
8.0 cycles -	***	***
8.5 cycles -	1 case	1R, 0D
9.0 cycles -	1 case	1R, 0D

Deformations occurred with arcing times up to 4.0 cycles and all cases with longer times ruptured, including three GSU transformers not listed above that had arcing times in the ‘seconds” time frame.

It is significant that ten ruptures occurred with arcing times in the range of **3.5 to 4.5 cycles**.

Arcing time vs. Fault Currents



Selected Trends Identified

- Most of the failures occurred on 345, 500, and 765 kV systems
- GSU units will probably rupture for an internal fault
- Autotransformers show both ruptures and deformations
- Reflecting application practice, autotransformer cases outnumbered GSU's by almost 2:1
- Both conservator and gas blankets exhibit deformation and rupture

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