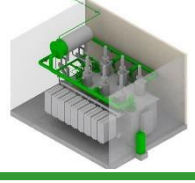
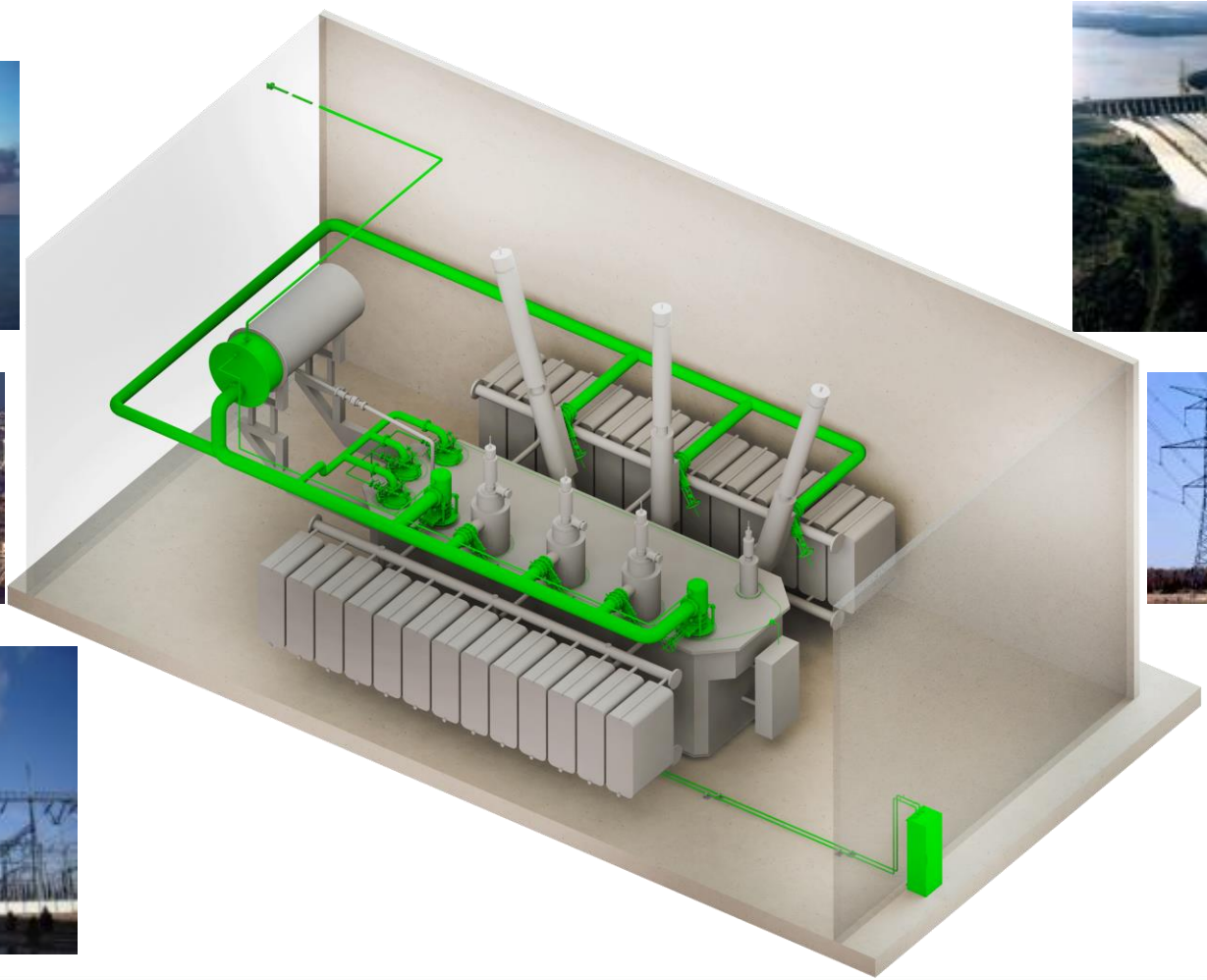
TRANSFORMER PROTECTOR



THE ONLY PROVEN SOLUTION AGAINST TRANSFORMER EXPLOSION

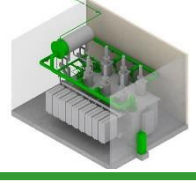


Template ref: Amxae170329Fe

Doc Reference: AtTPghc16-211027Fe

During a transformer short circuit, the TRANSFORMER PROTECTOR is activated within milliseconds by the first dynamic pressure of the shock wave, avoiding transformer explosions before static pressure increase

TRANSFORMER PROTECTOR



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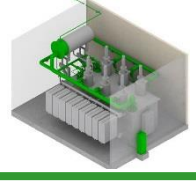

THE ONLY PROVEN SOLUTION AGAINST TRANSFORMER EXPLOSION

Power transformers are critical elements due to the large oil volume contained in contact with high voltage elements. A broad range of events can cause the transformer explosion and fire, such as:

- Design Defect
- Overcurrent / Overvoltage
- Lack of maintenance
- Oil humidity
- Material quality
- Insulating material quality
- Extreme environmental conditions
- Sudden failures
- Thunder
- Sabotage

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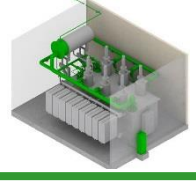


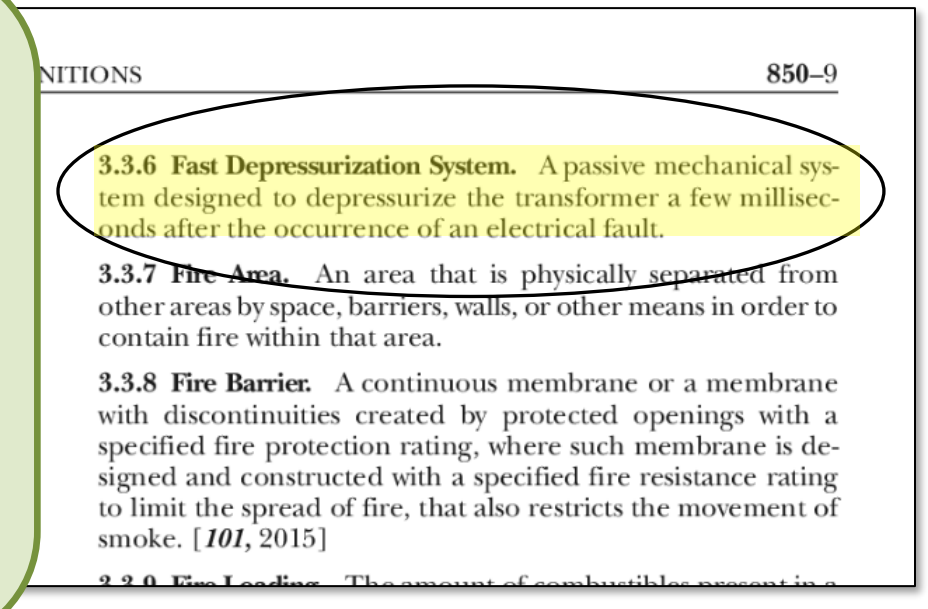
THE ONLY PROVEN SOLUTION AGAINST TRANSFORMER EXPLOSION

Reference to Fast Depressurization System in NFPA 850

NFPA 850 Recommendation

Review of the 4 defined criteria:

- **« A passive mechanical system »**
- **« Fast depressurization »**
- **« Triggered by the dynamic pressure peak generated by the short-circuit »**
- **« Activates within milliseconds before static pressure increases »**



NITIONS 850–9

3.3.6 Fast Depressurization System. A passive mechanical system designed to depressurize the transformer a few milliseconds after the occurrence of an electrical fault.

3.3.7 Fire Area. An area that is physically separated from other areas by space, barriers, walls, or other means in order to contain fire within that area.

3.3.8 Fire Barrier. A continuous membrane or a membrane with discontinuities created by protected openings with a specified fire protection rating, where such membrane is designed and constructed with a specified fire resistance rating to limit the spread of fire, that also restricts the movement of smoke. [*101*, 2015]

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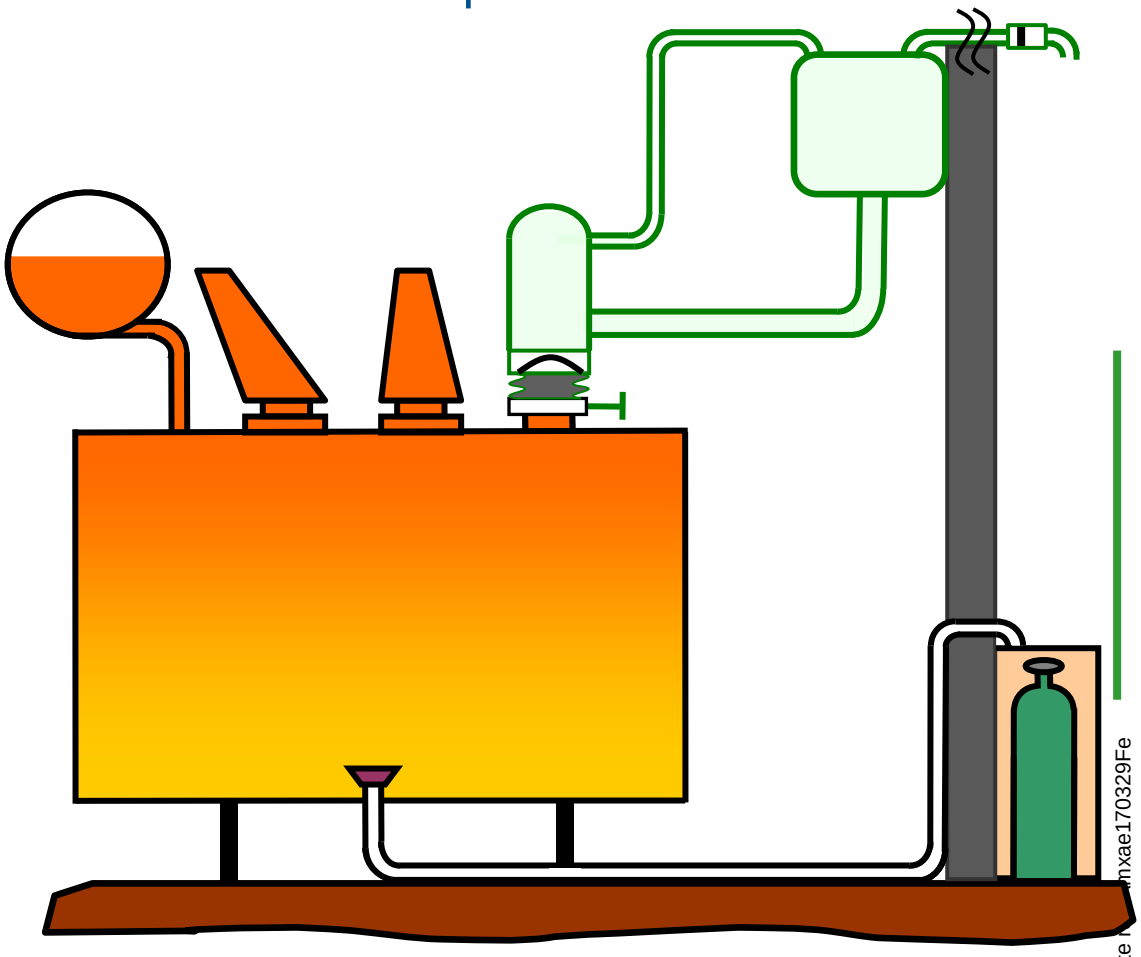
TRANSFORMER PROTECTOR

TRANSFORMER PROTECTOR Operation



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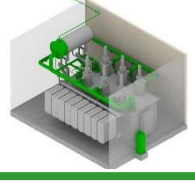
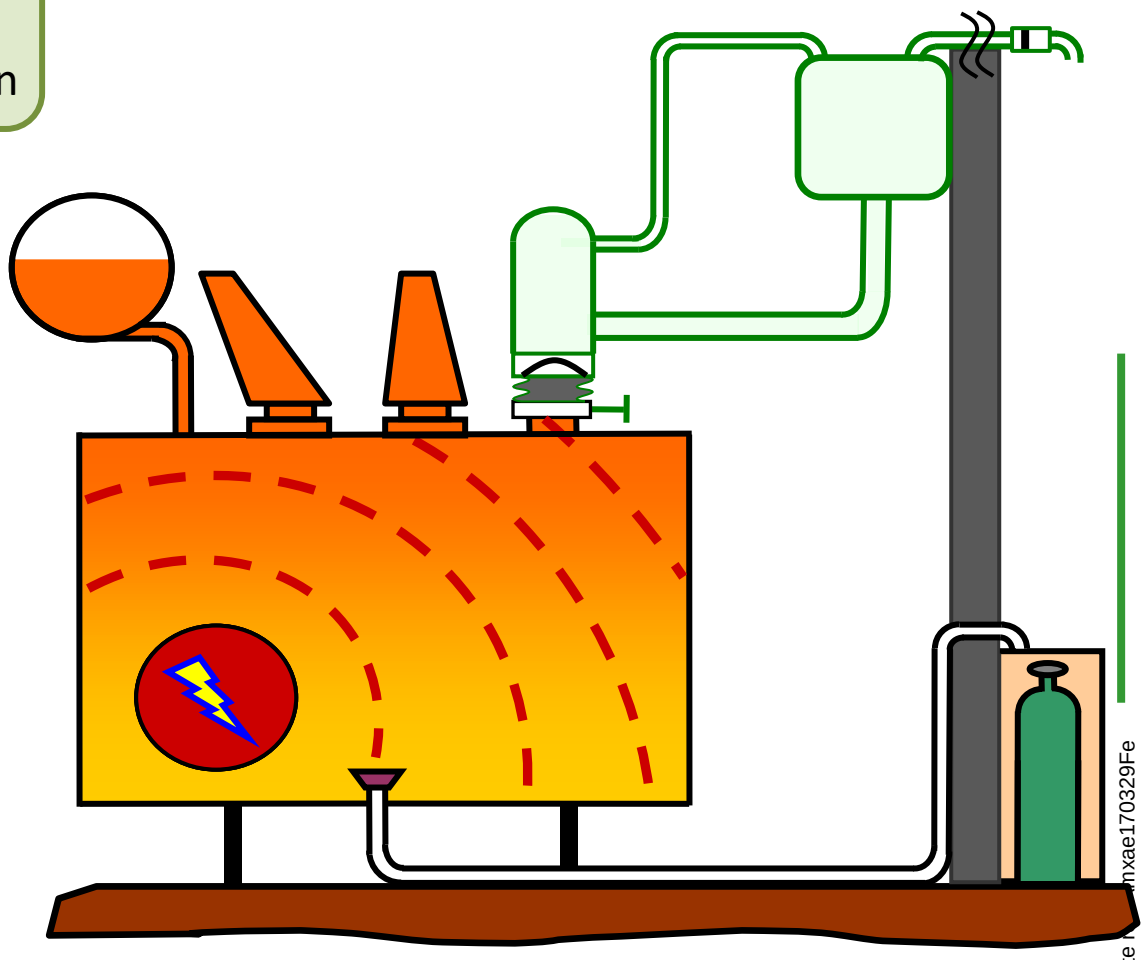


- Electrical arc
- Pressurized gas bubble
- Dynamic pressure peak propagation



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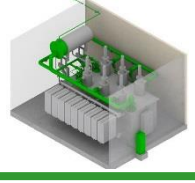
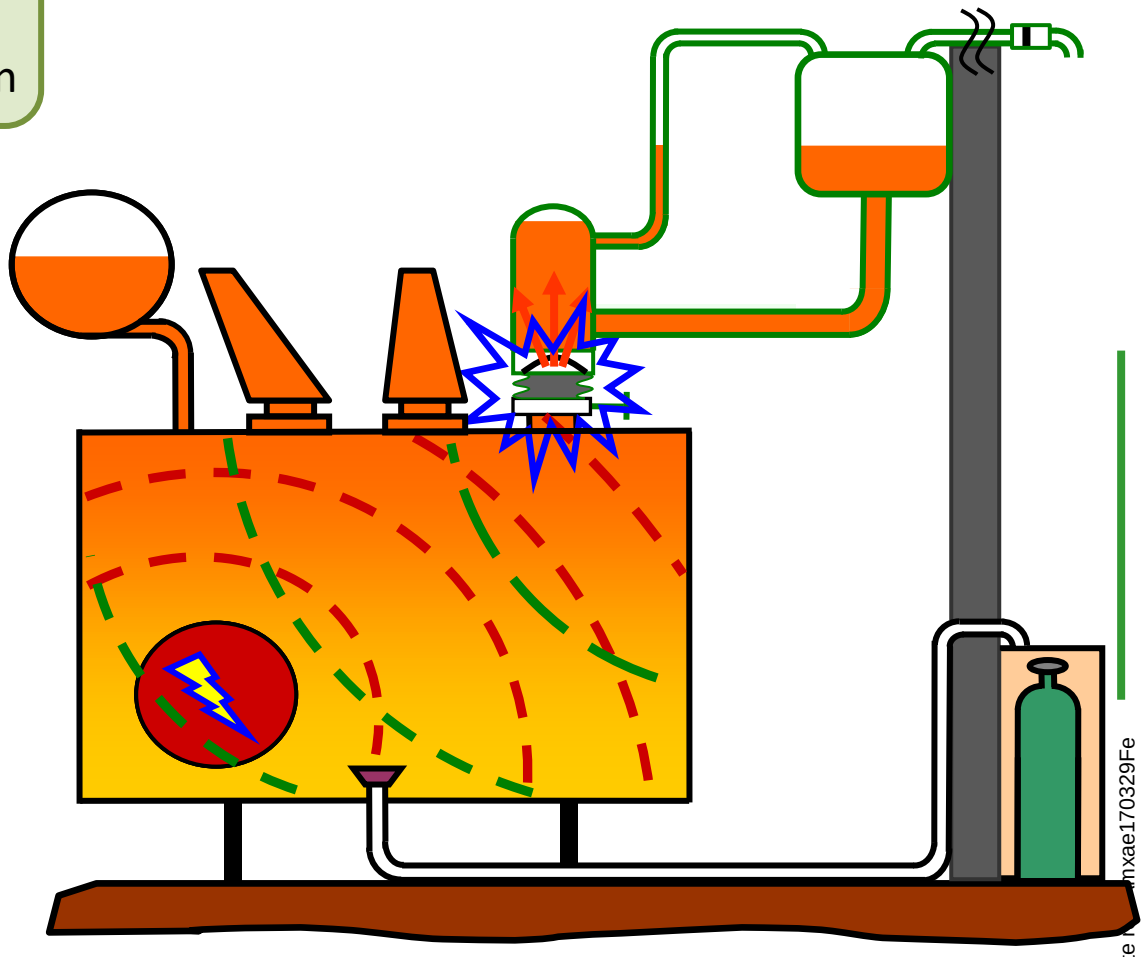


- Electrical arc
- Pressurized gas bubble
- Dynamic pressure peak propagation

1 TP Activation

Quick oil evacuation generating fast depressurization of the tank (within milliseconds)



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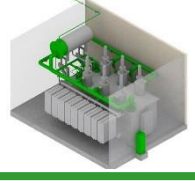
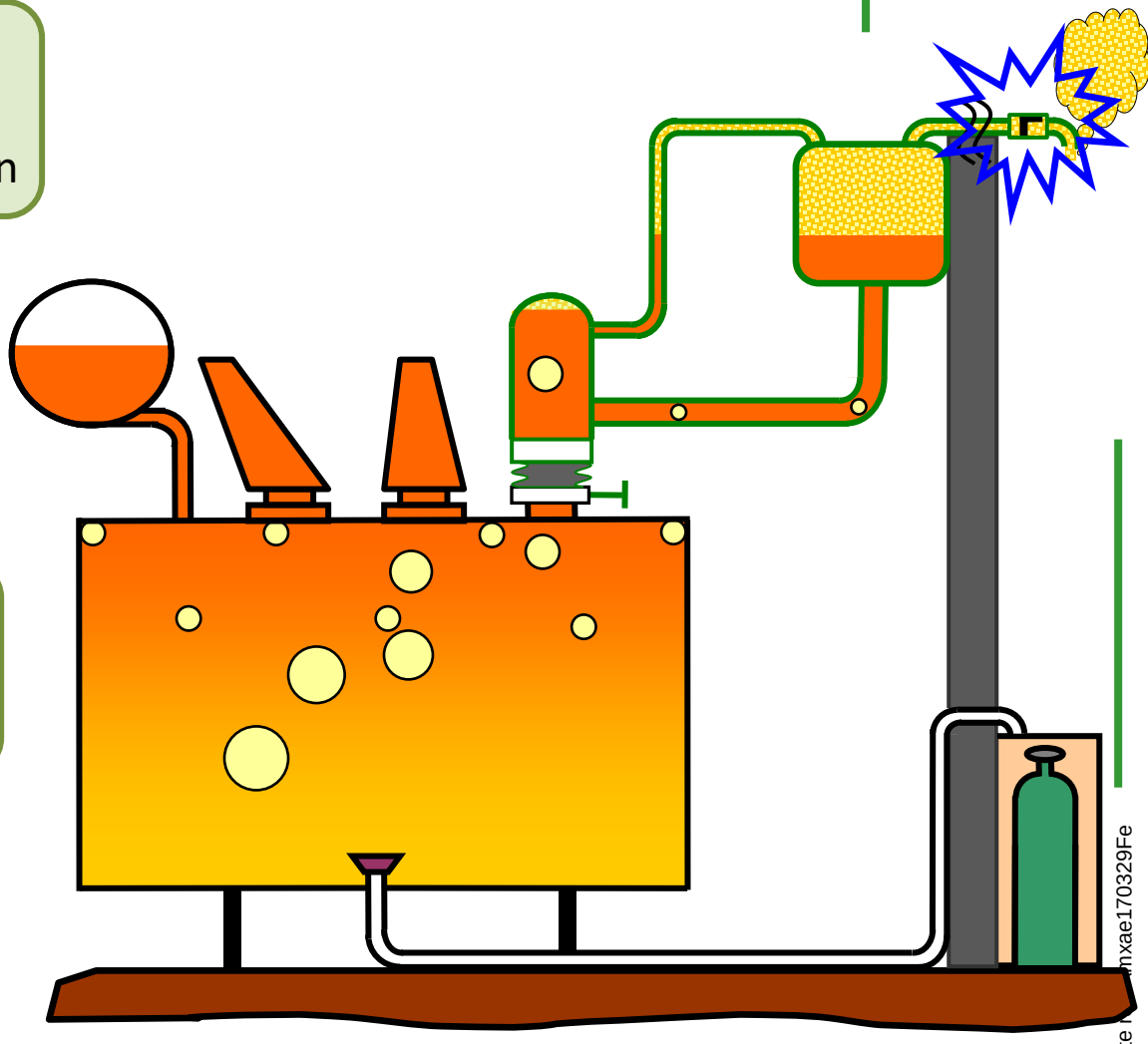


- Electrical arc
- Pressurized gas bubble
- Dynamic pressure peak propagation

1 TP Activation

Quick oil evacuation generating fast depressurization of the tank (within milliseconds)

- Explosive gases remain
- Melting parts of the windings are still emitting gases



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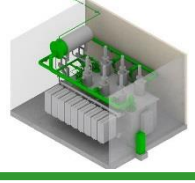
TRANSFORMER PROTECTOR



- Electrical arc
- Pressurized gas bubble
- Dynamic pressure peak propagation

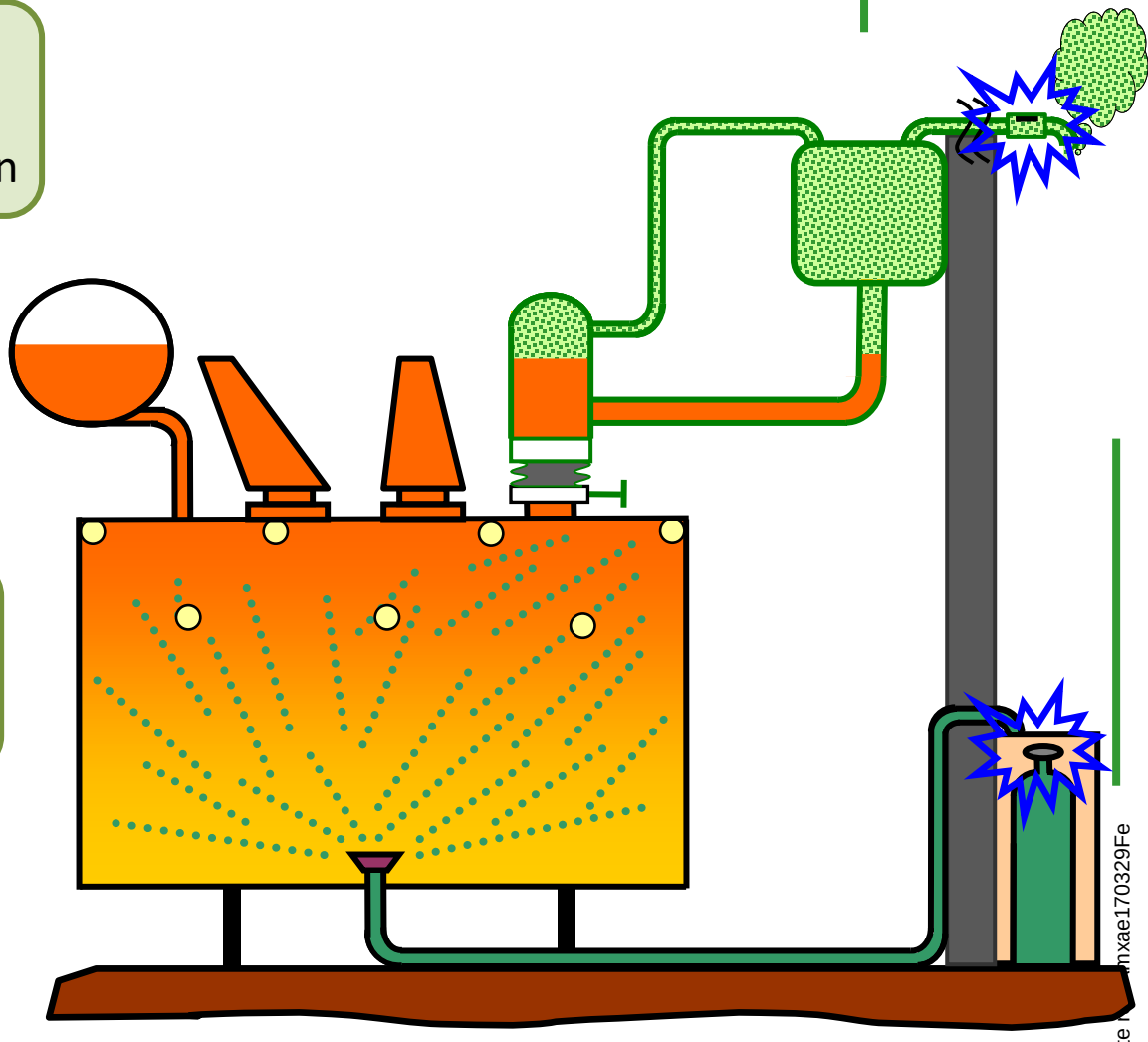
1 TP Activation

Quick oil evacuation generating fast depressurization of the tank (within milliseconds)

- Explosive gases remain
- Melting parts of the windings are still emitting gases

2 Injection of Inert Gas

Evacuation of the explosive gases until the melted parts are cooled down (~ 45 min)



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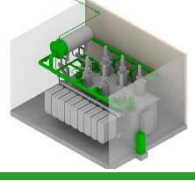

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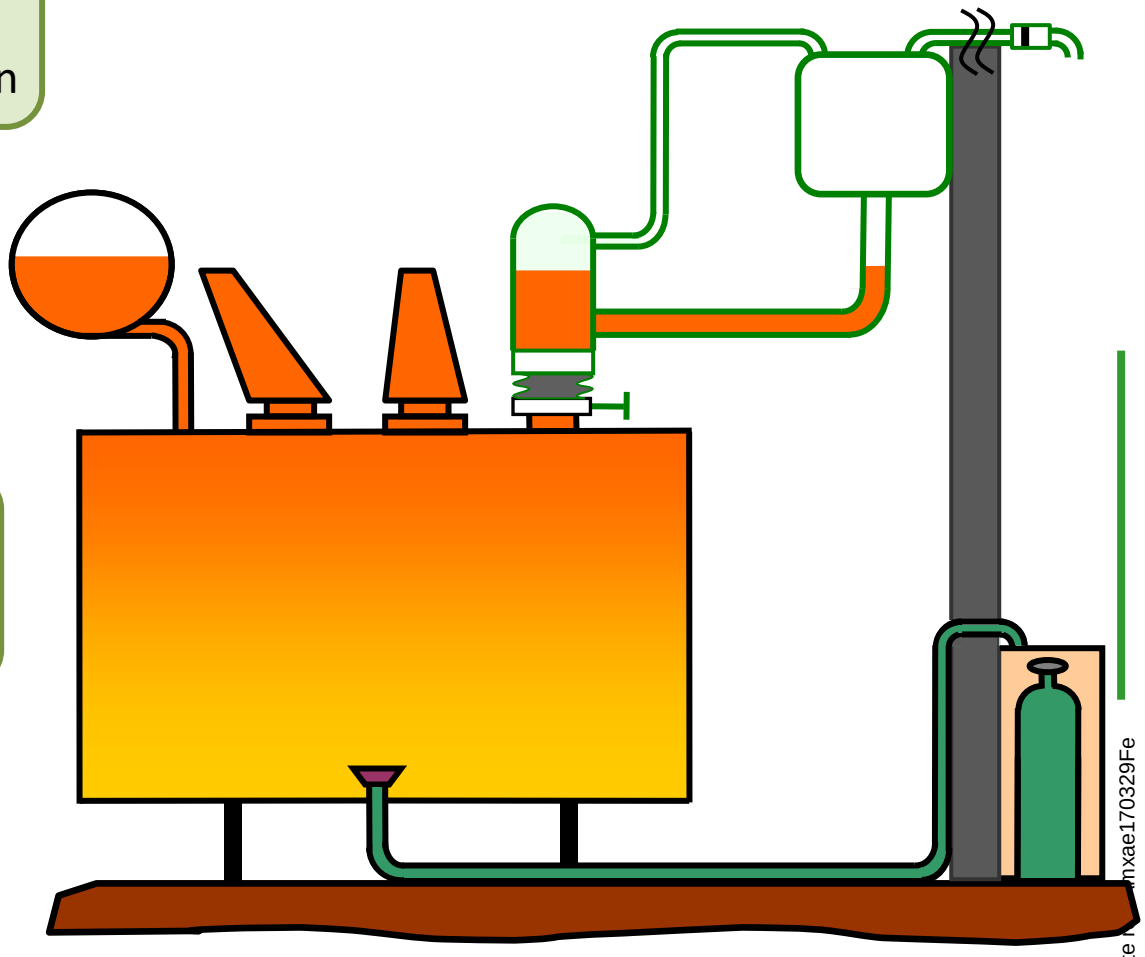


- Explosive gases remain
- Melting parts of the windings are still emitting gases

2 Injection of Inert Gas

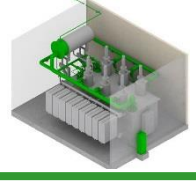
Evacuation of the explosive gases until the melted parts are cooled down (~ 45 min)

Transformer safe and ready for repair

Template Axxxae170329Fe

During a transformer short circuit, the TRANSFORMER PROTECTOR is activated within milliseconds by the first dynamic pressure of the shock wave, avoiding transformer explosions before static pressure increase

TRANSFORMER PROTECTOR



THE ONLY PROVEN SOLUTION AGAINST TRANSFORMER EXPLOSION

Click here to see the video

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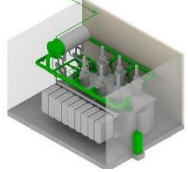
TRANSFORMER PROTECTOR



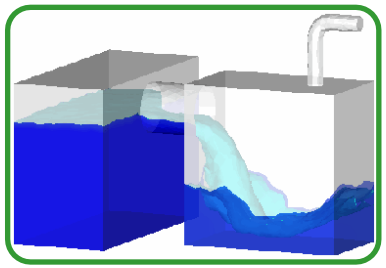
Physical Explanations and Testing of the TP
Simulation tool – Presentation

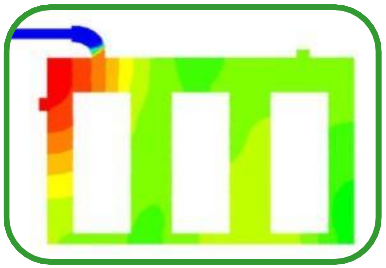
- ✓ During the 62 tests performed, electrical arcs were always ignited inside closed transformer tanks **equipped with TP**
  - ⇨ The TP always saved transformers without permanent tank deformation

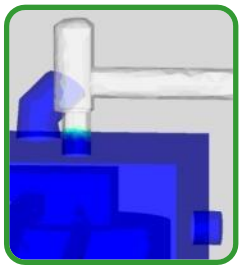
- ✓ What would happen without TP ? ⇨ Explosion: too dangerous to test
- ✓ What would happen in other configurations ? ⇨ Too costly to test

Using numerical simulations is an alternative

- ✓ TPC has developed its own simulation tool:
  - Simulate gas and liquid
  - Pressure propagation
  - Complex 3D geometries
  - Leads to various scientific publications (2008 PowerGen Conference Best Paper Award, IEEE, Cigre and ASME Conferences…)







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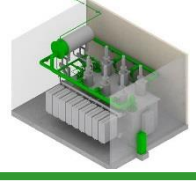
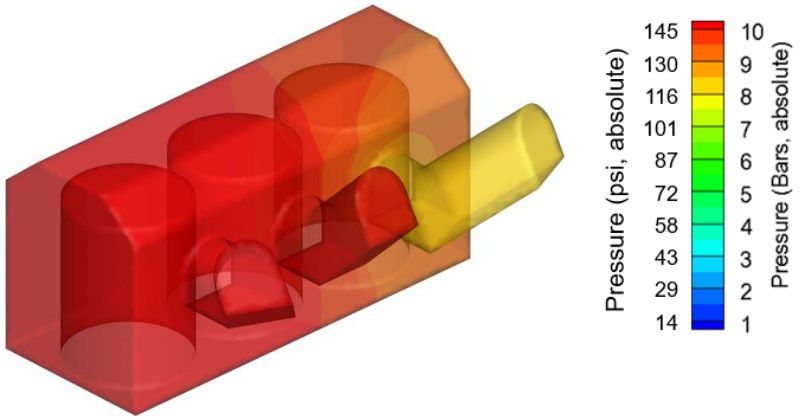


7.2 MJ Fault Simulations in 400 MVA Transformer Not Protected by TP

without TP



Transformer	400 MVA
Current (Peak)	$2.0*10^3$ A
Voltage (Peak)	$80.0*10^3$ V
Frequency	50.0 hz
Duration	0.110 s
Total Energy	7.1986 MJ

- **1 ms** — Gas bubble under pressure
- **4 ms** — The first dynamic pressure peak propagates
- **10 ms** — Reflects off the walls and creates complex pressure waves
- **50 ms** — Static pressure builds up
- **100 ms** — Static pressure stabilizes at 8 bars atm (116 psi)

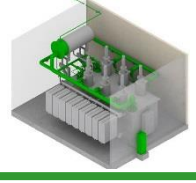
Transformer explodes

Template ref: Amxae1.0020.0

Doc Reference: AtTPghc16-211027Fe

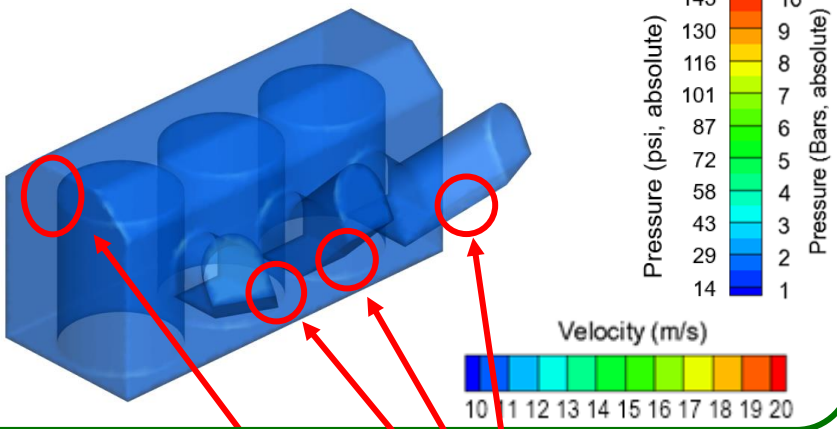
During a transformer short circuit, the TRANSFORMER PROTECTOR is activated within milliseconds by the first dynamic pressure of the shock wave, avoiding transformer explosions before static pressure increase

TRANSFORMER PROTECTOR

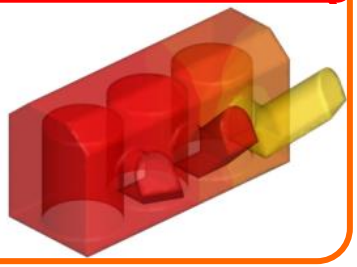


7.2 MJ Fault Simulations in 400 MVA Transformer Protected by TP

with TP



without TP



3 OBCB DS

HDS

4 Tank Depressurization Sets

1 ms	Gas bubble under pressure
4 ms	The first dynamic pressure peak propagates
10 ms	The dynamic pressure peak activates the TP
15 ms	Rarefaction waves are spread in the tank
30 ms	The tank depressurizes
60 ms	The tank is fully depressurized

Doc Reference: AtTPghc16-211027Fe

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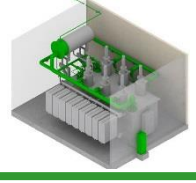
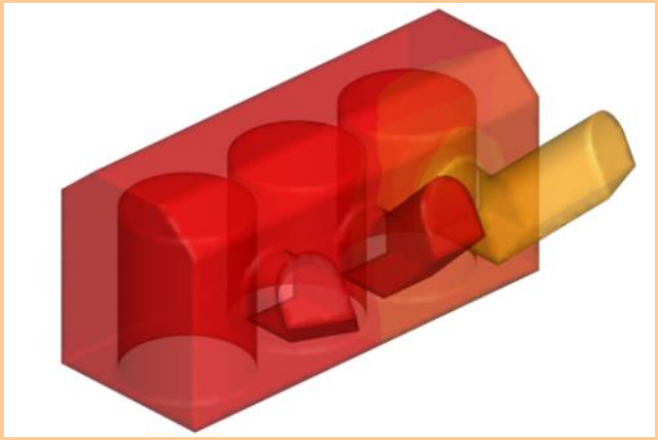


7.2 MJ Fault Simulations in 400 MVA Transformer Protected by TP

without TP	with TP

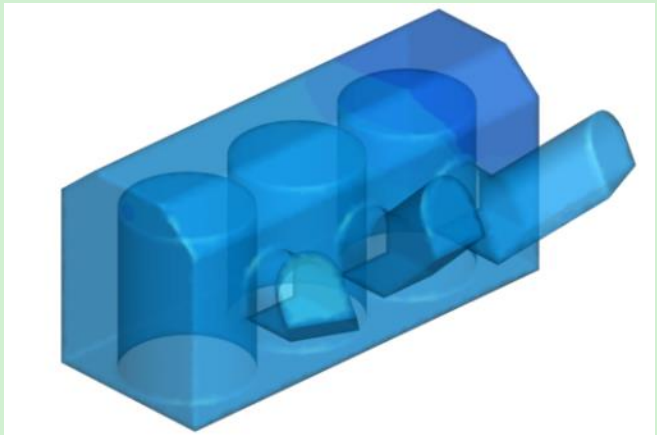
AFTER 150 ms



Average Pressure in the tank is over 8 bars atmospheric (116 psi)

⇩

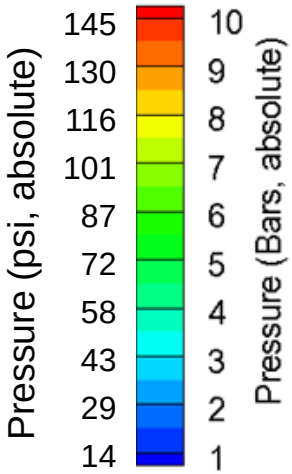
The tank explodes



Average Pressure in the tank is back to normal, less than 1 bar atmospheric (14 psi)

⇩

The tank is safe



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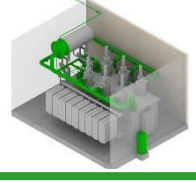
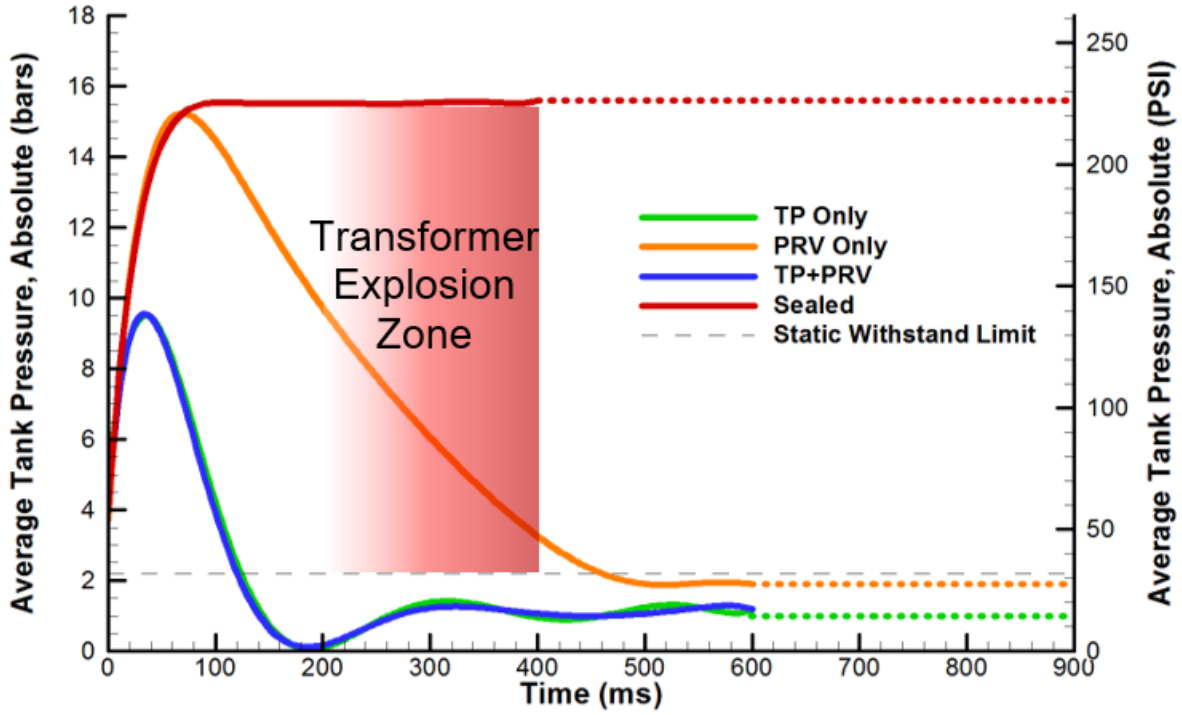


Spatially averaged pressures for a 400 MVA transformer subjected to a 6.6 MJ

Simulation of 4 different cases

Transformer	400 MVA
Current (Peak)	$4.5*10^3$ A
Voltage (Peak)	$44.5*10^3$ V
Frequency	50.0 hz
Duration	65 milliseconds
Total Energy	6.6 MJ



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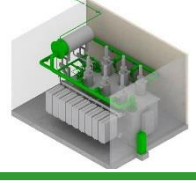

THE ONLY PROVEN SOLUTION AGAINST TRANSFORMER EXPLOSION

TRANSFORMER PROTECTOR Benefits

- Financial consequences due to transformer explosion and fire often reach hundreds of EUR millions.
- Using the Protection Financial Benefit ratio often used by Corporate Risk Managers and Insurers, the TP is strongly recommended as it compensates more than 1000 times the investment.

✓Sharply reduces Plant Outages and associated high costs
✓Prevents oil fire from spreading to the Transformer and its surrounding equipment
✓Transformers have always been back to service after TP activation
✓Prevents environmental pollution
✓Eliminates risk to human life
✓Saves company reputation

Template ref: Amxae170329Fe

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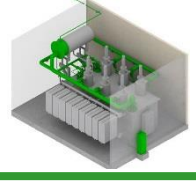


THE ONLY PROVEN SOLUTION AGAINST TRANSFORMER EXPLOSION

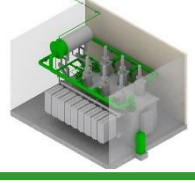
- **The TRANSFORMER PROTECTOR (TP) is activated within 0.5 to 10 milliseconds** by the first dynamic pressure peak of the shock wave, avoiding transformer tank rupture before static pressure increases.
- The **TP** can be **installed on existing or new transformers**, even in confined area.
- The **TP** is a **Fast Depressurization System** as defined by the **National Fire Protection Association (NFPA)**, code 850.
- It is the **only system successfully tested 62 times** with real electrical arcs in sealed transformer.
- Coverage of **EUR 15 Million lifetime liability insurance** per event. It has never been used since the TP creation in 2000, **proving the TP has never failed.**
- **Over 3,100 Installations with 28 activations under transformer operation, and always:**
  - Preventing transformer tank rupture;
  - Transformers have been back in service after repair;
  - Saving hundreds of millions of dollars to customers.

Visit our website: http://www.sergi-tp.com/

The TP is applicable for all transformers, existing and new, from 0.1 to 1,000 MVA and above for Generation, Transmission, Distribution and Industries.

During a transformer short circuit, the TRANSFORMER PROTECTOR is activated within milliseconds by the first dynamic pressure of the shock wave, avoiding transformer explosions before static pressure increase

TRANSFORMER PROTECTOR



THE ONLY PROVEN SOLUTION AGAINST TRANSFORMER EXPLOSION

SERGI
TRANSFORMER PROTECTOR

http://www.sergi-tp.com/

SERGI Transformer Protector (STP)
48-52 avenue des Châtaigniers, 95150 Taverny, France - Office: (+33) 1 39 22 48 40

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During a transformer short circuit, the TRANSFORMER PROTECTOR is activated within milliseconds by the first dynamic pressure of the shock wave, avoiding transformer explosions before static pressure increase