Internal Fault Detection in Distribution Transformers

FMEA Energy Connections Conference

November 6, 2015

Paul Henault – IFD Corporation
Why is internal fault detection important?
Why internal fault detection is important

**Linemen Safety**
- Operating challenges
- Crew pressures
- Risk every time we re-close

**Troubleshooting Effectiveness**
- Speed
- Accuracy

**System Reliability**
- Reduce outage times
- SAIDI/SAIFI
Why internal fault detection is important
What does an internal transformer fault look like?

- A rapid, transient pressure rise occurs in every internal arcing fault
- **Variable peak** pressure
- Consistent **rate of rise**
What does an internal transformer fault look like?

Certification tests at Powertech Labs

Arc Voltage
Fault Current
Pressure Rise

Normal Fault

IFD activates before peak 3 psi
What about PRV’s?

- PRV operation:
  \[ P > 10 \pm 2 \text{ psi} \]
  \[ \neq \text{Internal fault} \]

- (Poppet style PRV) ‘does not have time to react to the overpressure rates of rise and values produced when low-impedance faults occur.’
  
What causes transformer fuses to blow?
Causes of transformer fuse operations

* Source: Hydro Québec
Causes of padmounted transformer fuse operations

- Internal Transformer Faults
- Secondary Faults
- Overloads
- Oil Temperature
  - (Dual Element Fuse)
Current Industry Practices

1) Automatic Replacement

2) Field Testing

3) Trial & Error
**Sample utility procedures**

1. Always wear the appropriate personal protective equipment including fire retardant clothing, hard hats, safety glasses and rubber gloves.

2. When performing any close inspections of or repairs to the transformer always deenergize the unit and take precautions from any sources of power including customer generators.

3. Prior to re-fusing transformers, make a thorough inspection of the transformer and the surrounding area, looking for indicators such as: animal carcasses, bulged tank or cover, discolored tank, oil leak, burned oil aroma, flashed or broken bushings, any short circuits such as wrapped wires in the secondary or service.

4. Prior to re-fusing transformers, test the transformer with an approved instrument such as a Transformer Turns Ratio tester. Some companies require some form of testing on every transformer before they are energized.

5. When re-fusing a suspected faulty transformer, position yourself as far away as possible by using an extendable live line tool. Some companies specify maintaining a distance of at least 10 ft. when re-fusing transformers.

6. When re-fusing a suspected faulty transformer, always disconnect the customer’s load.

7. Test the transformer with a smaller test fuse. (Some companies have test fuse tables based on the transformer size and voltage).

8. If the transformer blows a fuse and the pressure relieve valve has operated, do not re-fuse and proceed with replacement.

9. If the transformer has an auxiliary current limiting fuse that has blown, do not re-fuse; proceed with replacement. Checking transformer condition

10. Maintain proper distance when re-fusing. In this condition: do not refuse

11. Always make sure the neutral is connected first before connecting a transformer and that it is removed last if disconnecting a transformer.

12. Do not allow the paralleling of transformers across any point that might be used to isolate a line section, such as switches, disconnects and double dead ends to avoid the possibility of back feed into a cleared line section.

13. Always wear rubber gloves when working on the secondary side of a suspected faulty transformer.

14. Take precautions when removing the lid from a suspected faulty transformer by operating the pressure relief valve. If it is an older unit without a valve, tie a sling over the lid before loosing the attachments.

15. Some companies have established step-by-step procedures for investigating transformer problems while others allow the lineworker to access the situation and take precautions they deem necessary within mandatory safety guidelines.

16. It is recommended that step-by-step procedures be developed as they are good training aids and can serve as a refresher for lineworkers. They also help ensure certain key steps are followed.
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Overview :: 2 functions

1. **Internal arcing fault detection** Flag comes out when internal fault has occurred

2. **Pressure relief device**
   Pull the ring to operate manually
New line crew practices

- If the IFD has activated, replace the transformer
  - it has failed internally and is dangerous to re-energize

- If fuse cutout is open and the IFD has not activated, likely OK
  - still conduct all your normal safety check procedures
How it Works

1. Fault occurs
2. Rapid pressure rise
3. IFD activates
One-Size-Fits All
Installation

- Air space, above oil
- Process adapted to each transformer manufacturer
3-Phase Overhead Banks

- Can be difficult to troubleshoot
  - Variety of connection types
  - Access/clearance issues

- The IFD speeds up the process
  - Looks only at sudden pressure
  - Independent of connection types or any other electrical considerations
IFD status today

- Installed since 2001
- Over 850,000 in service
- ~400 Utility Users
- ~50 Installers
- Canada: 85% usage rate

- ABB / PPI
- Central Moloney
- Howard
- ERMCO
- Cooper
- GE Prolec
- Solomon
- Emerald
- Moloney Electric
- SE Transformer
- Siemens
- Carte
- CamTran
- PTI
- CG Power Systems
- Others
IFD customers

http://ifdcorporation.com/product/our-customers/
Value Summary

<table>
<thead>
<tr>
<th></th>
<th>Pole mounted</th>
<th>Pad mounted</th>
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</thead>
<tbody>
<tr>
<td>Typical cost per transformer</td>
<td>$1,000</td>
<td>$10,000</td>
</tr>
<tr>
<td><strong>Efficiency</strong> (Trouble call time savings)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-phase</td>
<td>$120 – 350</td>
<td>$400 – 800</td>
</tr>
<tr>
<td>3-phase bank</td>
<td>$480 – 960</td>
<td>$400 – 800</td>
</tr>
<tr>
<td><strong>Materials Saved</strong></td>
<td></td>
<td></td>
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<tr>
<td>Fuses</td>
<td>$20 – 30</td>
<td>$20 – 30</td>
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<tr>
<td><strong>Diagnostics</strong></td>
<td></td>
<td></td>
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<tr>
<td>Keep good transformers in service</td>
<td>$3,000 – 4,000</td>
<td>$5,000 – 15,000</td>
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<tr>
<td><strong>Reliability</strong></td>
<td></td>
<td></td>
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<tr>
<td>Improve SAIDI / SAIFI</td>
<td>~ $200,000 / yr</td>
<td>~ $200,000 / yr</td>
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<tr>
<td><strong>Cost Avoidance</strong></td>
<td></td>
<td></td>
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<tr>
<td>Environmental</td>
<td>$1,000 – 60,000</td>
<td>$1,000 – 60,000</td>
</tr>
<tr>
<td>Worker / public safety</td>
<td>$ thousands to millions</td>
<td>$ thousands to millions</td>
</tr>
</tbody>
</table>

“...this is great, a safety device that makes us money.”
Vice-President T&D
Sample Specification Wording

“Each transformer shall be equipped with a non-resettable device which detects and provides external indication of internal transformer faults, and also incorporates pressure relief functionality. The approved device is manufactured by IFD Corporation or approved equal.”
THE GOAL

- Improve linemen safety
- Enable faster and more accurate decision making
- Provide condition status information for the entire life of the transformer
- Keep unfaulted units in service
- Improve system reliability