The Useful Life of Microprocessor-Based Relays: A Data-Driven Approach

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Overview

• Definitions
• Background and considerations
• Manufacturer perspective
• Utility-reported data
• Utility perspective
• Conclusions
Definitions

- **Reliability** – probability that product or system will perform specified function over a specified period in a defined environment

- **Latent defect** – defect that could not have been discovered by reasonably thorough tests or inspection before product was sold or placed in service
Definitions

• *Failure rate* – average number of failures over specified period, expressed in failures per year

• *Useful life or service life* – intended operational lifetime of device

• *End of useful life* – period following service life when device has an insupportable failure rate or experiences an unrepairable failure
• Field-observed reliability life cycle for specific vintage
• Elevated failure rates at any time from latent defects
• Common mode failure after 5 years
Manufacturer Perspective

- Accurate product return data
- Communication between manufacturers and end users
- Analysis of effects of aging on electronics
Considerations for Relay Replacement

- New technology
- Safety
- Compliance
- Obsolescence and form factor
- New primary equipment
- Budgeting for replacement
- Training and process
Accurate Product Return Data

- Relay return data from 2018
- Increased failure rates after 16 years
- Many failures caused by latent defects
Utility A observed higher failures in 1999 and 2000.

Service bulletin was issued in 2006.

Most devices were proactively replaced in 2007–2010.
Cumulative Failure Rate for Utility A

- Cumulative failure rate for relays made in 1999 and 2000
- Most devices proactively replaced in 2007–2010
Analysis of Effects of Aging on Electronics

- 11 relays examined from 11 utilities across U.S.
- Service lives ranged from 19–25 years
- Relay functions were tested and verified
- Various components were measured and verified
- Reliability of safety insulation systems was tested
- Solder joint integrity was tested
<table>
<thead>
<tr>
<th>PORT 2 EIA-232</th>
<th>PORT 3 and F EIA-232</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIN</td>
<td>PIN</td>
</tr>
<tr>
<td>OR +5Vdc</td>
<td>1 N/C OR +5Vdc</td>
</tr>
<tr>
<td>RXD</td>
<td>2 RXD</td>
</tr>
<tr>
<td>TXD</td>
<td>3 TXD</td>
</tr>
<tr>
<td>IRIG-B</td>
<td>4 N/C</td>
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## Utility-Reported Data

<table>
<thead>
<tr>
<th>Utility</th>
<th>In-Service Relays More Than 20 Years Old</th>
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</thead>
<tbody>
<tr>
<td>X</td>
<td>1,844</td>
</tr>
<tr>
<td>Y</td>
<td>194</td>
</tr>
<tr>
<td>Z</td>
<td>294</td>
</tr>
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About 70% of relays older than 20 years are still in active service.
Utility Perspectives

- Replace only after relay failure
- Base on specific time or relay age
- Use more sophisticated approaches
## Example of Time-Based Approach

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Planned Action</th>
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<tbody>
<tr>
<td>Initial install (0 years)</td>
<td>Perform commission testing and put into service</td>
</tr>
<tr>
<td>12 years</td>
<td>Perform periodic maintenance NERC requirements</td>
</tr>
<tr>
<td>24 years</td>
<td>Replace / upgrade protection or perform periodic maintenance per NERC requirements and put on a list to replace before next maintenance interval</td>
</tr>
</tbody>
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Utility B matched replacement time with required maintenance intervals
Conclusions

• Microprocessor-based relays can reliably perform during and beyond intended service life of 20 years

• Measurements confirm relays in service for greater than 20 years showed no signs of wearing out

• Utilities are keeping relays in service beyond manufacturer warranty and beyond service life expectations
Conclusions

• Manufacturers and end users should collect and maintain data on relays

• Manufacturers should have proactive and robust process for communicating service bulletins to end users

• End users should have robust process for evaluating and acting on service bulletins
Manufacturers and end users should partner to make best data-driven decisions on useful life of microprocessor-based relays.
Questions?