Transmission Planning and Protection

End of Life (EOL) Project Methodology

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TPP-REF-023

Rev. 1 **Effective: 11/17/2022**

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End of Life Methodology for 100kV & Above Transformers and Lines

FirstEnergy determines an individual asset is near or at the end of its useful life based on an engineering recommendation driven by multiple factors, such as an asset failure or presenting undue risk of failure, uneconomical maintenance, and outdated or obsolete technology and equipment. Those factors for a particular asset that is near or at the end of its useful life are evaluated based upon the facility's health and condition, which can be determined by performance history, maintenance history, equipment criticality, risk, age, and other considerations for a specific facility.

1. End of Life Projects

Identifying FirstEnergy transmission facilities approaching their end of life is one of the core objectives of the EtF program. Strategically reviewing the present system is important to achieving this objective.

1.1. Transformers

It is imperative to gauge the health of transmission power transformers on the FirstEnergy system and to determine when those transformers are approaching their end of life and should be replaced. The following global characteristics may be considered:

- At or beyond expected service life typically in the range of 40-50 years
- Level of criticality to system performance and operations
- Outage frequency and/or durations
- Increasing negative trend in maintenance findings and/or costs
- Failure risk
- Limited availability of spare parts or vendor technical support
- Operational, Design, or other considerations
- Feasibility of repairs
- Environmental considerations

The review may also consider the following operational information, maintenance history, and ancillary equipment performance associated with the transformer.

1.1.1. Power Transformers

The following components and operational/maintenance history with degraded and/or unacceptable results may be considered to determine if power transformers have reached their end of life and should be replaced:

- Alarm and device testing (including thermometers, pressure devices, and nitrogen system)
- Between 40-50 years of service life
- Bushings
  - Known failure history
  - No monitoring capability
  - Bushing power factor (Doble)
- Core ground issues (heating, unintentional)
- Dissolved gas in oil
- Oxygen content
- Total combustible gas
- Insulation power factor (Doble™)
- Internal inspection of the clamping, blocking, steel core, and core and coil support structure
- Loading and fault history
- Moisture content
- Oil dielectric
- Oil screen
- Oxygen content
- Radiators or other cooling issues
- Turns ratio
- Oil Containment / Environmental considerations
- Frequency/severity of oil leaks
- Tap Changer
- Software Analytics Tools Scoring

1.2. Line Condition Rebuild/Replacement

The health of the FirstEnergy transmission facilities can be improved by rebuilding and/or replacing transmission lines where appropriate. FirstEnergy will review and assess existing transmission facilities for equipment characteristics that are near or beyond their existing service life or contain components or designs that are obsolete. To determine whether lines should be rehabbed, rebuilt, or replaced based on their age, performance, system criticality, risk, and condition-based assessment, the following global characteristics may be considered:

- Customer / Contingency risk
- Negative impact on equipment health
- Customer outage frequency and/or durations
- Increasing negative trend in maintenance findings and/or costs
- Failure risk, to the extent caused by asset design characteristics, or historical industry/company performance data
- Operation, design, or installation limitations
- Age/condition of wood pole transmission line structures typically replacement is considered beginning at 40 years of average age for a line segment
  - Must pass a hammer sound test
- Age/condition of steel tower or steel pole transmission line structures typically replacement is considered beginning at 60 years of average age for a line segment.
- Age/condition of transmission line conductors and hardware typically replacement is considered beginning at 40 years of average age for a line segment
- System characteristics including lightning and grounding performance, galloping overlap, insulation coordination, structural capacity needs, and future needs (e.g., fiber path)
- Current design criteria, applicable codes, and industry best practices
- Environmental factors

When evaluating the replacement of in-service transmission line assets, the review may also consider maintenance operating experience, manufacturer and accepted industry practices, and current engineering design standards associated with the asset types listed in the Index summarized below and further described within this document. The lists of components and operational/maintenance history described within this document are not a fully inclusive list of considerations.

Index	Asset Type
1.2.1	Transmission Steel Tower, Wood & Steel Poles
1.2.2	Transmission Line Conductor
1.2.3	Transmission Power Cable and Support Equipment

1.2.1. Transmission Steel Tower, Wood & Steel Poles

The following components and operational/maintenance history with degraded and/or unacceptable results may be considered to determine if transmission steel towers and wood/steel poles should be rebuilt or replaced:

- Access to the structure
- Structural steel
  - Anchor bolts
  - Joints and flanges
  - Tubular steel
  - Lattice
  - Bolts/fasteners
  - Insulator attachment points
- Foundations
  - Direct Embedded
  - Grillage
  - Concrete
- Weathering steel structures
  - Members
  - Material loss
  - Hardware
- Wood components
  - Poles
    - Phase raisers
    - C-truss reinforced
    - Pole top extensions
    - General condition & remaining strength
  - Crossarms
  - Braces
- Hardware
  - Insulators
    - Polymer
    - Porcelain
    - Glass
  - Clamps
  - Armor rod
  - Dampeners
  - Corona rings
- Grounding system

1.2.2. Transmission Line Conductor

The following components and operational/maintenance history with degraded and/or unacceptable results may be considered to determine if transmission line conductors should be rebuilt or replaced:

- Conductor between 50 - 60 years of service life
- Multiple splices per phase per mile
- Conductor core/strands
- Connector
- Corrosion
- Heat damage
- Span Length
- Metal type
- Shield wires

1.2.3. Transmission Power Cable and Support Equipment

The following components and operational/maintenance history with degraded and/or unacceptable results may be considered to determine if transmission power cable and support equipment should be rebuilt or replaced:

- Flexible power cable
  - Between 25-40 years of service life
  - Conduit
  - Impulse test
  - Insulation
  - Shielding
  - Terminators between 25 – 40 years of service life
- High pressure oil insulated pipe type cable
  - Between 60-75 years of service life
  - Conduit
  - Impulse test
  - Insulation
  - Monitoring and protection system
  - Nitrogen gas system
  - Oil preservation system
  - Pressure system
  - Shielding
  - Terminators between 25 – 40 years of service life

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Related Documents

Title
N/A

Revision History

Rev.	Date Review Started	Effective Date	Preparer	Review / Revision Comments
0	11/12/2020	xx/xx/xxxx	M. Barnes	Initial procedure creation.
1	9/2/2022	11/17/2022	L. Koshar/ C. Adanitsch	Biennial Review. Minor revisions. Updated verbiage throughout document. Updated format to more closely align with C&P standard.

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Approval Page

Approvals

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FE Director, Transmission & Substation Services	Richard M. Vavrek	*Richard M. Vavrek*	11/16/2022