

BCH Strategy on Managing Underground Distribution Cable Assets

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OUTLINE

- BACKGROUND
- MAINTENANCE INSPECTIONS
- CONDITION ASSESSMENT
- PRIORITIZATION
- REPAIR/REPLACEMENT STRATEGY

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Issues That Make Aging Cable Asset Management Challenging

- Serious safety, reliability and financial consequences
- Insufficient data (age, service conditions such as slope, environment)
- Asset Health
- Diagnostic tests
- Budget Constraints
- Limited Resources

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Background: Cable Assets

- 1200 Feeders, *approx. 2000 km (U/G)*
- PILC , *approx. 53%*
- XLPE, *approx. 47%*
- All PILC are three-phase
- Unjacketed before 1970
- XLPE started in mid 70's

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Background: Cable Assets

- Average failure per year:
 - 41 failures per year, one failure per 30 miles (pre-program implementation)
 - 22 failures per year, one failure per 50 miles (after program implementation, 2005)
- Cable failures – 45%
- Component Failure – 55%

INSPECTIONS

- Routine (every 5 years)
- Detailed Condition Assessment (Selected Feeders) :
 - Visual Inspection*
 - Electrical ,*
 - Metallurgical*

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Detailed Condition Assessment (DCA)

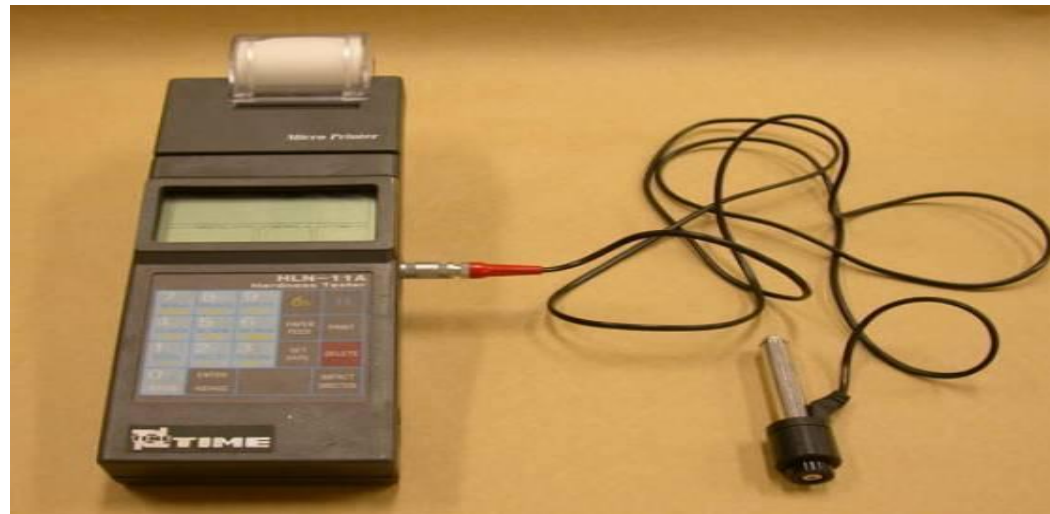
- Previous Practice (Pre 2005) – Blanket Replacement program of PILC UJ
- Pilot program (2005 – 2006) - developed inspection indices
- Current Practice consists of a systematic feeder selection criteria:
 - *previous failure history,*
 - *customer importance,*
 - *number of customers,*
 - *feeder load,*
 - *safety,*
 - *service condition.*

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Detailed Condition Assessment

Manhole Inspection

- > Close visual inspection of splices and cables in the manholes
- > Hardness test on lead along cable (metallurgical)



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Condition Assessment

Visual Inspection



Figure B11: MH 363. Circuit 12F89. Splice collapsed and leaked.



Dual Radial III - Project 16853-21

Powertech Labs Inc.



Figure A17: Vault 7U - Oil leak at gasket

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Distribution - Strategic Asset Management

Detailed Condition Assessment

Electrical Inspection in Manholes

- Infrared temperature scan
- RF Probe PD scan

*Also use Radar
Engineers RF Probe*



- Ultrasonic PD scan in MH

CEATI Report # T044700-5048

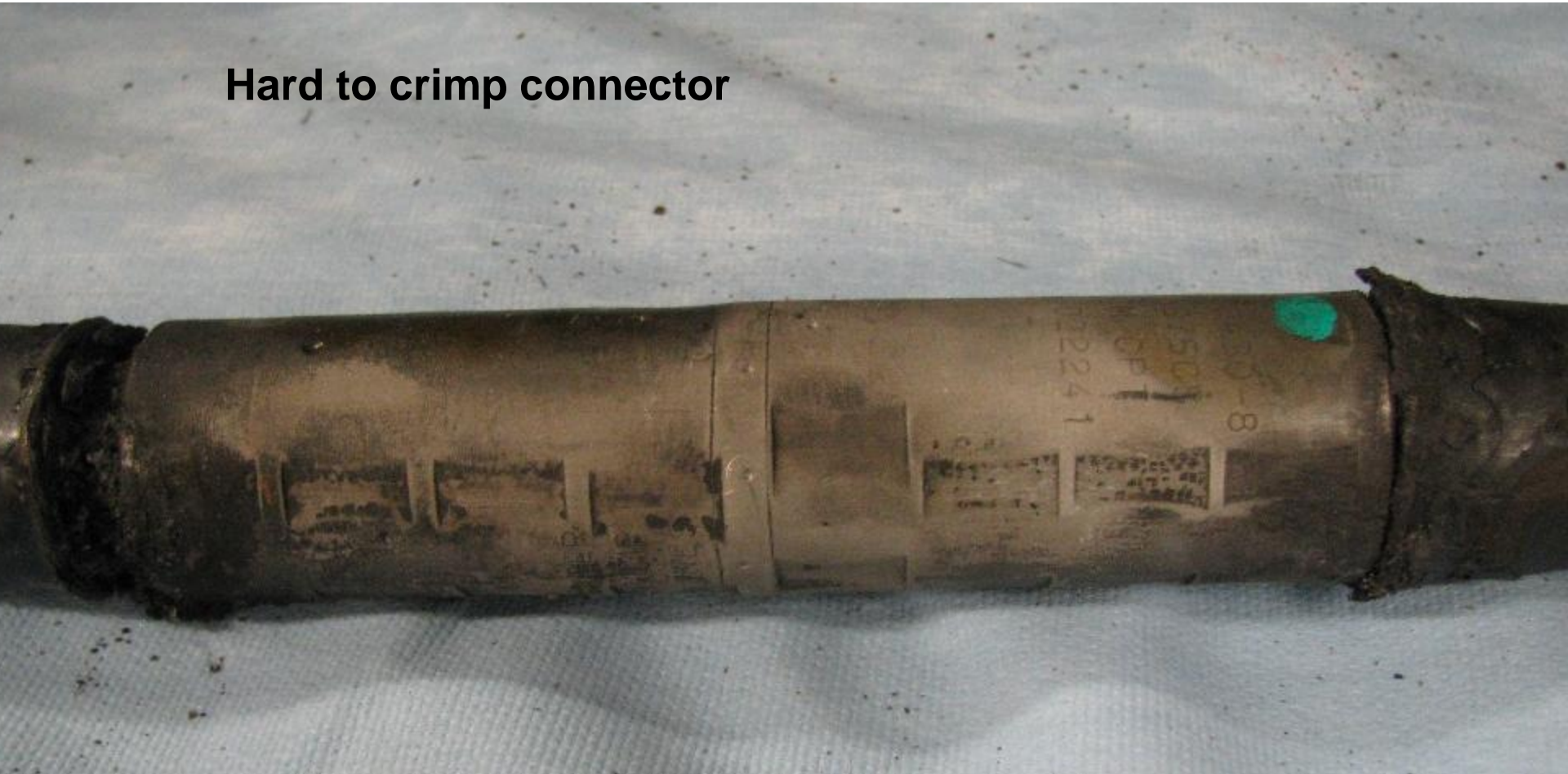


*Photo shows PD detection with
the UltraProbe 9000*

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Detailed Condition Assessment

Hard to crimp connector



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Detailed Condition Assessment

Electrical Inspection

- > Time Domain Reflectometry (TDR) (non-branched only)
- > LIpATEST™ (determines the integrity of the cable insulation)

Note: above tests are performed on de-energized circuit

Temperature Ranking Index

Index	Temperature Difference between Splice and Cables	Recommended Action
5	(Splice temp. – Cable temp.) > 3 °C (for T- Connectors) (Splice temp. – Cable temp.) > 6 °C (for other connectors)	Get out / restrict entrance to MH and repair or replace immediately *
4	3 °C < (Splice temp. – Cable temp.) ≤ 6 °C *	Repair / replace ASAP, but no later than 6 months. *
3	1 °C < (Splice temp. – Cable temp.) ≤ 3 °C	Repair / replace within 2 years (next fiscal)
2	0 °C < (Splice temp. – Cable temp.) ≤ 1 °C	Retest in 3 years
1	(Splice temp. – Cable temp.) ≤ 0 °C	No further action.

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Partial Discharge Ranking Index

Index	Partial Discharge State	Recommended Action
PD5	PD is audible or visible arcing without a detection device	Get out / restrict entrance to MH and repair or replace immediately
PD4	PD level is > 8 dB	Get out / restrict entrance to MH and repair or replace ASAP but no later than 2 weeks
PD3	$4\text{dB} \leq \text{PD level} \leq 8$	Repair or replacement ASAP, but no later than 2 months.
PD2	PD < 4dB or PD audible with equipment, but too low to have a reading	Repair or replacement ASAP, but no later than 4 months.
PD1	No partial discharge	No further action.

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LipATEST Ranking Index

Index	Cable State	LipATEST Reading At 4 -8 kV (A/F)	LipATEST Reading At 12 kV (A/F)	LipATEST Reading At 16 kV (A/F)	Recommended Action
5	Severely deteriorated	Test aborted			Plan to replace immediately
4	Cables / Splices are in very poor condition		> 50	> 50	First Priority for further Investigation, replace or repair.
3	Heavily aged		30 ~ 50	30 ~ 50	Retest in two years (next fiscal).
2	Moderately aged		20 ~ 30	20 ~ 30	Retest within three years.
1	Like new condition		< 10	< 10	Retest in five to ten years.

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Metallurgical Ranking Index of Cable and Splices

Index	Damage Level	Cable State	Splice State	Recommended Action
5	Safety Hazard/imminent Failure	Fully open cracks causing discontinuity in the metallic shield and oil leaks	Open splice, fully open cracks causing discontinuity in the metallic shield, improvised ground connections and oil leaks	Get out/ restrict entry to MH, Repair or Replace immediately
4	Major damage: Imperfections that are detrimental to the system and may cause failure immediately	Cracks and severe deformities (kinks, thinning and bulging) and corrosion	Cracks, or compound leak, and severe deformities (swollen, collapse and bulge) and corrosion	Repair or replace ASAP, but no later than 6 months.
3	Moderate damage: Imperfections that are of moderate in nature and may cause failure in the near future	Mild ($\leq 1\text{mm}$) cracks (without oil leaks) and mild deformities and corrosion	Mild cracks, small compound leak and mild deformities and corrosion	Retest, repair or replace in 2 years (next fiscal).
2	Minor damage: Imperfections that are of superficial in nature, immediate failure unexpected	Scratches, minor dents and cuts	Scratches, minor dents and cuts	Retest after 3 years.
1	No damage	Good	Good	Retest after 5 years.

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Table II-1: Cable Section Ranking of Running Circuit 12F225 CSQ

Segment	MH cable in	MH cable out	Length (m)	Cable Type	Electrical Ranking at MH Cable Out						Electrical Ranking		Metallurgical Ranking at MH Cable Out				Final Ranking and Recommendation						
					Cable in		Splice/Pothead		Cable out		Cable	Splice at MH cable out	Cable in		Splice/Pothead	Cable out		Cable	Splice at MH cable out	Cable		Splice/Pothead	
					PD	Temp	PD	Temp	PD	Temp			Eddy	VT & PT		Eddy	VT & PT			Eddy	VT & PT	Rating	Roomm
1	Sub	2249	20	A26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
2	2249	2248	*	A26	1	1	0	0	1	1	1	0	1	0	1	1	0	1	0	1	0		
3	2248	2247	9	A26	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	1	0		
4	2247	2248	*	A26	1	1	0	0	1	1	1	0	1	0	1	1	0	1	0	1	0		
5	2248	2445	30	A26	N/A	N/A	N/A	N/A	N/A	N/A	1	0	NACS	NACS	NACS	0	NACS	1	0	1	0		
6	2445	1539	55	A8	NACS	NACS	NACS	NACS	NACS	NACS	0	0	NACS	NACS	NACS	0	NACS	0	0	0	0		
7	1539	137	*	A8	1	1	0	0	1	1	1	0	1	0	1	1	0	1	0	1	0		
8	137	1537	47	A8	N/A	N/A	N/A	N/A	N/A	N/A	1	0				0	0	1	0	1	0		
9	1537	81	*	A8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
10	81	82	95	A8	1	1	1	1	1	1	1	1	1	4	1	1	4	1	1	4	RS		
11	82	83	43	A8	1	1	1	0	0	1	1	1	1	0	1	1	0	1	1	1	1		
12	83	58	13	A8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
13	58	59	42	A8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
14	59	1536	39	A8	N/A	N/A	N/A	N/A	N/A	N/A	1	0	N/A	N/A	N/A	0	N/A	1	0	1	0		
15	1536	2306	9	A8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
16	2306	1538	9	A8	N/A	N/A	N/A	N/A	N/A	N/A	1	0	N/A	N/A		1	N/A	1	0	1	0		
17	1538	136	28	A8	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1		
18	136	154	23	A8	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	2	1		
19	154	153	43	A8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
20	153	133	88	A8	1	1	1	3	1	1	1	3	1	1	1	1	1	1	1	3	IN2		
21	133	132	97	A8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
22	132	944	19	A8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
23	944	989	75	A8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
24	989	2474	70	A8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		

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DETAILED CONDITION ASSESSMENT RANKING

Powertech			BCH	Recommended Corrective Action Corrective Timeline
DCA Met. and Temp. Ranking	DCA PD Ranking	DCA LIpA Test Ranking	Harmonized	
5	4 and 5	5	1	Fix within 2 weeks (Emergency case)
4	2 and 3	4	2	Fix within months (6 months)
3		3	3	Fix within the next fiscal year
2		2	4	Increase frequency above normal frequency (e.g. Retest in three years)
1	1	1	5	No further action, inspection in normal frequency

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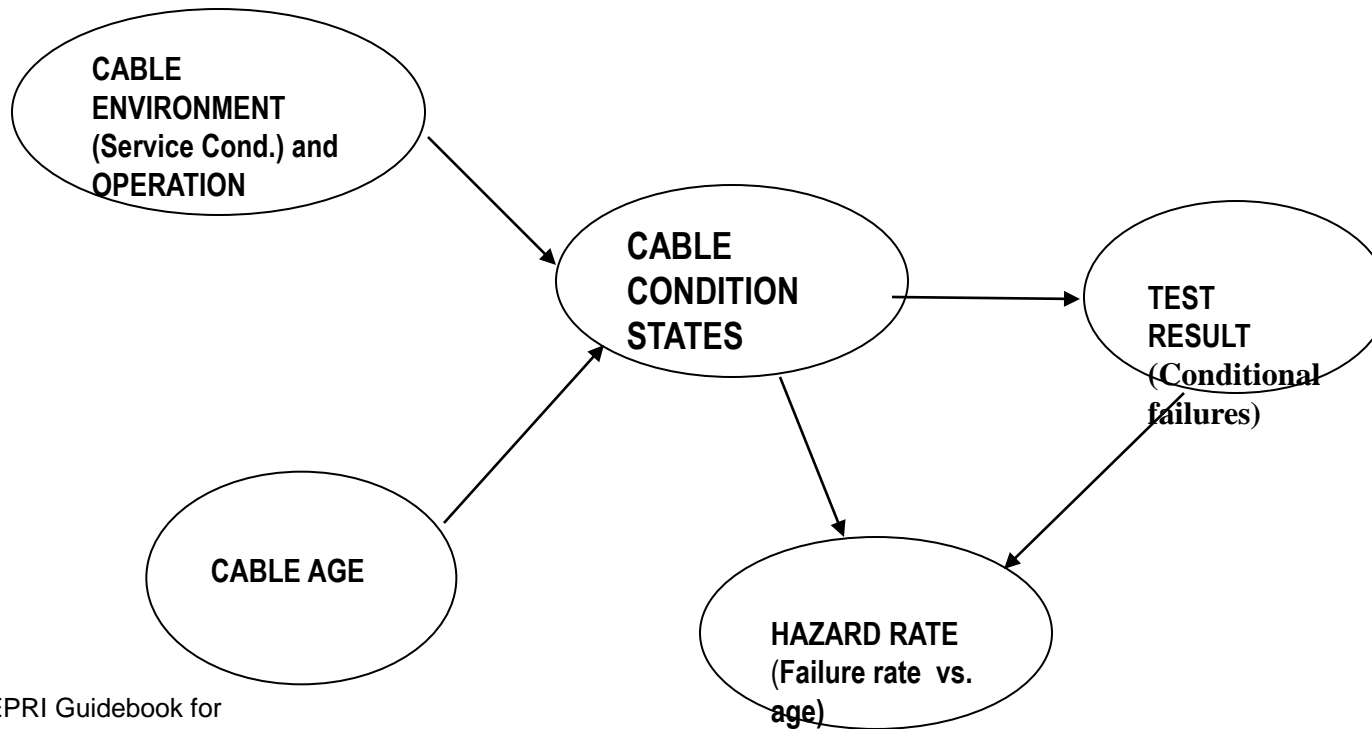
Summary.

Detailed Condition Assessment - Integrated Approach

- Evaluates All system components
- Condition of insulation
- Condition of terminations, splices and accessories

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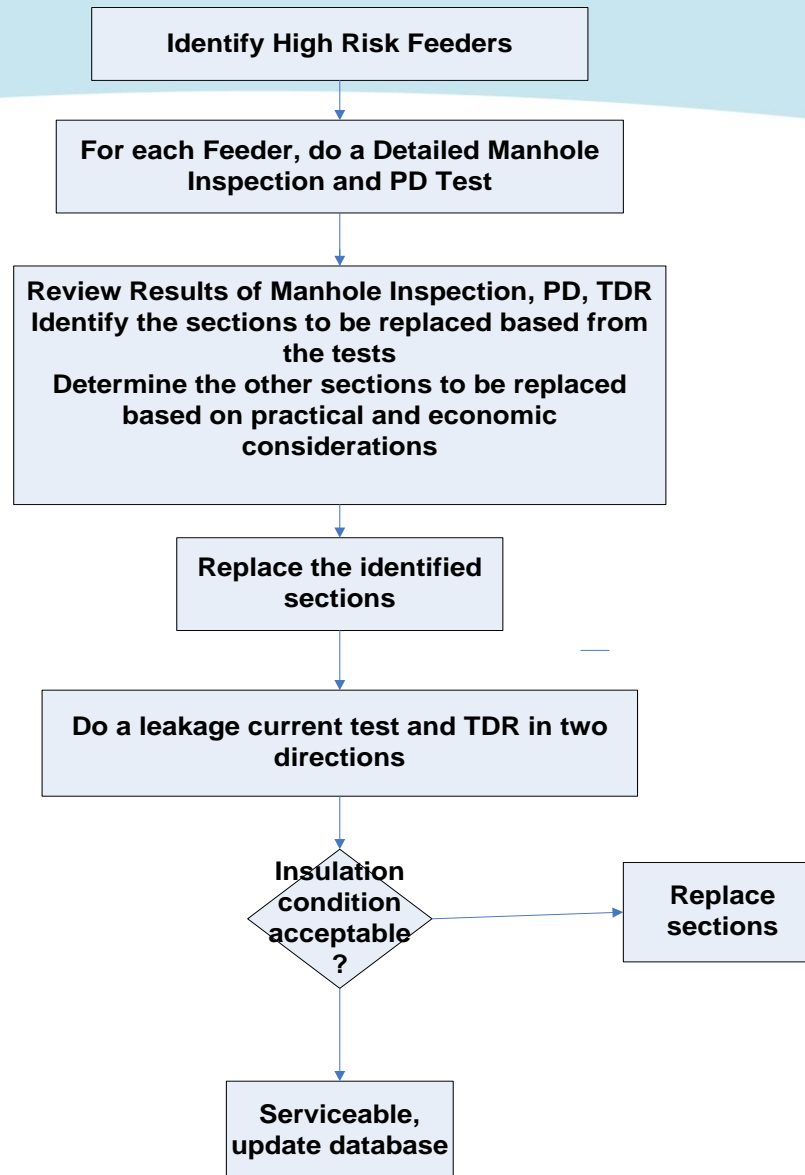
How Equipment Condition Influences Failure Rates



Source: EPRI Guidebook for
Intelligent Asset and Risk
Management – Underground
Cables 1010740

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Flowchart (STRATEGY)



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PILC Replacement Strategy

Few Scenarios:

For 100% PILC feeders:

- *If a segment (MH to MH) is recommended for replacement, the segment is replaced with PILC.*

For mixed PILC and XLPE feeders:

- *If segments of PILC's are assessed to be defective, we replace those defective portions with XLPE as long as there is space for transition splice (not congested) and duct size is not a constraint.*
- *If the defective segments are located on a slope, use XLPE as long as there is enough space for transition splice (not congested) and duct size is not a constraint.*

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Maintenance Trends:

- **Use of Robots for Inspections**
- **Diagnostic Tools that are easy to handle, practical, accurate and can eliminate noise**
- **Use of effective age in the absence of actual age.**
- **Probabilistic Approach in Managing Cable Assets, Failure rates, Reliability Curves (used for Maintenance and predicting End of Life)**
- **More Collaborative Efforts among Utilities**

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Conclusion:

- **Continue to use Condition Based Monitoring System**
- **Continue to verify our Condition Assessment results in the lab**
- **Review the program on a regular basis**
- **Combine our DCA program with probabilistic approach to manage repair or replace assets**
- **Look for other innovative solutions.**

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Thank you for your attention.

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