Considerations on managing critical MV cable circuits

IEEE-PES-ICC Spring 2022 – Sub F

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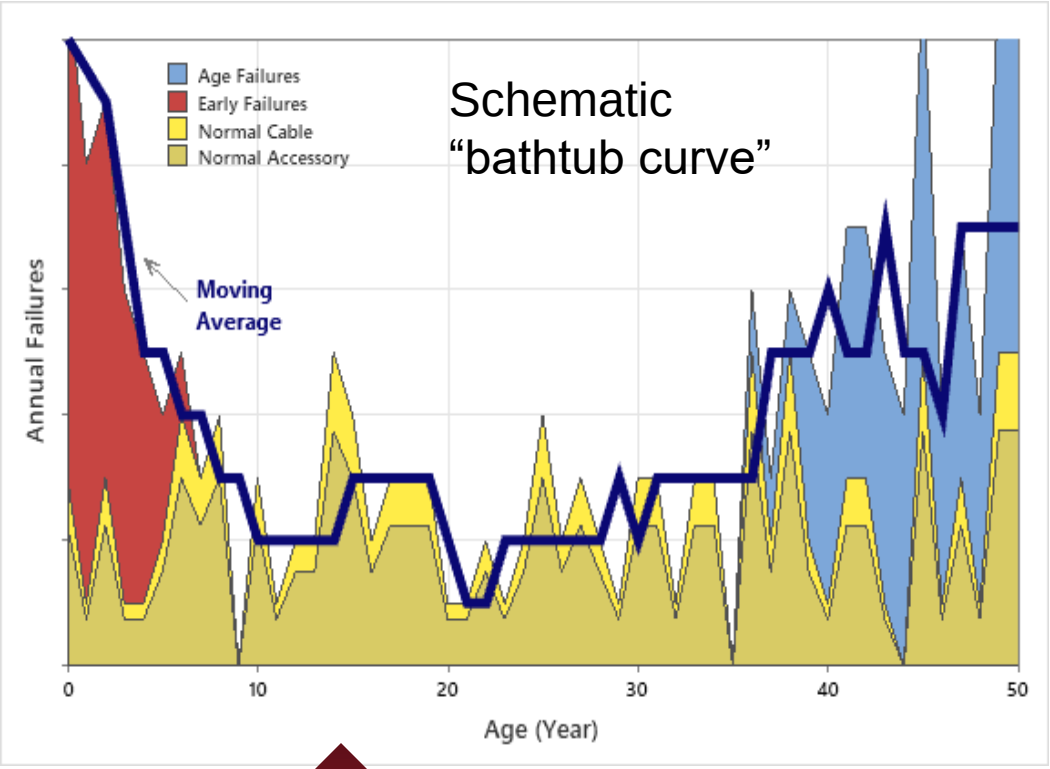
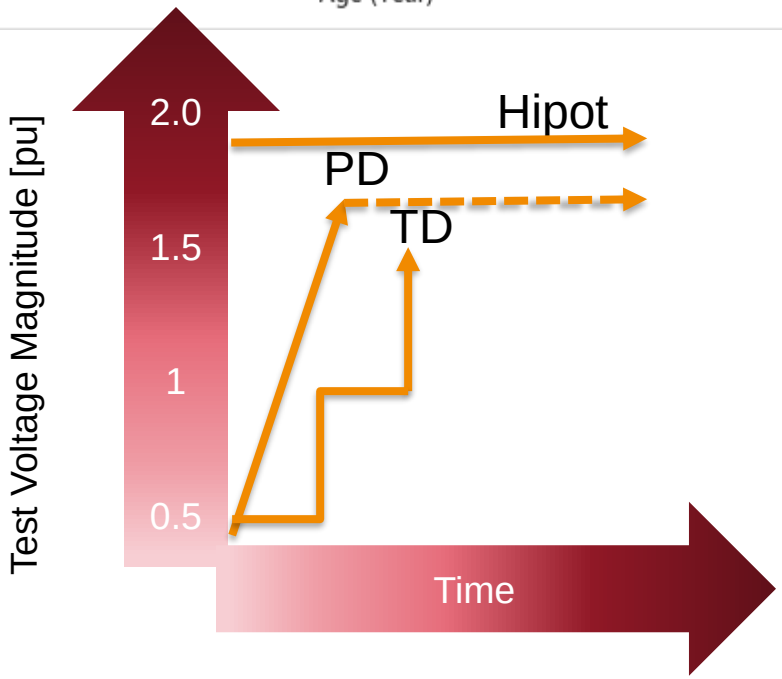
Background

Utilities recognize the value of commissioning and condition-based asset management of their distribution cable circuits.

In traditional applications, there is ready availability of voltage sources, and well-established condition assessment criteria with which to undertake the condition-based maintenance.

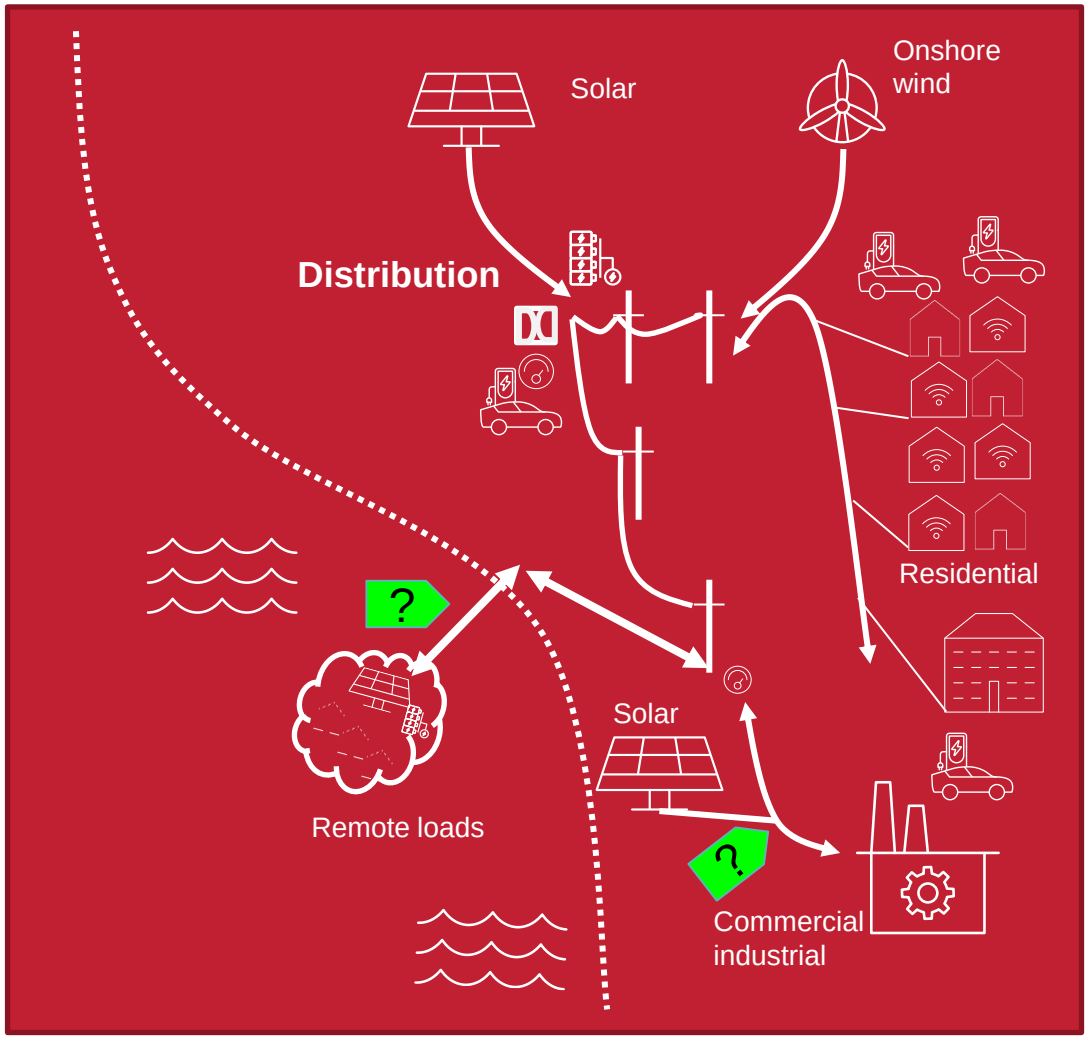
In this presentation, the authors address the approaches and considerations required to support the asset management of critical Medium Voltage (MV) cable circuits.





Critical circuits

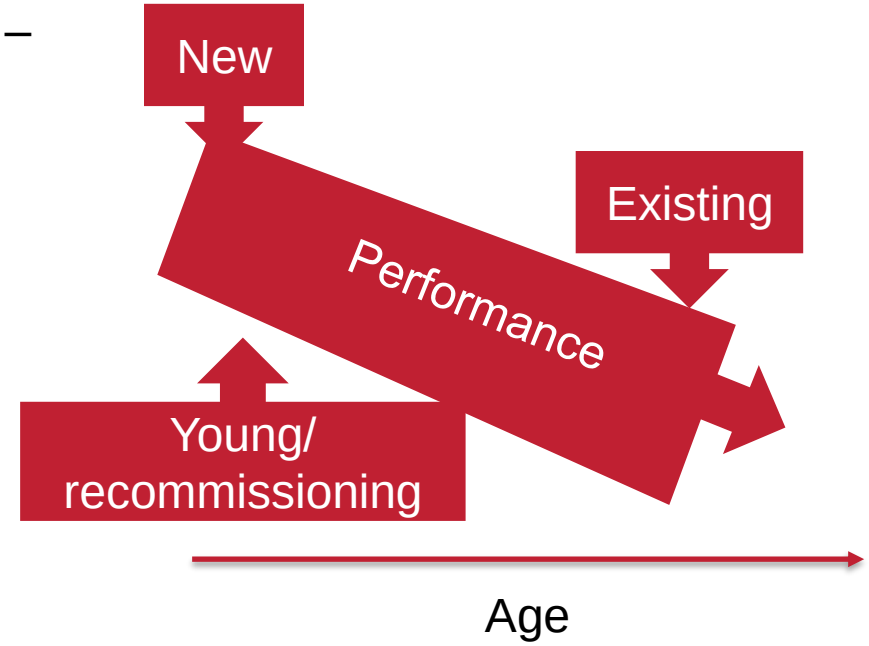
- Circuits are considered critical when the risk of failure profile and related consequences for repair/replacement are significantly different from traditional distribution applications.
  Drivers might include:
  - Critical infrastructure
  - Impact on the end customer
  - SAIFI and SAIDI
  - Circuit access/location/parts
- In these cases, the common protocols (time/voltage) and installation/test sequences may not be optimal.
- There is a different balance between the knowledge gained from tests and the failure risk during test.
- These situations are increasingly common and not straightforwardly addressed in the current guides/practice:
  - Hybrid (new and legacy)
  - Long length crossings
  - Offshore
  - Circuits difficult to repair/access
  - Others



Knowledge base – classification of critical circuits

Critical circuits may be placed into four broad groups:

- **New** – a continuous record of factory, QA, and handling exists
- **Young/recommissioning** – repairs required after a short time of operation
- **Existing with diagnostic record** – risk profile may be established; trend may be used for assessment
- **Existing with no diagnostic record** – risk profile is unknown; special care, health unknown prior to test



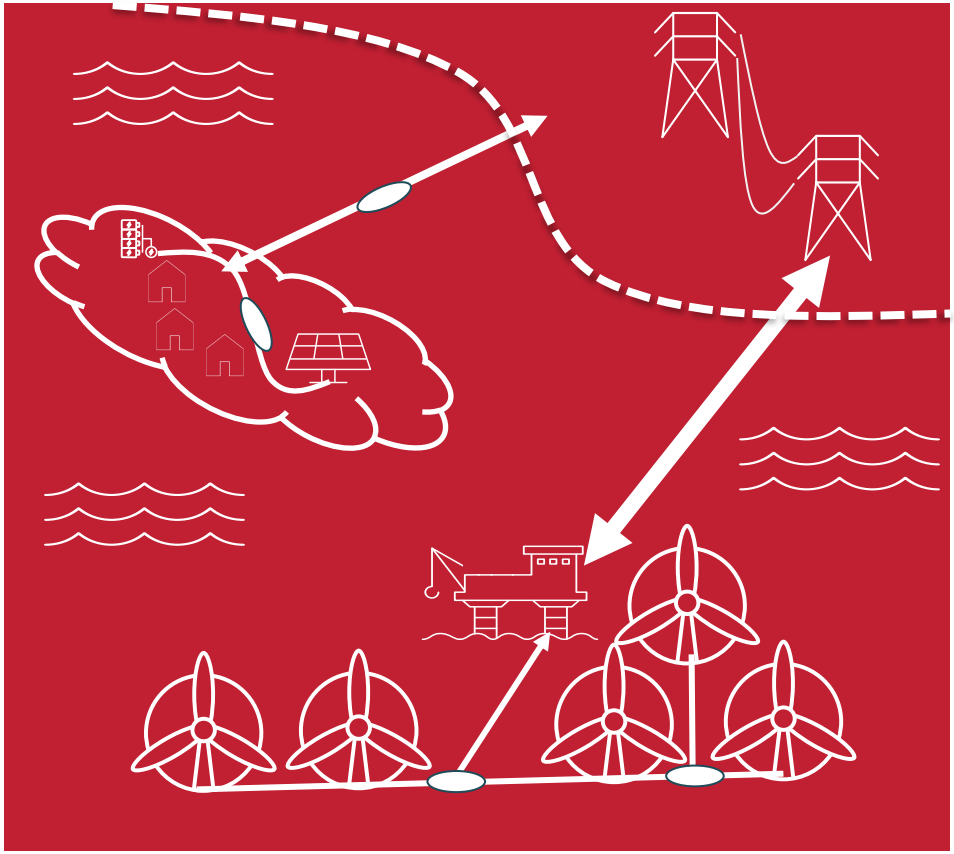
New circuits

		New circuits
Source of criticality	Impact to the end customer	√
	Reliability (SAIDI/SAIFI)	
	Circuit access/ location	√
	Maintenance repair	√

Generally, concerns over the test protocol (time and voltage) are minimal.

Sequencing (installation/testing) is the major concern due to the difficulty of repair.

Traditionally, commissioning testing is undertaken upon project completion, prior to handover



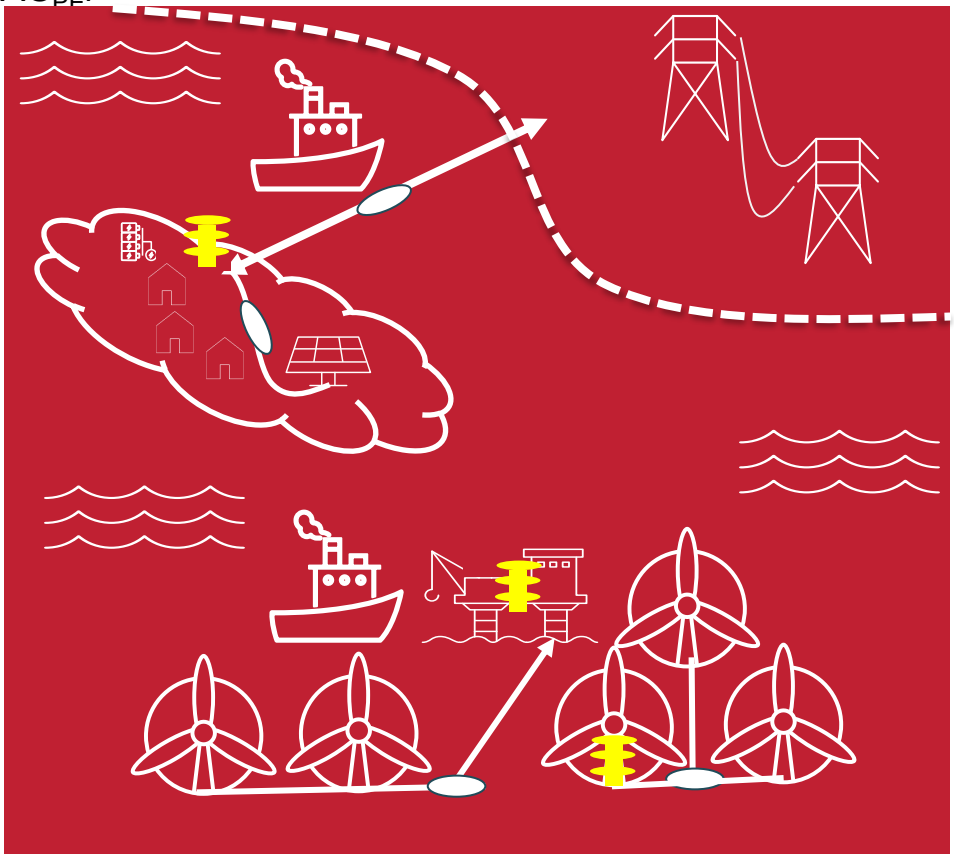
New circuits

		New circuits
Source of criticality	Impact to the end customer	√
	Reliability (SAIDI/SAIFI)	
	Circuit access/ location	√
	Maintenance repair	√

Repair options, installation handleability, and accessibility are important factors to consider when developing a diagnostic schedule.

On critical circuits, diagnostic testing may often be preferred within the installation schedule because if any issues are observed, then repair resources are on hand.

The size/handleability/power requirements of the diagnostics employed can be an important consideration, i.e., comparing footprints of AC_{VLF}, and AC_{PF}.



Early fails and recommission

		Early fails
Source of criticality	Impact to the end customer	√
	Reliability (SAIDI/SAIFI)	√
	Circuit access/ location	
	Maintenance repair	√

Population forensics assesses context and provides guidance.

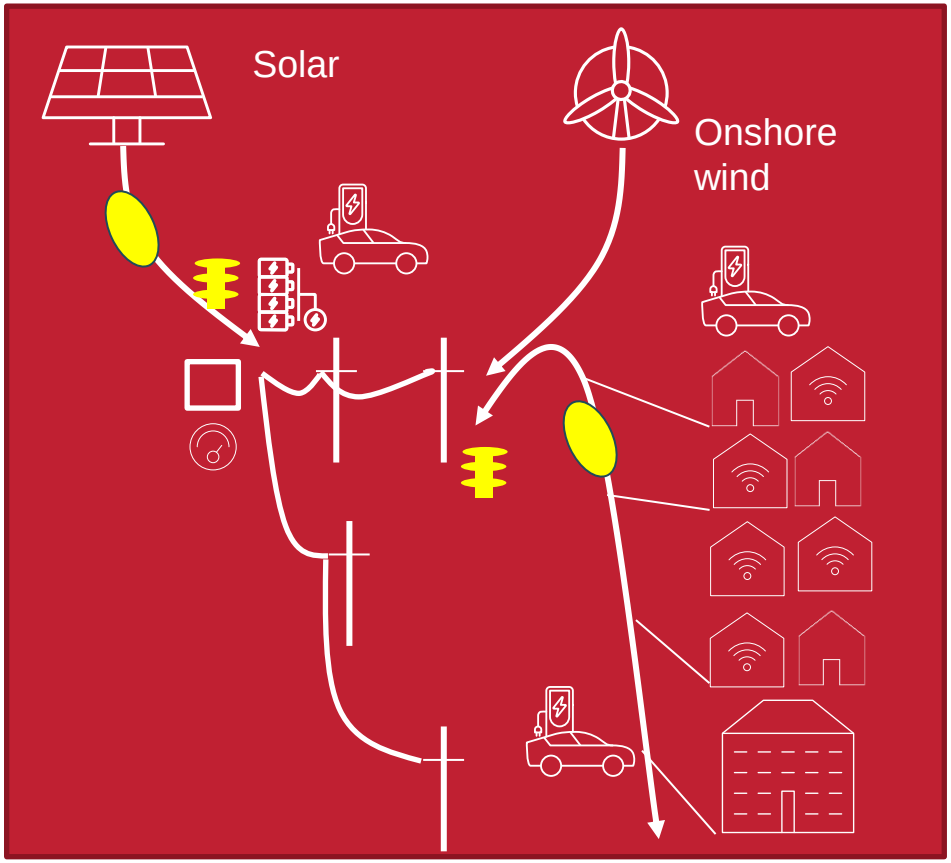
The health of the whole circuit and the ultimate goals are important when deciding the exposure to be used within a diagnostic protocol.

Premature failures raise concerns over the health of the asset as they are unexpected early in life.

Population forensics can assist in assessing context.

When a repair is made, the recommissioning tests confirm a) the health of the remaining parts and b) the efficacy of the repair.

Not clear if recommissioning should be conducted as if it were i) new or ii) had seen some aging.



Existing with diagnostic record

		Existing with record
Source of criticality	Impact to the end customer	
	Reliability (SAIDI/SAIFI)	√
	Circuit access/ location	√
	Maintenance repair	√

Interpretation of the health levels should be reported and archived with the outcomes.

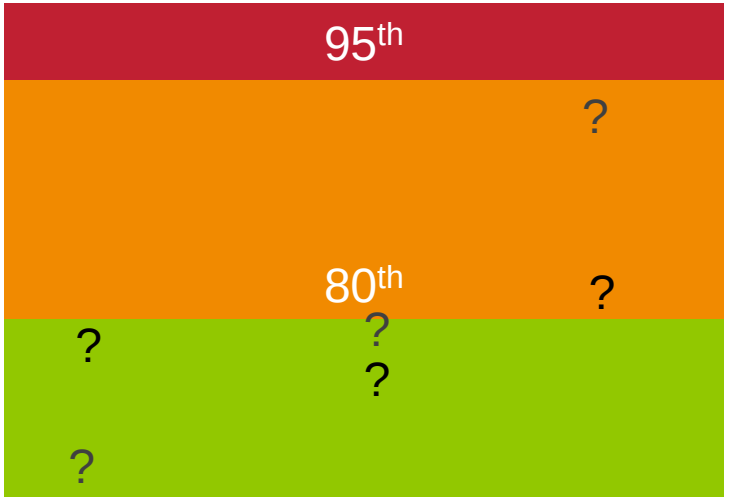
Prior health of a circuit can be used to guide testing.

Forensics provides confirmation of correct diagnostic.

However, it is important to have a clear interpretation of the outcomes from prior testing.

If possible, the context of the reporting should be recorded with the results.

Interval	Test date minus		
	8 years	4 years	1 year
Diagnostic outcome	No action required	No action required	Further study



Trending could bring a valuable diagnostic feature

Existing with diagnostic record

		Existing with record
Source of criticality	Impact to the end customer	
	Reliability (SAIDI/SAIFI)	√
	Circuit access/ location	√
	Maintenance repair	√

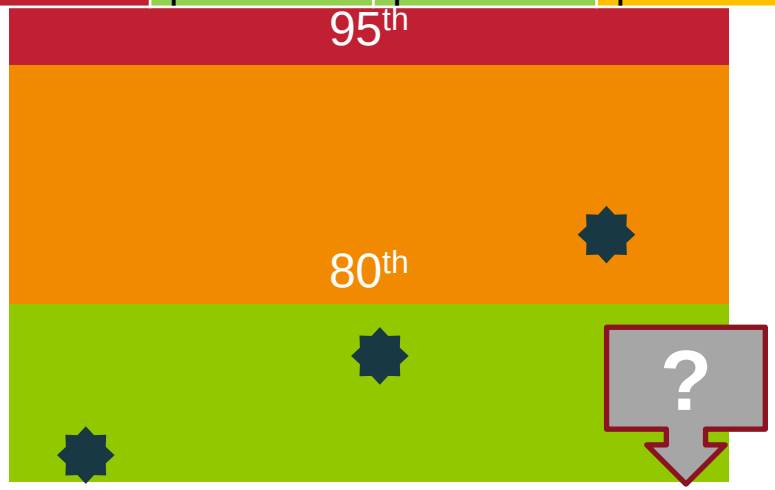
Interpretation of the health levels should be reported and archived with the outcomes.

The health metrics deliver optimal value and permit the use of robust trending as part of the assessment.

The history guides subsequent testing.

Context is as important are the detailed results and should be recorded together.

Interval	Test date minus		
	8 years	4 years	1 years
Diagnostic outcome	No action required 70th percentile	No action required 78th percentile	Further study 85th percentile



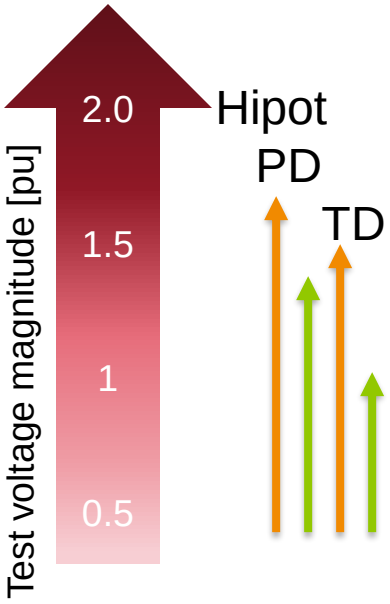
Match testing with a good estimate of current health.

Existing no diagnostic record

		Existing no record
Source of criticality	Impact to the end customer	√
	Reliability (SAIDI/SAIFI)	√
	Circuit Access/ location	√
	Maintenance repair	√

This is the most difficult scenario for critical circuits since there is no way to judge the health prior to testing.

The only plausible protocols that can be deployed here is to obtain and digest diagnostic information whilst minimizing the risk.



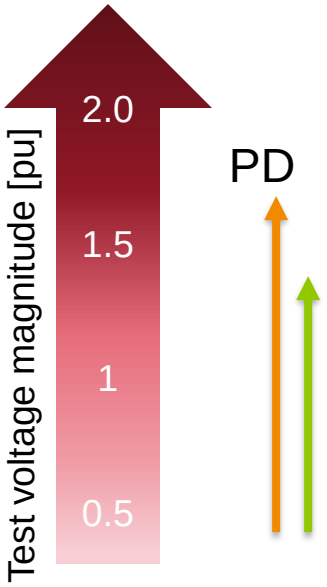
What are the appropriate:

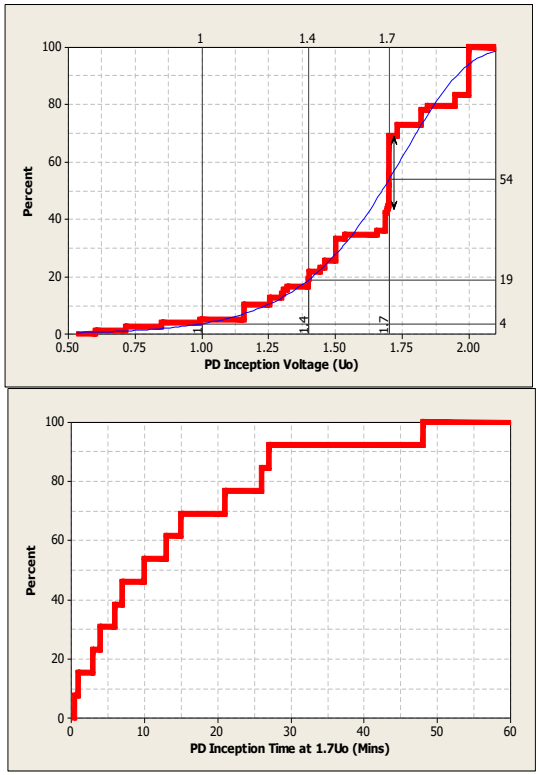
1. Levels
2. Features
3. Criteria

Existing no diagnostic record

Reducing the exposure (time and voltage) reduces risk; however, it also reduces the detection sensitivity of a diagnostic.

		Existing no record
Source of criticality	Impact to the end customer	√
	Reliability (SAIDI/SAIFI)	√
	Circuit access/ location	√
	Maintenance repair	√





Important to balance the benefit and risk.

Source: CIGRE B1.28

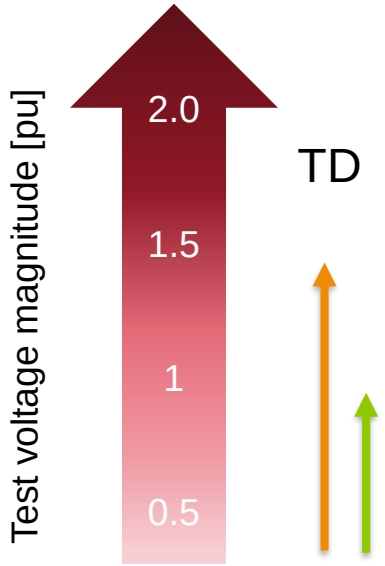
Existing no diagnostic record

		Existing no record
Source of criticality	Impact to the end customer	√
	Reliability (SAIDI/SAIFI)	√
	Circuit access/ location	√
	Maintenance repair	√

If lower exposures (time/voltage) are used, it is likely that there will be different diagnostic features and criteria.

Features and criteria cannot be arbitrarily chosen; the analysis needs to be in line with the goals of the testing.

Condition assessment	STD U_0 [E-3]	TU $1.5U_0$-0.5 U_0 [E-3]	TD U_0 [E-3]
Action required	>0.5	>80	>50



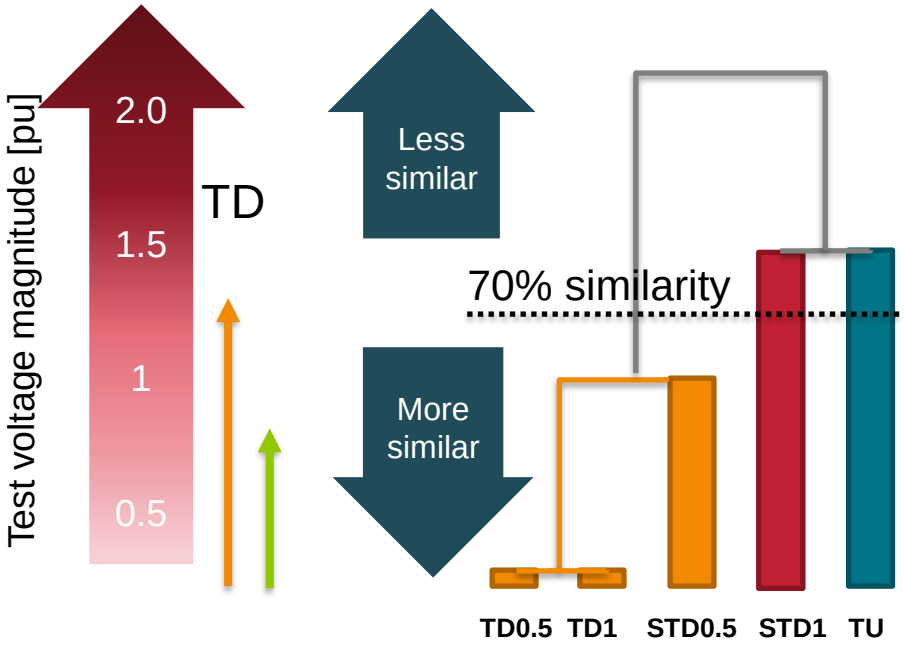
Existing no diagnostic record

		Existing no record
Source of criticality	Impact to the end customer	√
	Reliability (SAIDI/SAIFI)	√
	Circuit access/ location	√
	Maintenance repair	√

If lower exposures are used, it is likely that there will be different diagnostic features and criteria.

Features and criteria cannot be arbitrarily chosen; the analysis needs to be in line with the goals of the testing.

Condition assessment			
Action required			



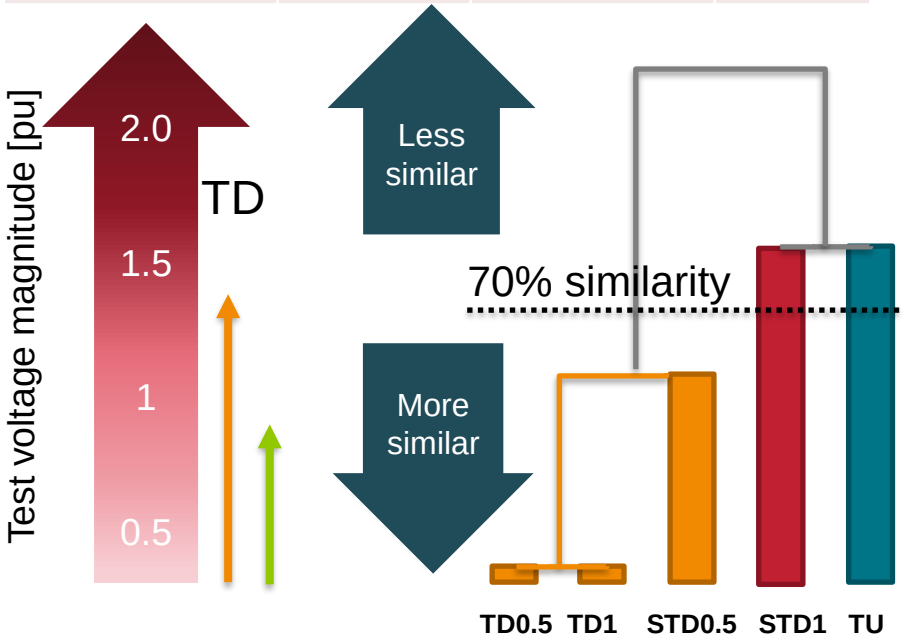
Existing no diagnostic record

		Existing no record
Source of criticality	Impact to the end customer	√
	Reliability (SAIDI/SAIFI)	√
	Circuit access/ location	√
	Maintenance repair	√

If lower exposures are used, it is likely that there will be different diagnostic features and criteria.

Features and criteria cannot be arbitrarily chosen, the analysis needs to be in line with the goals of the testing.

Condition assessment	**STD U_0**	**TU U_0-0.5 U_0**	**TD U_0**
Condition assessment	**TU U_0-0.5 U_0**	**STD U_0**	**STD 0.5 U_0**



New features developed for the test protocol from the analysis of historical data.

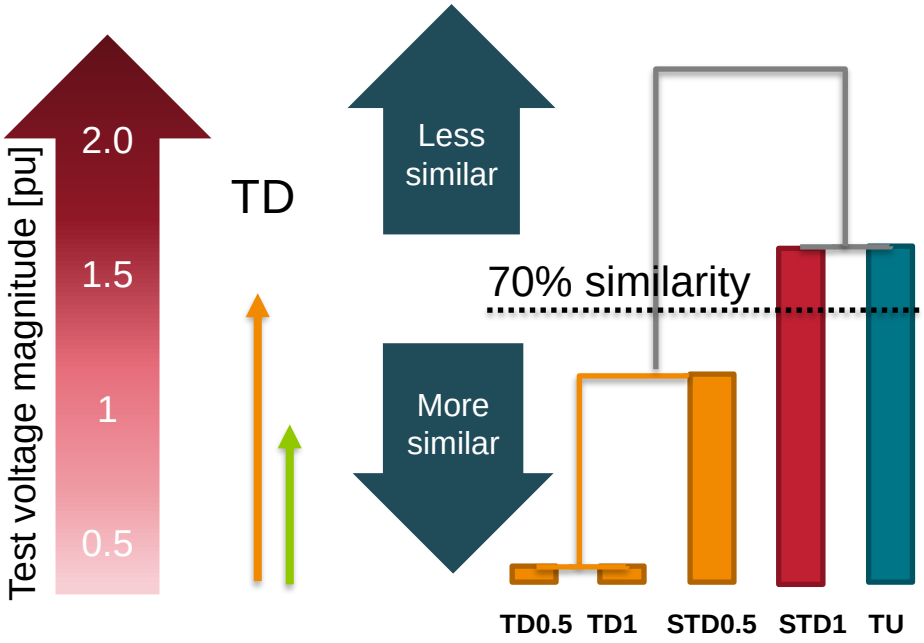
Existing no diagnostic record

If lower exposures are used, it is likely that there will be different diagnostic features and criteria.

Features and criteria cannot be arbitrarily chosen; the analysis needs to be in line with the goals of the testing.

		Existing no record
Source of criticality	Impact to the end customer	√
	Reliability (SAIDI/SAIFI)	√
	Circuit access/ location	√
	Maintenance repair	√

Condition assessment	STD U_0 [E-3]	TU U_0-0.5 U_0 [E-3]	TD U_0 [E-3]
Action required	>1	>60	>70



Studies of performance are required to determine the features and criteria needed to give the desired benefit.

Conclusions

1. On new circuits, repair options and accessibility are important considerations when developing a diagnostic schedule and deciding on technologies.
2. When recommissioning young circuits, the health of the whole circuit and the ultimate goals are important considerations when assessing the exposure to be used within a diagnostic protocol.
3. Interpretation of the health levels should be reported and archived with the outcomes so that they may be easily accessed and used in future studies.
4. When no history or diagnostic data are available:
    - It’s important to balance benefits and risks.
    - Studies are required to determine the features, levels and criteria required to give the desired benefit.
    - Deploy/diversify additional diagnostic techniques with no inherent risk.
5. Forensics, preferably population forensics, compliment diagnostic for critical circuits as they support the choice of the correct diagnostic for the situation.