



Identifying Levels of Corrosion and Condition of Hardware and Insulators on Transmission Line Structures and Supports

Effective: 08/31/2020 Rev: 1

PPE:

Standard T-Line PPE,
including:

- Hard Hat
- Safety Glasses
- Gloves
- FR Clothing
- Safety Boots
- Fall Protection

Tools:

- Binoculars
- Camera

Guidance Document References:

[TD-1001M, “Electric Transmission Preventive Maintenance Manual”](#)

Level of Use:

- ☐ Information
- ☒ Reference
- ☐ Continuous

Purpose:

This job aid provides consistent evaluation of rust and corrosion on hardware and insulators on Transmission Line (T-Line) structures. The evaluation will classify the severity and potential impact of the rust, corrosion or deterioration, and the description of each condition level. The Qualified Company Representative (QCR) combines hardware or insulator condition with other as-found conditions and risk factors to assess and recommend the appropriate priority level.

The QCR should use this guide to select the appropriate condition representing the as-found corrosion or deterioration level for assigning the recommended priority code. Follow instructions in the [ETPM Manual](#), in conjunction with this guide, to document the condition(s) on an SAP notification.

Corrosion:

- The corrosion conditions in this job aid apply to the conditions found on painted/ coated steel, galvanized steel, and weathering steel. Any steel exposed to environmental conditions, including compromised/missing/deficient galvanization, should be addressed to mitigate corrosion.
- The recommended priority code is determined based on the corrosion condition, other as-found conditions, the risk factors, corrosion areas as defined in [Numbered Document 032911, “Corrosion Area – Overhead Lines,”](#) and the QCR’s experience and judgement.
- Some occurrences, particularly heavy to severe corrosion, require an engineering assessment. For these items, submit a request for an engineering evaluation.
- Follow instructions in the [ETPM Manual](#), in conjunction with this guide, to document the corrosion condition on an SAP notification.



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Insulators and Hardware:

- Risk factors, such as structure location (e.g. coastal zone, residential area) should be considered when assigning the recommended priority code. For example, insulator strings and hardware near the coast may be more critical and may need to be replaced more urgently.
- Some insulator and hardware conditions may require an engineering assessment. For these items, submit a request for an engineering evaluation.
- For multi-circuit structures, ensure tags for insulator and/or hardware work are created on the correct SAP ID (Structure or Host Insulator or Guest Insulator). Please refer to the table below for further guidance.

Equipment	FDA	SAP ID
Insulator String	Insulator	Insulator
Cold-End Hardware (C-Hooks etc.)	Insulator	Insulator
Hot-End Hardware (Shoes etc.)	Insulator	Insulator
Hanger Plate	Hardware – Steel	If on Host: Structure If on Guest: Insulator

- For structures with worn hanger plates and rusty insulators, two separate tags should be created – one for the hanger plates and one for the insulators.

Condition Codes:

Inspect the structure using the form to record issues. Determine the condition of each item. Consider all conditions to determine the appropriate Priority Code for any Notification, if required.

- 5 = Heavy Damage with Safety Concerns
- 4 = Heavy Damage
- 3 = Moderate Damage
- 2 = Light Damage
- 1 = No Visible Damage

Insulator Decision-Making Trees

See [Exhibit 10, “Insulator Decision-Making Trees”](#) in ETPM Manual.



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WildfireMitigationPlans_DR_CalAdvocates_036-Q13Atch04

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Guide for Replacing Damaged Insulators:

- The table below is based on ANSI C29.1 dry flashover insulator characteristics. If possible, replace insulators before the onset of wet weather.
- Adjust the Priority Code based on the various conditions that may exist, including:
 - Priority Code A** (fix immediately) for 2 or more insulators less than the G.O. 95 requirement
 - Priority Code B** (fix within 3 months) for 1 insulator less than the G.O. 95 requirement
 - Priority Code E** (fix within 1 year) if less than design, but more than the G.O. 95 requirement
 - Number of insulators fewer than G.O. 95 requirement may be due to damaged insulators or previous designs
- If an insulator string has broken insulators and the remaining number of good insulators in the string exceeds the design number of units, assign Priority Code E.

Voltage	Configuration	Contamination District	G.O.95 Minimum Requirements		Design # of Units	Minimum # of Units	# of Broken Units	
			Dry Flashover	# of Units			1	2 or more
							Priority Code	
500kV	Dead-end	AAA	1,190 kV	23	34	32	E	B
	Dead-end	B, C, D			34	32	E	B
	Vee String	AAA			36	34	E	B
	Vee String	B, C, D			34	32	E	B
	Suspension	AAA			32	30	E	B
	Suspension	B, C, D			32	30	E	B
230kV	Dead-end	AAA	582 kV	12	24	20	E	B
	Dead-end	A			24	20	E	B
	Dead-end	B, C, D			15	13	E	B
	Suspension	AAA			15	13	E	B
	Suspension	A, B, C, D			15	13	E	B
115kV	Dead-end	AAA	333 kV	6	12	10	E	B
	Dead-end	A			11	9	E	B
	Dead-end	B			10	8	E	B
	Dead-end	C, D			9	8	E	B
	Suspension	AAA			10	6	E	B
	Suspension	A, B			8, 9	6	E	B
	Suspension	C, D			8	6	E	B
60/70kV	Dead-end	AAA	180 kV	3	7	5	E	B
	Dead-end	A, B			6	5	E	B
	Dead-end	C, D			5	5	E	B
	Suspension	AAA, A, B			5	3	E	B
	Suspension	C, D			4	3	E	B



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Insulator Conditions:

- Broken insulators have one or more of the following conditions ¹:
 - Glass or porcelain is broken and only the hub is remaining.
 - Porcelain insulators cracked to the hub may not have the same mechanical strength. See TD-1001M, Table 4, Priority A.
 - One or more skirts are broken and a piece is missing.
 - The insulator is cracked.
 - Glass insulators retain 80% of the M&E rating, thus if a glass insulator is broken, use the Table on Page 3 to assign priority code to replace the broken insulator(s).
- Chipped insulators generally have little effect on the reliability of the insulator and do not need to be addressed, unless one or more of the conditions listed below are present. If any of these conditions exist, evaluate the insulator like it was a broken insulator in the Table on Page 3.
 - A crack extends from the chip.
 - The chip is larger than 2 inches in diameter.
 - The chip is located next to a grouted fitting where it will trap water and could freeze.
- The priority for a flashed insulator depends on the type of insulator. The following information provides some direction for assigning priorities to the various types of insulators:
 - Porcelain - Replace the entire insulator string or post insulator. Depending on the weather conditions, contamination present on the insulator, and the contamination area, assign Priority Code A, B, or E. If assigning a Priority Code B or E, the insulator must be washed or cleaned as soon as practical to prevent it from flashing over again before it is replaced.
 - Glass - Glass insulators do not always need to be replaced when flashed. If the glass is intact, cleaning the insulator usually restores its electrical strength. However, if the glass is broken, replace the insulator(s) and assign the Priority Code using the criteria for broken insulators.
 - Non-Ceramic - If the flashover damaged the insulator sheds or end fittings, assign Priority Code A and replace the insulator. If there is no visible damage to the insulator skirts or end fittings, the insulator does not need to be replaced and does not need a Priority Code.

¹ R. S. Gorur, "Failure Modes of Porcelain and Toughened Glass Suspension Insulators", IEEE Trans 2011 Electrical Insulation Conference, June 2011, 978-1-4577-0279-2/11.

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Hardware Condition Levels and Impact

Condition 5

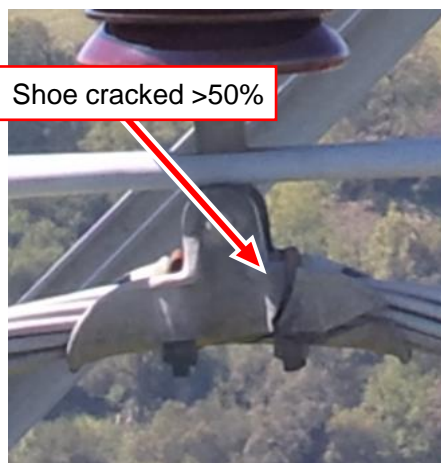
Severe corrosion with an **immediate** safety concern or potential to impact operations

- Rust >50% material loss
- Worn >50% material loss
- Cracked >50%
- Contaminate (Arcing)
- Cotter Key missing AND Retainer Pin not fully seated
- <1/4" thickness on hanger plate

Hardware tags include work on Bolts, J-Bolts, U-Bolts, Links, Clamps, Hot-End and Cold-End Hardware, Shoe Assembly, Shackles, Cotter Keys/Pins, Turnbuckles.

Action:

1. Request engineering assessment of the structural integrity.
2. Take photos of damage.
3. Priority Code A.



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Hardware Condition Levels and Impact

Condition 4

Heavy damage. Severe corrosion with **possible** near term impact to safety, facility integrity or operations.

- Cracked 30% - 50%
- Rust 30 - 50% material loss
- Worn 30 - 50% material loss
- Missing hardware (if necessary, send to engineering for evaluation)
- Cotter Key missing or loose (Retainer Pin well seated)

Hardware tags include work on Bolts, J-Bolts, U-Bolts, Links, Clamps, Hot-End and Cold-End Hardware, Shoe Assembly, Shackles, Cotter Keys/Pins, Turnbuckles.

Action:

1. Request engineering assessment of the structural integrity.
2. Take photos of damage.
3. Choose Priority Code B.



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Hardware Condition Levels and Impact

Condition 3

Moderate damage or moderate corrosion with **possible** longer term impact to safety, facility integrity or operations.

- Cracked 5% - 30%
- Loose bolts
- Turnbuckle out of threads

Hardware tags include work on Bolts, J-Bolts, U-Bolts, Links, Clamps, Hot-End and Cold-End Hardware, Shoe Assembly, Shackles, Cotter Keys/Pins, Turnbuckles.

Action:

1. Choose Priority Code E.
2. Take photos of damage.



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Condition 2

Light damage or light corrosion with no expected near term impact to facility integrity or operations.

- Turnbuckles not punched.

Hardware tags include work on Bolts, J-Bolts, U-Bolts, Links, Clamps, Hot-End and Cold-End Hardware, Shoe Assembly, Shackles, Cotter Keys/Pins, Turnbuckles.

Action:

1. Take photos of damage.
2. Choose Priority Code F.



Hardware Condition Levels and Impact

Condition 1

No visible damage

Action:

1. None.
2. Take photos.
3. Continue monitoring.
4. No Priority Code.



Step bolts present and in good condition. No visible rust.



No visible rust on cold-end hardware.



No visible rust on hot-end hardware.

Insulator Condition Levels and Impact

Condition 5

Severe deterioration with an **immediate** safety concern or potential to impact operations

- Rust >50% material loss
- Worn >50% material loss
- Cracked >50%
- Porcelain cracked to the cap
- Contaminated (Arcing)

Action:

1. Request engineering assessment of the structural integrity.
2. Take photos of damage.
3. Choose Priority Code A.



Porcelain disc cracked to the cap.

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Insulator Condition Levels and Impact

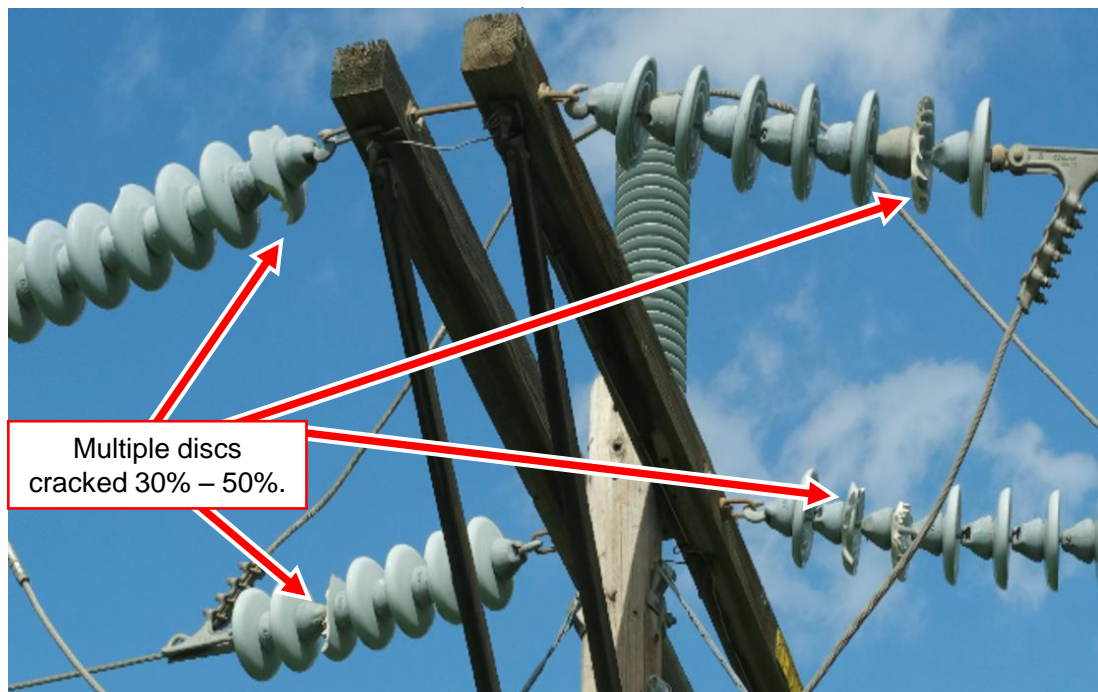
Condition 4

Heavy damage with **possible** near term impact to safety, facility integrity or operations.

- Cracked 30% - 50%
- Contaminated (Heavy)
- Tracking (Heavy)
- Chalking/Cracking on Polymer
- Missing/Loose/Not fully seated Cotter Key or Retainer Pin
- Out-of-plumb post or suspension insulator exhibiting signs of impacting conductor.

Action:

1. Request engineering assessment of the structural integrity.
2. Take photos of damage.
3. Choose Priority Code B.



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Insulator Condition Levels and Impact

Condition 3

Moderate damage with **possible** longer term impact to safety, facility integrity or operations.

- Rust 30% - 50% material loss
- Worn 30% - 50% material loss
- Cracked 5% - 30%
- Out-of-plumb suspension insulator > 2 bells out of plumb
- Out-of-plumb post insulator > 6"
- Contaminated (Medium)
- Tracking (Medium)
- Missing Grading Ring on Polymer (where necessary)
- Corona Rings damaged, missing (where required) or improperly installed (500kV only)

Action:

1. Choose Priority Code E.
2. Take photos of damage.
3. Identify location of foundation damage.



Suspension insulator strings are 2 or more bells out of plumb.



Insulator chipped 5% - 30%.

30% rust on a majority of caps.





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Condition 2

Light damage with no expected near term impact to facility integrity or operations, but should be monitored to check on the rate of advancement.

- No Priority F, i.e., 24 month, tags for insulator work.

Action:

1. Continue monitoring.
2. Take photos.

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Insulator Condition Levels and Impact

Condition 1

No visible damage.

Action:

1. None.
2. Take photos.
3. Continue monitoring.
4. No Priority Code.

No visible damage.
Insulators in good condition.

