



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

WMP-Discovery2023_DR_CalAdvocates_021-Q003Atch04

TD-1001M-JA07

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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 steps for consistent evaluation of rust and corrosion on hardware and insulators on Transmission Line (T-Line) structures. The evaluation classifies the severity and potential impact of the rust, corrosion, or deterioration, and provides 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 must 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:

- Consider risk factors, such as structure location (e.g., coastal zone, residential area) when assigning the recommended priority code. For example, insulator strings and hardware located 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 that tags for insulator and/or hardware work are created on the correct SAP ID (Host Insulator or Guest Insulator). See Table 1 below for further guidance.

Table 1

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 (see NOTE below)	Insulator

NOTE

- For hanger plates on wood or light duty steel poles, use Hardware-Wood.
- For hanger plates on tubular steel poles, use Hardware-Steel.
- For all others, use Hardware-Tower (most common).

- For structures with worn hanger plates, create two separate tags – 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*.

Criteria to Determine Wear on C-Hook and Hanger Plate Assemblies

Using the wear percentages in the [ETPM Manual](#), Table 4 is a proactive approach to replacing hardware. The levels presented in Table 4 are conservative.

During the inspection, follow criteria below when determining C-hook and hanger plate wear.

- When possible, observe the C-hook and hanger plate from multiple angles.
- When inspecting an asset with several C-hook/hanger plate assemblies, estimate the highest level of wear among any C-hook or any hanger plate.
- The 3D models provide various simulated levels of wear. Note that wear may occur at uneven rates across all components on a structure and may not exactly match the models.
- Create notification(s) when ANY of the following conditions are observed:
 - **When evaluating the C-hook for individual wear:** Individual component has estimated wear of 30% or more.
 - **When evaluating the hanger plate for individual wear:** Individual component has less than 1/2" of material remaining (as measured from the bottom of the hole to the bottom of the plate).
 - <1/4" (approximately < 33%) material remaining on plate is Priority A.
 - 1/4–1/2" (approximately 34%–70%) material remaining on plate is Priority B.

NOTE

Thickness of material (i.e., plate thickness) can determine if it is Priority A or Priority B. A relatively thin plate (e.g., less material) is a Priority A.

- **When wear cannot be definitively determined to be lower than 30%.**
- Use [ETPM Manual](#), Table 4 to set the appropriate priority.
- Centralized Inspection Review Team (CIRT) has the discretion to upgrade, downgrade, or cancel notifications with additional information (e.g., other inspection methods or a field review).
- During the repair, if the hanger plate is determined not to be worn, provide a picture of the unworn hanger plate to cancel/close the hanger plate replacement line corrective (LC) notification.

See [Figure 1](#) below and [Figure 2](#) on Page 5 for examples of hardware assemblies of C-hooks and hanger plates with various percentage of material loss. The figures show the same level of wear on each component, providing front and side view.

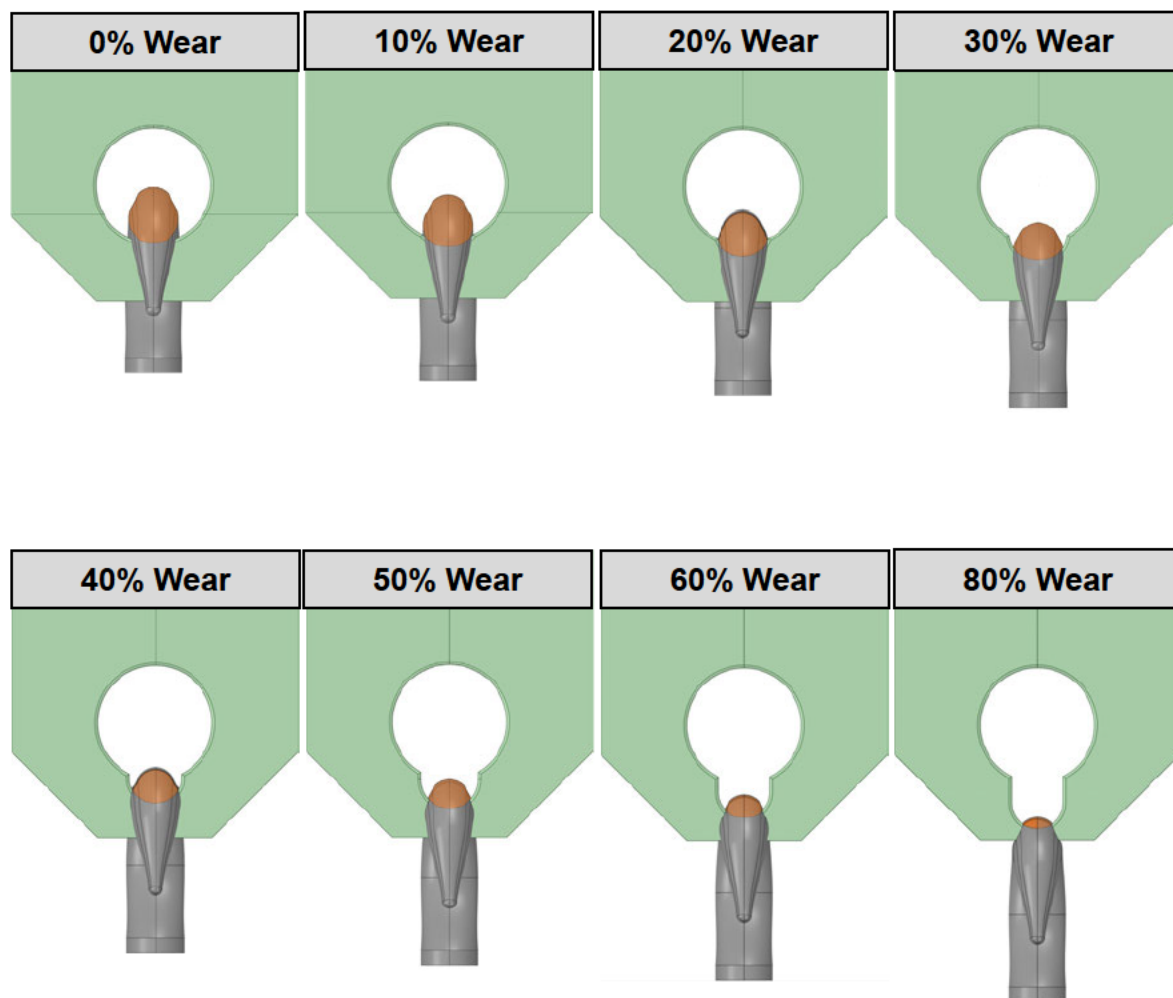


Figure 1. Front View

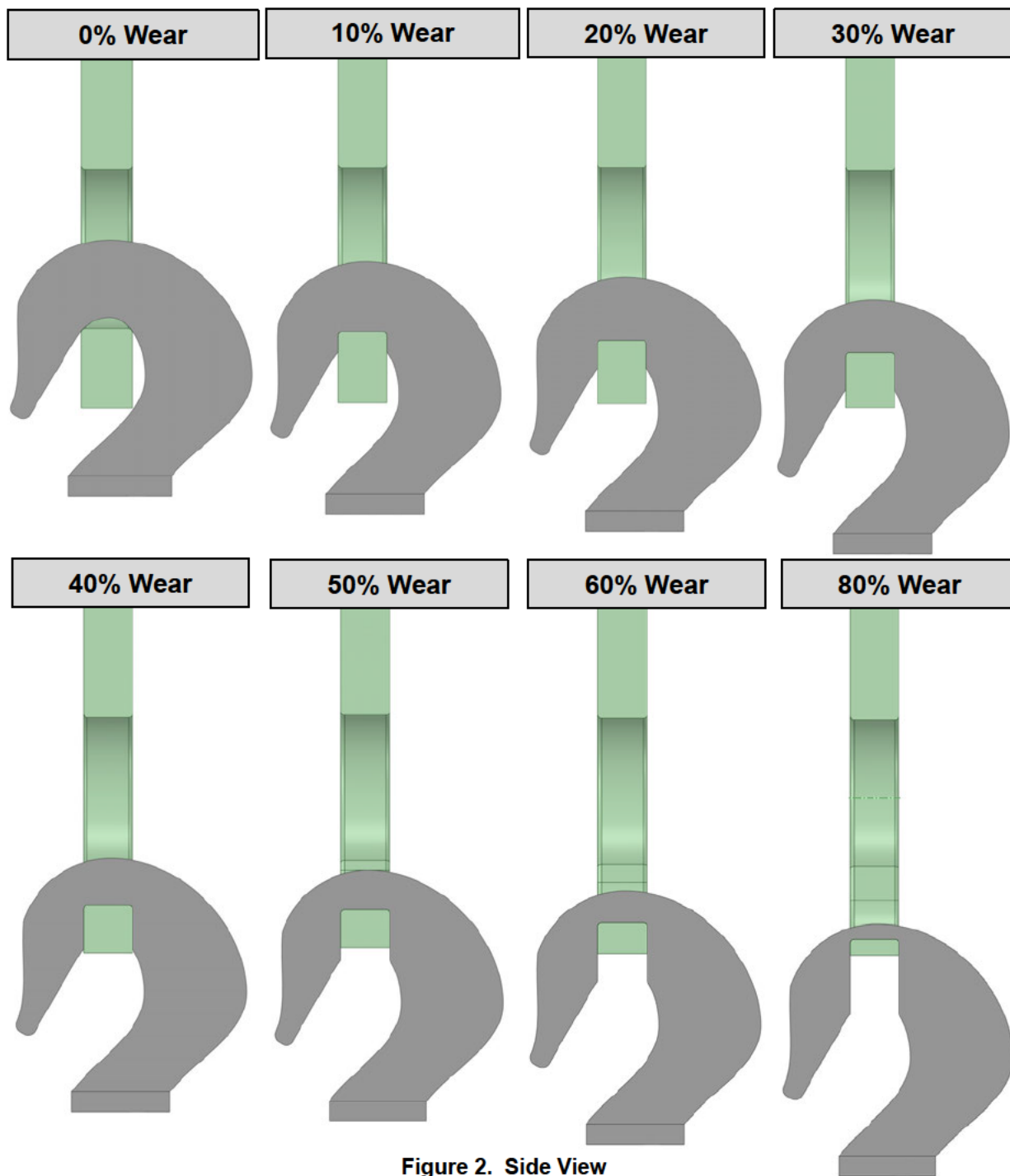


Figure 2. Side View



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See the following exhibits in *ETPM Manual* for 3D hardware assemblies of C-hooks with various percentages of material loss:

- [Exhibit 11, "3D Hardware Assembly of C-Hooks with 1/4-inch 0% Material Loss"](#)
- [Exhibit 12, "3D Hardware Assembly of C-Hooks with 1/4-inch 10% Material Loss – Plate Only"](#)
- [Exhibit 13, "3D Hardware Assembly of C-Hooks with 1/4-inch 30% Material Loss – Plate Only"](#)
- [Exhibit 14, "3D Hardware Assembly of C-Hooks with 1/4-inch 50% Material Loss – Plate Only"](#)
- [Exhibit 15, "3D Hardware Assembly of C-Hooks with 1/4-inch 70% Material Loss – Plate Only"](#)
- [Exhibit 16, "3D Hardware Assembly of C-Hooks with 5/8-inch 0% Material Loss"](#)
- [Exhibit 17, "3D Hardware Assembly of C-Hooks with 5/8-inch 10% Material Loss – Plate Only"](#)
- [Exhibit 18, "3D Hardware Assembly of C-Hooks with 5/8-inch 30% Material Loss – Hook Only"](#)
- [Exhibit 19, "3D Hardware Assembly of C-Hooks with 5/8-inch 50% Material Loss – Hook Only"](#)
- [Exhibit 20, "3D Hardware Assembly of C-Hooks with 5/8-inch 70% Material Loss – Hook Only"](#)

NOTE

Follow this link for instructions on how to enable Acrobat Reader to move 3D objects:
<https://helpx.adobe.com/acrobat/using/enable-3d-content-pdf.html>.



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Guide for Replacing Damaged Insulators:

- Table 2 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 the following:
 - Priority Code A** (fix immediately): for two or more insulators fewer than the G.O. 95 requirement.
 - Priority Code B** (fix within 3 months): for one insulator fewer than the G.O. 95 requirement.
 - Priority Code E** (fix within 1 year): if less than design, but more than or equal to 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, THEN assign Priority Code E.

Table 2

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



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Insulator Conditions:

- Broken insulators have one or more of the following conditions¹:

- Glass or porcelain is broken and only the hub is remaining.
- One or more skirts are broken, and a piece is missing.
- The insulator is cracked.
- Glass insulators retain 80% of the M&E rating.

IF a glass insulator is broken,

THEN use [Table 2](#) on Page 7 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.

- A crack extends from the chip.
- The chip is larger than 1-1/2 inches in diameter.
- The chip is located next to a grouted fitting where it could trap water and freeze.

IF any of these conditions exist,

THEN evaluate the insulator as a broken insulator in [Table 2](#).

- 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. When assigning a Priority Code B or E, wash or clean the insulator as soon as practical, if contaminated. This is 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.

IF the glass is broken,

THEN 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, THEN assign Priority Code A and replace the insulator.
 - IF there is no visible damage to the insulator skirts or end fittings, THEN 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.

Hardware Condition Levels and Impact

Condition 5

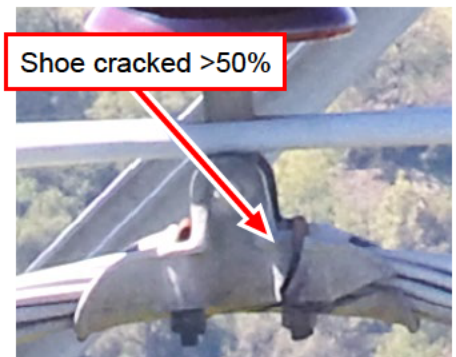
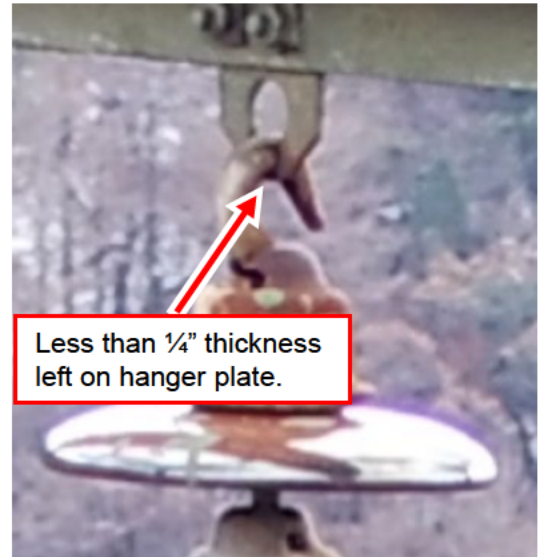
Severe corrosion with an **immediate** safety concern or potential to impact operations

- 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 the damage.
3. Priority Code A.



Hardware Condition Levels and Impact (continued)

Condition 4

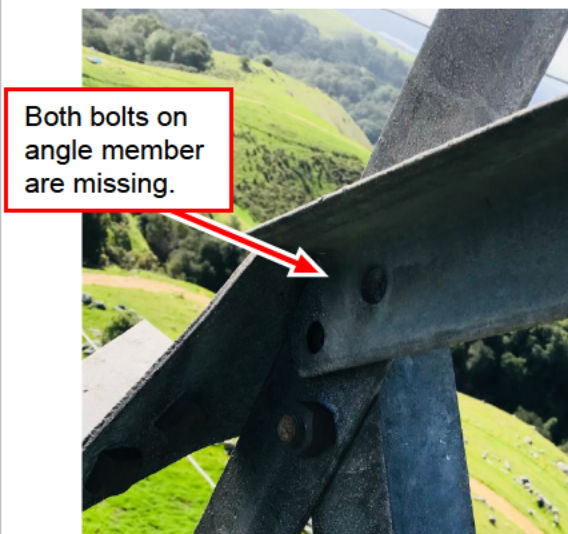
Heavy damage. Severe corrosion with possible near-term impact to safety, facility integrity, or operations.

- Cracked 30–50%
- Rust 30–50% material loss
- Worn 30–50% material loss
- Missing hardware (if necessary, send to engineering for evaluation)
- Missing cotter key; loose cotter key in retainer pin
- 1/4–1/2" 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 the damage.
3. Choose Priority Code B.



Hardware Condition Levels and Impact (continued)

Condition 3

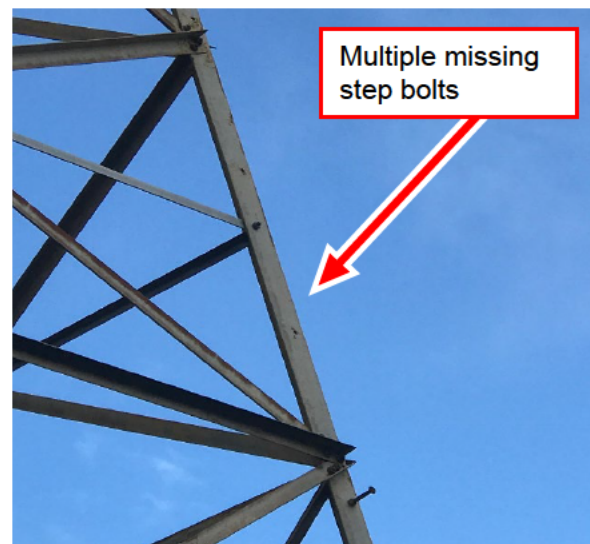
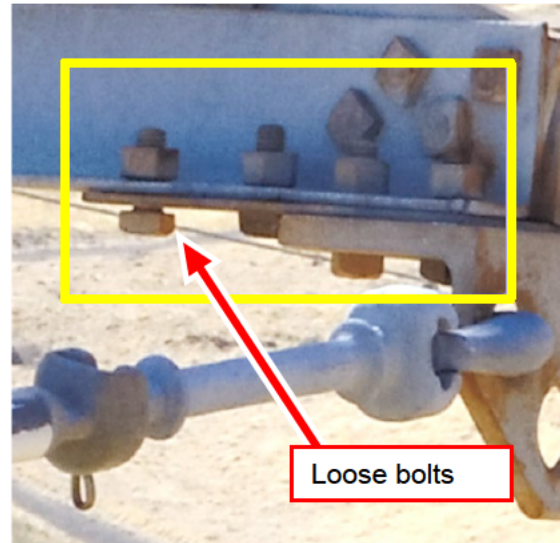
Moderate damage or moderate corrosion with possible longer-term impact to safety, facility integrity, or operations.

- 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 the damage.



Hardware Condition Levels and Impact (continued)

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 the damage.
2. Choose Priority Code F.



Hardware Condition Levels and Impact (continued)

Condition 1

No visible damage

Action:

1. Take photos.
2. Continue monitoring.
3. 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



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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
- Contaminated (arcing)

Action:

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

Insulator Condition Levels and Impact (continued)

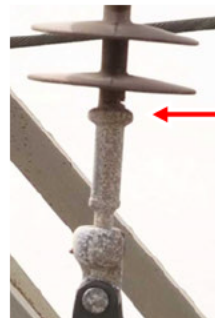
Condition 4

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

- 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:

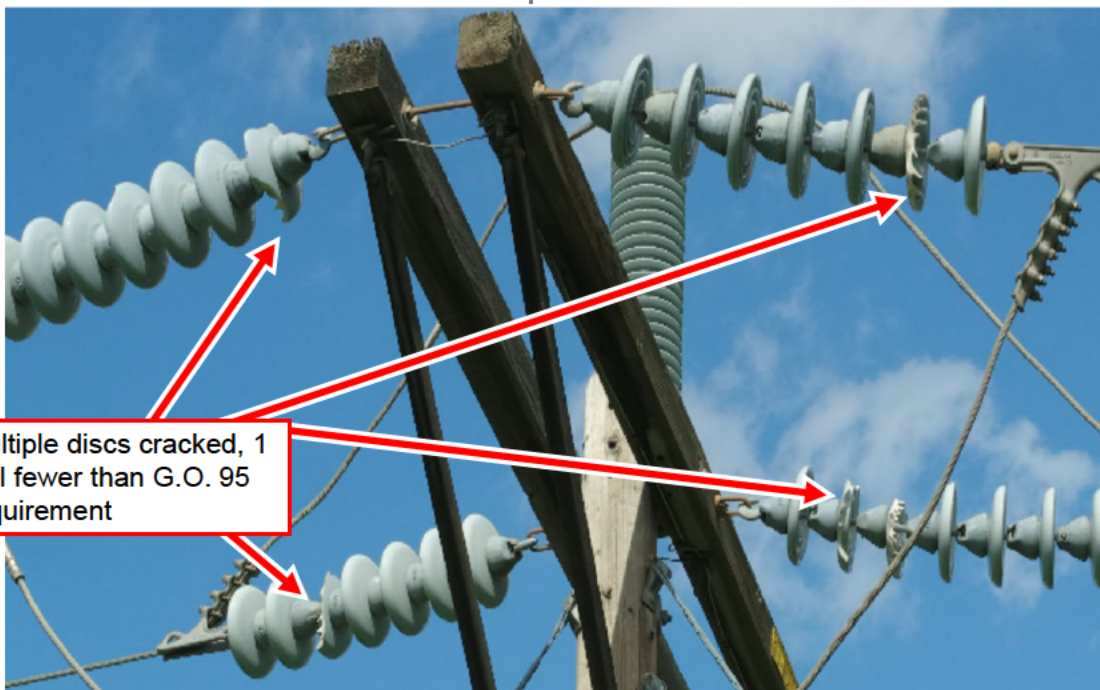
1. Request engineering assessment of the structural integrity.
2. Take photos of the damage.
3. Choose Priority Code B.



Cracked polymer insulator



Multiple bells have been flashed



Multiple discs cracked, 1 bell fewer than G.O. 95 requirement

Insulator Condition Levels and Impact (continued)

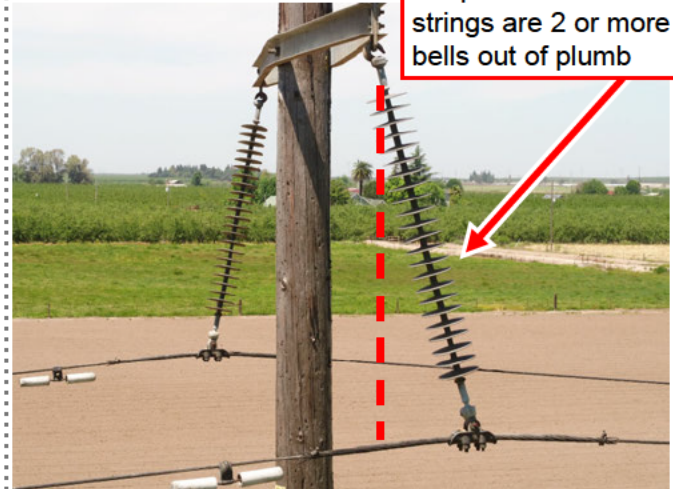
Condition 3

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

- Rust 30–50% material loss
- Worn 30–50% material loss
- 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 (500 kV only)

Action:

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





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Insulator Condition Levels and Impact (continued)

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.

Insulator Condition Levels and Impact

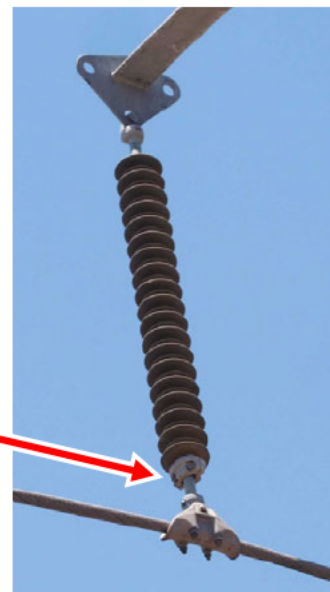
Condition 1

No visible damage.

Action:

1. Take photos.
2. Continue monitoring.
3. No Priority Code.

Grading ring present on polymer suspension insulator.



No visible damage. Insulators are in good condition.

